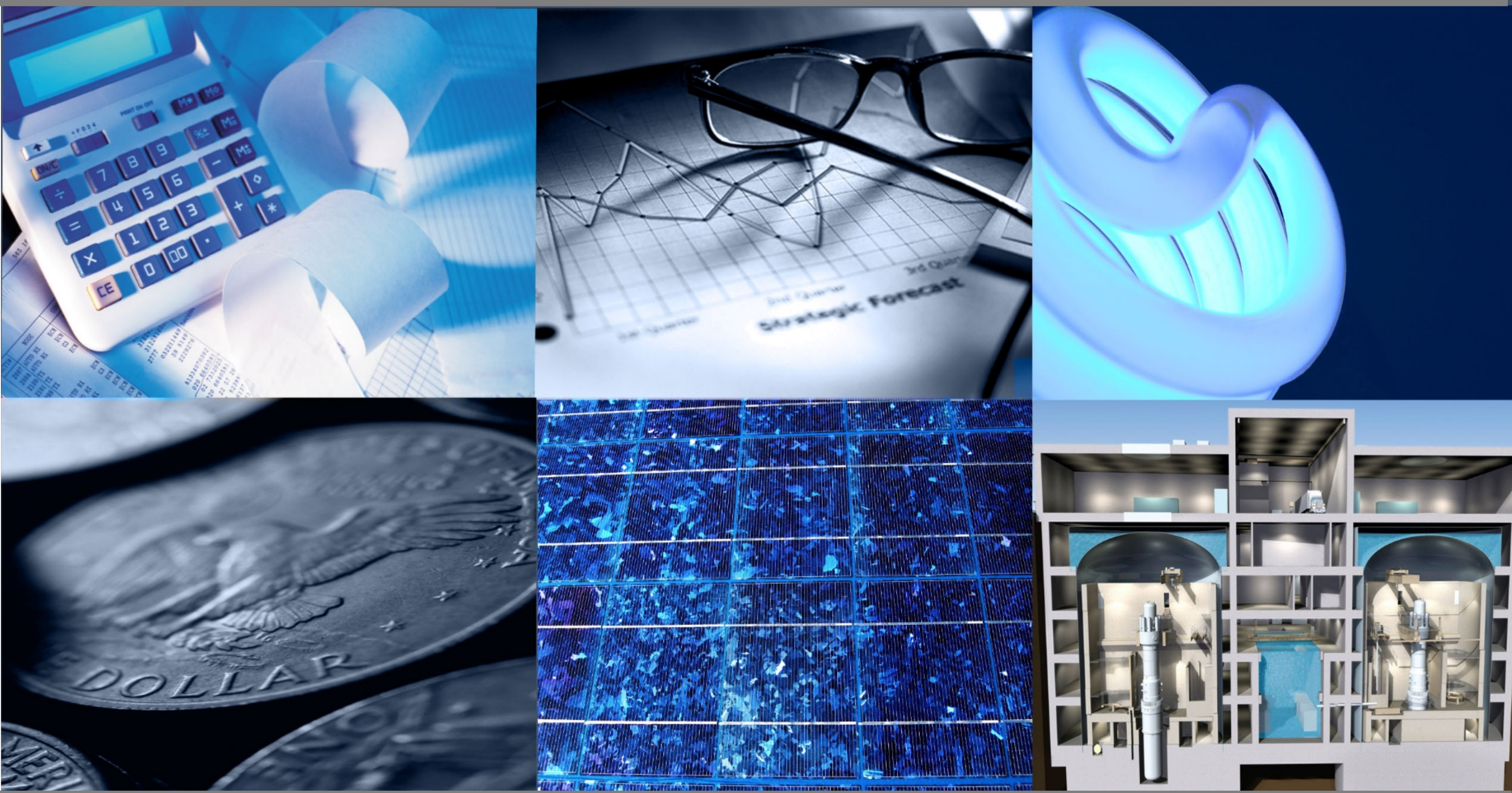

Examination of Federal Financial Assistance in the Renewable Energy Market

Implications and Opportunities for Commercial Deployment of Small Modular Reactors

SCULLY CAPITAL

KUTAKROCK

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EXECUTIVE SUMMARY

In numerous sectors of the economy, the Federal government has utilized financial incentives to mobilize private sector investment and advance policy objectives. The renewable energy sector provides a highly relevant example of how financial assistance in the form of demand mandates and financial incentives can spur industry development. Today, renewable energy generation is transforming the power sector in many states, challenging traditional utility business models, and in many cases displacing traditional baseload sources during hours of peak generation.

This report introduces these incentives, discusses how they have been utilized over the past decade to stimulate investment in the renewable energy sector, provides data on their cost and on their effectiveness in meeting policy objectives, and offers observations on how Small Modular Nuclear Reactors (SMRs) could benefit from similar forms of government support.

ES.1 MANDATES AND INCENTIVES FOR RENEWABLE ENERGY

For decades, multiple Presidential Administrations attempted to promote the use of renewable energy such as solar and wind. Such use had been limited by the higher cost of renewables due to the lack of demand and technology development and the failure of commercial markets to accept the technologies. While several Presidents were able to establish renewable energy goals and policies, it was not until the period following the passage of the Energy Policy Act of 2005 (EPAct or the Act) that significant renewable penetration was achieved in the U.S. power sector. This market penetration can be attributed to several factors:

- State-imposed standards to increase the use of renewable energy (Renewable Portfolio Standards or RPS);
- Federal policies, mandates, and incentives enacted by EPAct and subsequent legislation; and
- Executive Orders and Agency actions supporting the purchase of renewable energy.

Collectively, these measures created a multipronged approach that encouraged utilities to enter into long-term renewable power purchase agreements with project developers, drove down the cost of renewable energy through Federal tax and credit incentives, and harnessed the purchasing power of the Federal government.

ES.2 PROJECT LEVEL EFFECTS OF FINANCIAL INCENTIVES

The financial incentives introduced by EPAct and subsequent legislation addressed several financing challenges being faced at the time: first, renewable energy projects had a limited track record of commercial deployment, particularly with the newer technologies being introduced at the time; and second, for several years the financial markets were recovering from the 2008-2009 economic downturn, limiting the availability of low cost, long term debt. The financing tools introduced by the Federal government made renewable energy projects financially feasible.

The financial incentives introduced or extended by EPAct and subsequent legislation can be broadly categorized into two types: tax-based incentives and credit-based incentives.

ES.2.1 Tax-Based Incentives

Tax-based incentives offer the benefit of being relatively easy to introduce and administer. Once enacted, investors will realize the value of tax incentives by claiming credits or deductions on their tax filings. The tax incentives utilized in the renewable sector include:

- **Investment Tax Credits (ITCs):** ITCs give a business a tax credit for a specified percentage of capital expenditures for qualifying energy projects. ITCs are an investment-based subsidy as they provide upfront financial support for the construction of a project which is expected to deliver a specified good or service in the future (renewable energy in this case).
- **1603 Cash Grants:** The Federal government briefly offered cash grants to developers of renewable energy projects as an alternative to ITCs in response to a decline in tax equity financing during the 2008-2009 economic downturn which reduced the number of investors interested in tax credits. Section 1603 of ARRA offered cash payments to developers equal to, and in lieu of, the existing ITC (30% of qualifying investment). This allowed developers to receive a benefit equivalent to the ITC without relying on a tax equity investor.
- **Production Tax Credits (PTCs):** PTCs give a taxpaying entity a tax credit for power output, in terms of a fixed dollar amount per unit of output. A PTC can thus be considered a form of results-based subsidy, in that it is only paid out when the intended product (renewable energy in this case) is delivered.[1]
- **Accelerated Depreciation:** Accelerated depreciation—formally Modified Accelerated Cost Recovery System (MACRS)—is a way for businesses to realize higher

[1] Results-based subsidies, also commonly referred to as results-based financing (RBF) in international development, have been used to support investment in renewables and other infrastructure. https://openknowledge.worldbank.org/handle/10986/17481

depreciation expenses, and in turn, lower tax liabilities, earlier in the life of an asset while still incurring the same total depreciation.

ES.2.2 Credit-Based Incentives

Credit-based incentives provide low cost, long-term debt financing at terms that are unavailable in the private capital markets. Section 1703 of EPAct established the DOE's loan program targeted at projects employing innovative technology. Under the program, DOE provides a direct loan through the Federal Financing Bank (FFB), which serves as the lender. FFB charges interest slightly above U.S. Treasury rates. DOE then guarantees 100% of the FFB loan. Alternatively, DOE guarantees loans provided by commercial lenders. DOE's guarantee amount is capped at 80% of principal for a given loan, thus requiring the lender to hold at least 20% of the credit exposure.

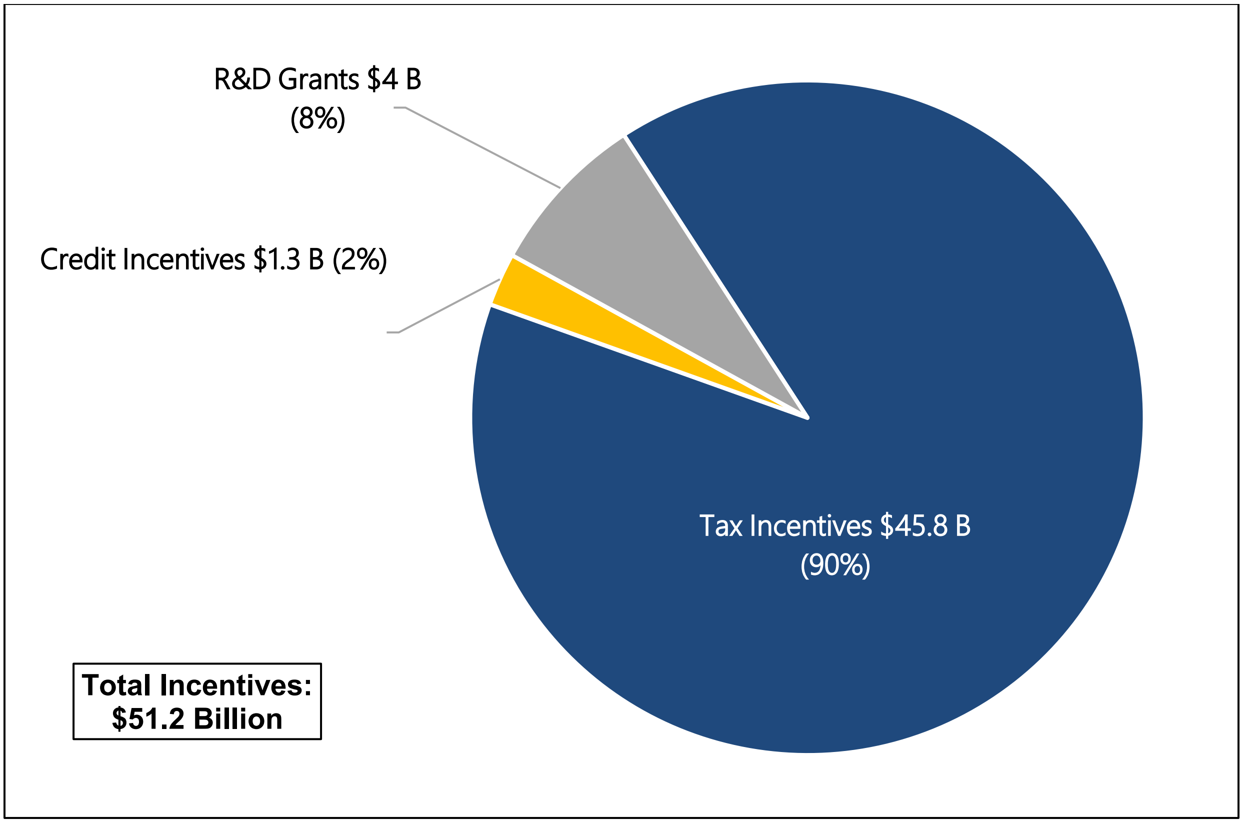
Collectively, tax and credit incentives help to reduce the cost of power from different generation technologies, thus enhancing their competitiveness against other power sources. Tax credits, accelerated depreciation, and credit support enable significant cost reductions when applied together, and enable power to be purchased by customers at a lower price. The combination of tax credits, accelerated depreciation, and credit support is estimated to reduce the cost of power by 48% for solar power, and 35% for wind.

ES.3 COSTS AND ECONOMIC BENEFITS OF SUPPORT PROGRAMS FOR RENEWABLES

Growth in the solar and wind power industries was supported by a combination of Federal spending on supply-side incentives (tax incentives, credit support, and R&D), and demand mandates by the Federal and state governments. To quantify the cost of incentive programs, this report examines the revenue loss associated with tax incentives, the appropriated credit subsidy associated with credit incentives, and the direct spending associated with research and development initiatives. This report does not attempt to quantify the cost of demand mandates implemented at the Federal and state level.

As illustrated in Exhibit ES-1, based on a review of incentives for solar and wind from 2005 to 2015, it is estimated that the Federal government spent $51.2 billion, with tax incentives accounting for 90% of the total.

Exhibit ES-1 Total Incentives for Wind and Solar[2],[3]



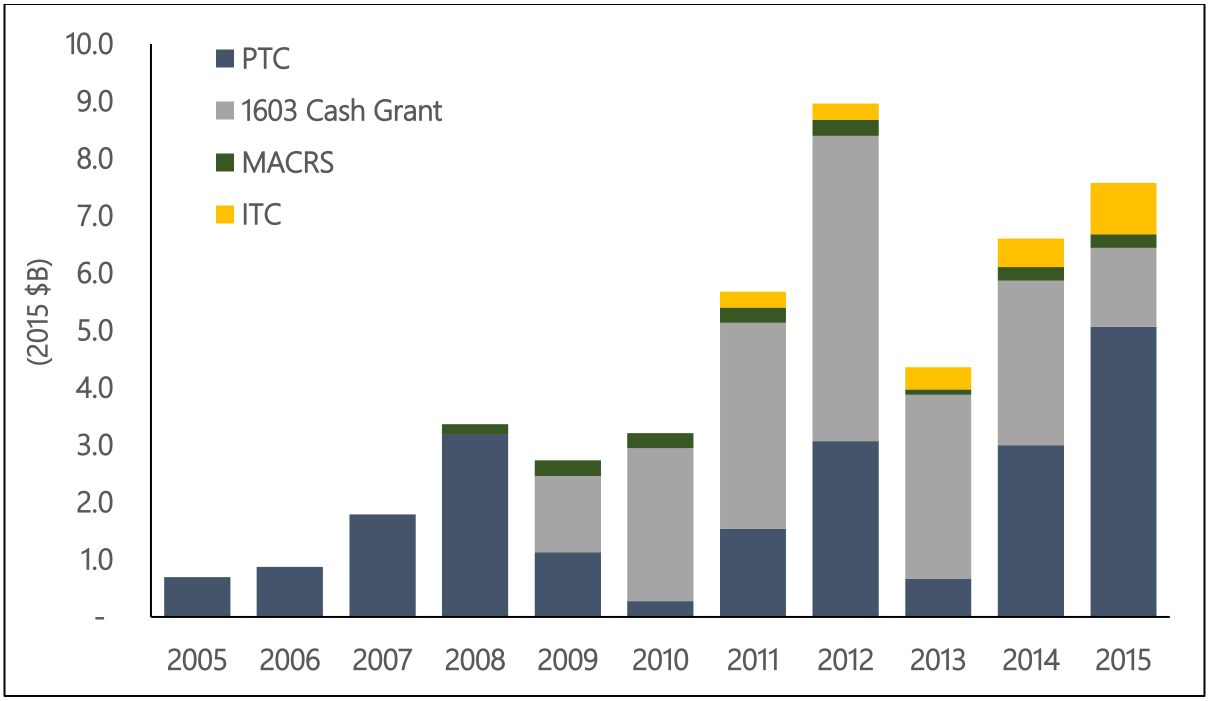
ES.3.1 Tax-Based Incentives

The cost of tax-based incentives is defined as the amount of tax revenue the Federal government abates through special tax credits and other incentives which reduce tax obligations. The Federal government spent a total of $45.8 billion on tax incentives for solar and wind from 2005 to 2015. Of this, production tax credits comprised 46.4%, or $21.3 billion. Spending on 1603 Cash Grants comprised $20.4 billion, or 44.5% of the total. This was followed by investment tax credits at $2.4 billion, or $5.13% of the total; it is worth noting that 1603 Cash Grants were effectively a substitute for ITCs, so investment-based subsidies were in fact very large if ITCs and 1603 Cash Grants are considered together. Lastly, MACRS incentives were worth $1.8 billion, or 3.97% of the total. This is summarized in Exhibit ES-2.

[2] Based on Scully Capital analysis discussed throughout this section.

[3] Chart shows $51.1 billion instead of $51.2 B of total incentives; slight difference due to rounding.

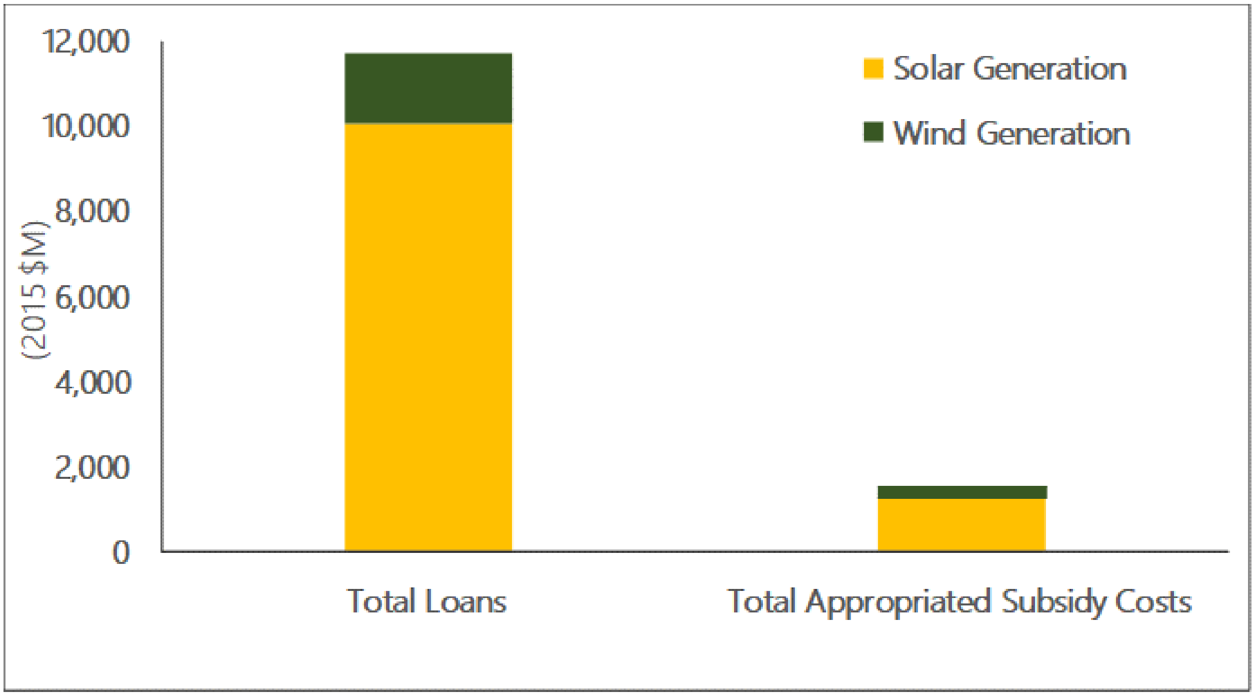
Exhibit ES-2: Summary of Tax-Based Incentives in 2015 Billions of U.S. Dollars



ES.3.2 Credit-Based Incentives

The Federal government offered significant credit support in the form of loans and loan guarantees for wind and solar through DOE's lending authority. As depicted in Exhibit ES-3, DOE provided $11.7 billion in credit assistance to 3,808 MW of solar and wind projects. Although the loans supported by DOE totaled $11.7 billion, the appropriated subsidy costs were only $1.3 billion, reflecting the use of credit subsidy in budgeting.

Exhibit ES-3: LPO Credit Incentive Spending for Wind and Solar[4]



Finally, supplementing the financial support through tax and credit incentives was R&D spending. R&D investment in solar power totaled $3.2 billion from 2005 to 2015 and totaled $880 million for wind power over same period.

ES.3.3 Benefits of Incentive Programs

While the Federal government's $51.2 billion investment in solar and wind represents a large commitment, the impact on the industry and U.S. generation mix has been significant. Strong government support resulted in meaningful growth in generation capacity and power production for solar and wind, and stimulated related employment.

The incentive programs sparked growth in the solar and wind power industries. Deployment of solar and generation capacity, and the resulting electricity, have grown sharply since 2005. From 2005 to 2015, solar capacity grew by 77,794 MW and wind capacity grew by 446,548 MW. This also facilitated growth of employment in solar and wind jobs, such that those industries are expected to provide the two fastest growing occupations through 2026. Both industries make strong contributions to the wider economy, including stimulating growth in other sectors and making significant tax payments. Power production has become more efficient, and costs have fallen, for both technologies.

[4] Government Accountability Office, "DOE Loan Programs: Current Estimated Net Costs…," April 2015.

ES.4 APPLICATION TO SMRS

Electric utilities in the United States currently operate in a rapidly evolving market environment which has challenged conventional notions of how electric power is generated and delivered to customers, presenting uncertainty for electric utilities facing long-term investment decisions. Nevertheless, capital will continue to be deployed in power production assets that can reliably provide energy, capacity, and flexibility. As the nation's traditional baseload generation assets, largely consisting of large coal and nuclear power plants, are phased out, utilities will seek opportunities to replace these assets with more resilient energy systems that recognize the long-term impacts of distributed energy resources (DERs) while at the same time provide for safe, reliable, and resilient performance over the long term.

Rising use and affordability of renewables, and significant retirements of coal and nuclear generation assets raise fundamental questions about what kind of generation is needed on the grid. While the power market may not require the levels of baseload generation prevalent decades ago, the grid is not ready to be free of baseload entirely. Furthermore, the North American Electric Reliability Corporation (NERC) indicated in its 2017 Long-Term Reliability Assessment that fuel assurance is a significant concern in planning for adequate reserve margins, especially for markets with high renewable penetration and significant reliance on natural gas.[5]

The current trends in the electric power sector present opportunities for SMR development as a flexible, carbon-free baseload generation resource which can be built on a smaller scale than traditional nuclear plants. In order to capture the benefits, as a new and complex technology, SMRs will have to address several challenges to commercial deployment, including:

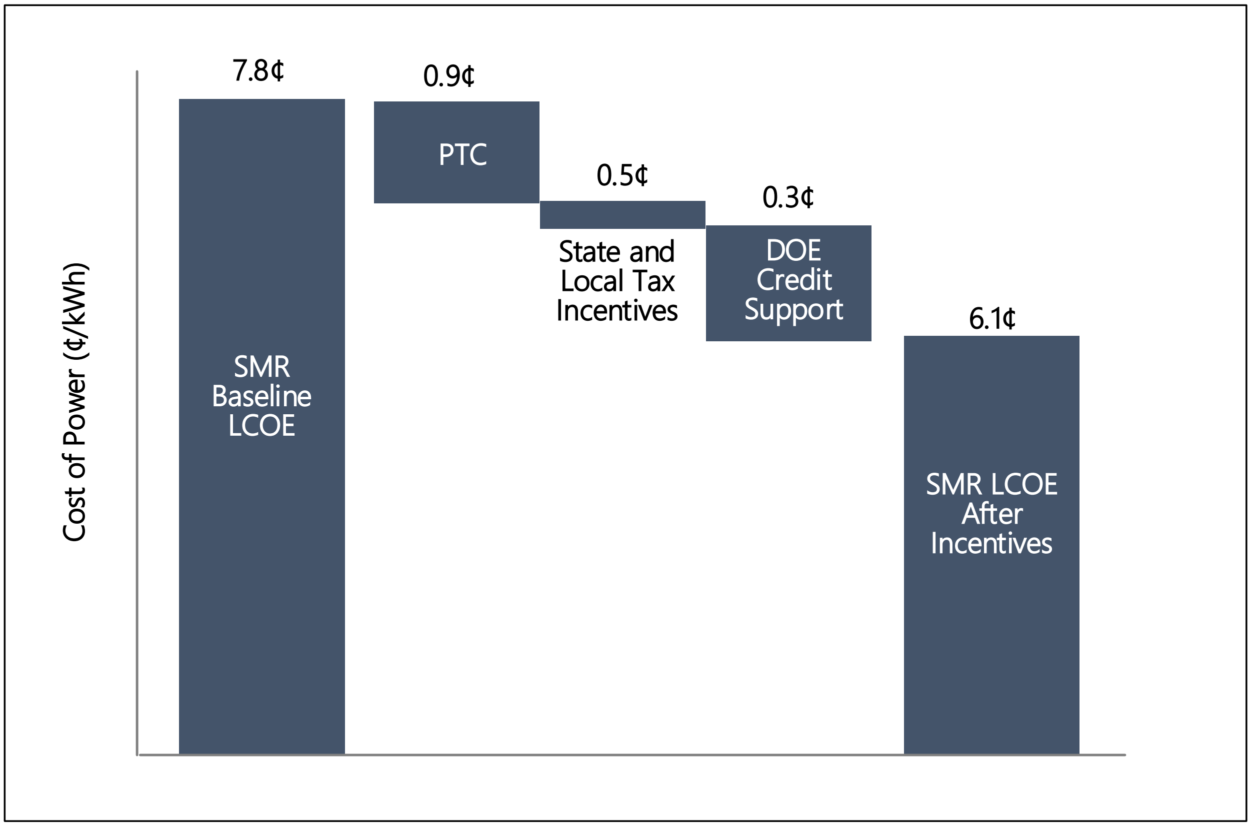
- Development of Manufacturing Ecosystem;
- Licensing Risk;
- Development Timeline;
- First of a Kind (FOAK) Costs; and
- Uncertainty in Long-Term Energy Markets.

Federal financial assistance can help address these challenges. Tax and credit incentives clearly contribute to significant reductions in the cost of electricity while demand mandates assure off-take at predictable prices. Such incentives could also potentially be applied to

[5] North American Electric Reliability Corporation, "2017 Long-Term Reliability Assessment," March 2018.

support the development of SMRs. Exhibit ES-4 illustrates SMR Start's estimate of the potential savings to an SMR's LCOE based on the application of tax and credit incentives.

Exhibit ES-4: LCOE of SMR[6]



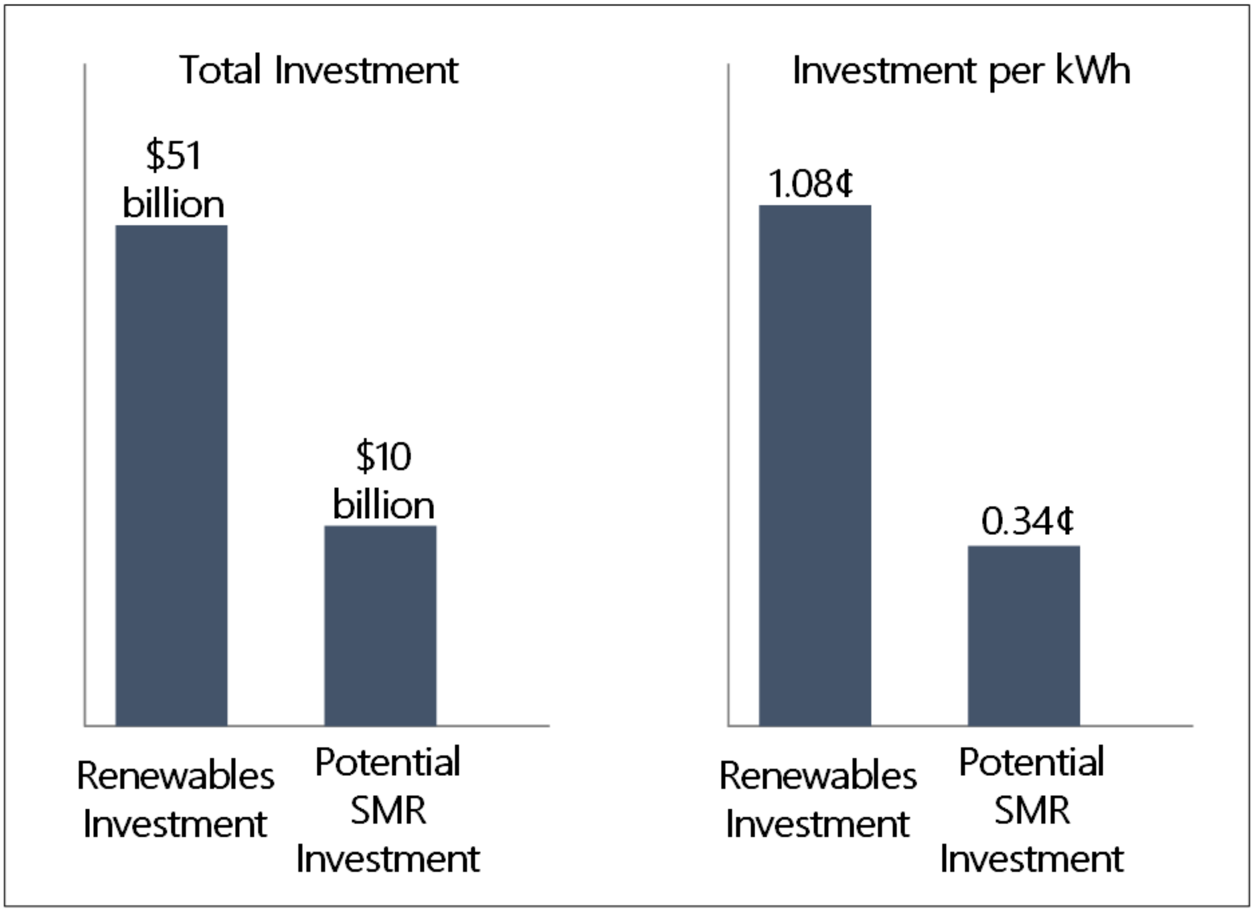
SMR Start estimates that allowing SMRs to receive PTCs would reduce the cost of power by just under 1¢ per kWh. Credit incentives (loan guarantees) are estimated to reduce the cost of power by another 0.3¢. State and local tax incentives, such as sales and use tax exemptions and property tax abatements, could further reduce costs by 0.5¢. Altogether, these would reduce the cost of power by 22%.[7]

To meaningfully impact commercial deployment, these incentives would need to be applied to several SMRs in combination with demand mandates to assure off-take. Construction of 6 GW of SMR capacity by 2035 would comprise about 5% of total capacity additions through that year. This would amount to 15 SMR projects with capacity of 400 MW each. The total cost to the Federal government of supporting 15 such SMR project with PTCs and DOE credit

[6] SMR Start, "The Economics of Small Modular Reactors," September 14, 2017.
[7] IBID

support is estimated to cost approximately $10 billion. While this level of support is significant relative to the capacity deployed, the high capacity factors and long operating lives of SMRs support an attractive return on the government's investment. Specifically, the $10 billion assistance estimate equates to approximately $0.0034/kWh. By comparison, the investments in wind and solar equaled approximately $0.0108/kWh.[8] This comparison is presented in Exhibit ES-5.

Exhibit ES-5: Investment to Support SMR Generation



As illustrated above, when viewed in terms of spending per unit of power produced (cents per kWh), the proposed support for SMRs compares favorably against the historic support for solar or wind. This is because SMRs are expected to realize capacity factors of 92.1% or above and have very long operating lives. Nevertheless, important questions remain regarding the cost of commercially deploying SMRs and whether 6 GW of induced capacity

[8] Scully Capital calculations, see Appendix C.

would be sufficient to develop the industrial capabilities necessary to support the industry over the long-term.

ES.5 NEXT STEPS

Given recent retirements of coal and conventional nuclear plants, and significant retirements expected in coming years, an opportunity exists for SMRs to enter the market and meaningfully contribute to the country's need for energy security and energy resilience. However, SMRs face significant challenges in commercial deployment, including the need to develop a manufacturing ecosystem for a new technology, significant work remaining to license and develop a working generation facility, and costs which may be high relative to other energy sources in the competitive and quickly evolving power markets.

The success of Federal financial incentives for renewables presents a promising model of financial support for power project development, which could be applied to other innovative power technologies, including SMRs. Federal expenditure for SMRs could be impactful even if on a smaller scale than the $51 billion spent on solar and wind from 2005 to 2015.

The Federal government has made progress supporting SMR development with Federal incentives. DOE currently has an open solicitation for loan guarantees for nuclear projects including SMRs.[9] Congress also voted to extend nuclear PTCs passed the planned expiration in 2020, which would enable projects completed after 2020 to benefit from them.[10] While those actions could be helpful for SMRs, other steps could further help SMRs to commercialization:

- **Examine Potential Market Associated with SMRs:** In order to establish a business case for Federal financial assistance, the potential of SMRs as a source of power generation and as a commercial enterprise should be analyzed, and if possible, quantified. This should include consideration of financial, legal, regulatory, and technical issues related to SMRs' integration into the power system, including consideration of the entire value chain, cost competitiveness, and other matters. The objective of this undertaking would be fourfold:
  - Confirm the suitability of SMRs to address the baseload power replacements which will be driven by coal and conventional nuclear retirements;
  - Identify how the SMR supply chain will need to develop in order to achieve the n^{th}-of-a-kind cost targets;

[9] https://www.energy.gov/lpo/advanced-nuclear-energy-projects-solicitation
[10] https://www.nei.org/news/2018/congress-passes-nuclear-production-tax-credit

  - Validate or refine the 6 GW estimate of SMR commercial deployments required to establish SMRs as a viable baseload option; and
  - Develop an order of magnitude estimate of technology export value based on the U.S. experience with conventional nuclear power plants.

- Create Project-Level Business Case: Analyses of the impact of financial incentives have focused on LCOE, which is a useful metric for comparing costs of different technologies or considering an indicative project. To further DOE's understanding, a project-level business case that contemplates the site-specific costs, load profiles, and financial structure is warranted. This feasibility analysis would seek to identify the cost of service of a proposed SMR and would measure the impact of incentives and the uncertainties that could increase costs, identify key risks and mitigants, and integrate financial, legal, regulatory, and technical considerations.

  While the analysis could draw upon conceptual design data, site-specific costs, infrastructure requirements and customers would be examined with the objective of refining DOE's understanding of the financial feasibility of one or two "first movers." Additionally, the analysis would consider the host utility's ownership, the proposed credit structure of the project and the economic objectives and constraints of the host utility's customer base. This effort would result is assessment the opportunities and challenges to SMR commercial deployment and would inform the design of incentives around specific market conditions and other constraints.

- Identify Obstacles that Require Legislative Action: Enhancing Federal support for SMRs will require Congress to pass legislation. To facilitate the eventual enactment of new incentives, key initiatives should be identified for development into law. This would be informed by the findings of the project-level business case analysis, and could focus on matters such as identifying appropriate existing legal authorities for supporting Federal power purchase agreements, finding ways to modify or extend existing incentives, creating budget scoring alternatives or developing roadmaps for implementing new programs or legislation.

CHAPTER 1: INTRODUCTION

In numerous sectors of the economy, the Federal government has utilized financial incentives to mobilize private sector investment and advance policy objectives. The renewable energy sector provides a highly relevant example of how financial assistance in the form of demand mandates and financial incentives can spur industry development. Today, renewable energy generation is transforming the power sector in many states, challenging traditional utility business models, and in many cases displacing traditional baseload sources during hours of peak generation.

Over the next 20 years, the United States is expected to encounter challenges in providing adequate supply of baseload power as some of the country's coal-fired power plants and nuclear generation stations are retired. The estimated electricity output from coal and to a limited extent nuclear sources is expected to decline significantly due to regulatory drivers, changes in state and Federal energy policy and competition from low cost sources such as natural gas.[11] Further, integration of growing power supply from intermittent renewable power sources requires adequate supply of steady power to balance renewables when their power production is lower due to variation in intermittent resources.[12]

The development and construction of new baseload power plants, like Small Modular Reactors (SMRs), represents a highly uncertain endeavor. Investment in additional generation requires consideration of customers' long-term demand for power, existing and future regulations, competing alternatives, and changes in market dynamics. Despite the uncertainties, large-scale baseload power plants will need to be developed, designed, and constructed to replace an aging fleet consisting largely of coal and nuclear generation.

These challenges are likely to remain in the near term. However, government financial incentives could be utilized to encourage investment in targeted sectors and technologies. Previous analyses sponsored by the Department of Energy (DOE) have examined how the Federal government can support SMR investment in its capacity as power purchaser.[13,14] Government incentives can take other forms such as direct grants, tax incentives, credit incentives, and demand mandates. This report introduces these incentives, discusses how

[11] U.S. Energy Information, "Annual Energy Outlook 2018: Table: Electricity Generating Capacity," https://www.eia.gov/outlooks/aeo/data/browser/#/?id=9-AEO2018&cases=ref2018&sourcekey=0, referenced April 27, 2018. Cited data is for the Reference Case.

[12] Department of Energy, "Staff Report on Electricity Markets and Reliability," August 2017.

[13] Kutak Rock, LLP, and Scully Capital Services Inc., "Small Modular Reactors: Adding to Resilience at Federal Facilities," published by U.S. Department of Energy, December 2017.

[14] Kutak Rock, LLP, and Scully Capital Services Inc., "Purchasing Power Produced by Small Modular Reactors: Federal Agency Options," published by U.S. Department of Energy, January 2017.

they have been utilized over the past decade to stimulate investment in the renewable energy sector, provides data on their cost and on their effectiveness in meeting policy objectives, and offers observations on how SMRs could benefit from similar forms of government support.

This report is organized as follows:

- **Overview of Mandates and Incentives for Renewable Energy:** This chapter provides a comprehensive overview of the multi-pronged strategy employed at the Federal and state level to drive the renewable energy market.
- **Project Level Effects of Financial Incentives:** This chapter describes the purpose and structure of financial incentives. Also, this section explores how incentives reduce the cost of power, and estimates the effect of Federal tax and credit incentives on indicative solar and wind power projects in terms of the levelized cost of electricity (LCOE).
- **Costs and Economic Benefits of Support Programs for Renewables:** This chapter describes spending on renewable support and growth in installed renewable power capacity since 2005, and the resulting benefits in terms of power outputs, jobs, and other areas.
- **Application to SMRs:** This chapter provides an overview of current U.S. electric market conditions and how it has evolved over time, describes how SMRs can address emerging concerns in the power sector, and proposes models of incentives to support SMR commercial deployment.
- **Next Steps for Supporting Commercial Deployment of SMRs:** This chapter provides recommendations for developing and implementing incentive programs for SMR commercialization.

CHAPTER 2: OVERVIEW OF MANDATES AND INCENTIVES FOR RENEWABLE ENERGY

For decades, multiple Presidential Administrations attempted to promote the use of renewable energy such as solar and wind. Such use had been limited by the high cost of renewables due to the lack of demand and technology development and the failure of the commercial market to accept the technologies.

While several Presidents were able to establish renewable energy goals and policies, it was not until the period following the passage of the Energy Policy Act of 2005 (EPAct or the Act) that significant renewable penetration was achieved in the U.S. power sector. This market penetration can be attributed to several factors:

- State-imposed standards to increase the use of renewable energy (Renewable Portfolio Standards or RPS);
- Federal policies, mandates, and incentives enacted by EPAct and subsequent legislation; and
- Executive Orders and Agency actions supporting the purchase of renewable energy.

Collectively, these measures created a multipronged approach that encouraged utilities to enter into long-term renewable power purchase agreements with renewable project developers, drove down the cost of renewable energy through state and Federal tax and credit incentives, and harnessed the purchasing power of the Federal government. These actions increased the demand for renewable energy, while at the same time lowered costs through financial incentives, increasing the supply of competitive renewable power. The Federal government has also supported research and development (R&D) for renewable generation technologies.

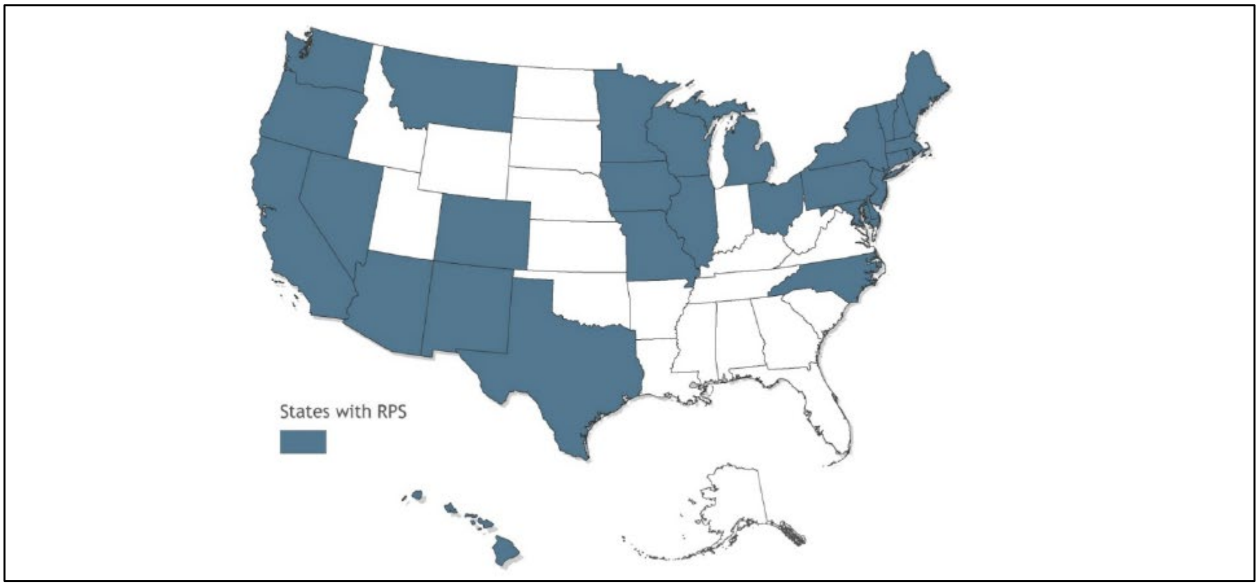
This section details the state and Federal incentives that supported the development of renewable energy projects during the period following the passage of EPAct and highlights how these policies worked together to significantly expand renewables in the U.S. energy markets.

2.1 STATE RENEWABLE PORTFOLIO STANDARDS

As states have become increasingly concerned about climate change and reducing pollution, they have enacted Renewable Portfolio Standards (RPS). An RPS is a requirement that retail electricity suppliers procure a certain minimum quantity of eligible renewable energy or capacity, measured in either absolute units (kWh or kW), or as a percentage share of retail sales. RPS policies are generally designed to maintain and/or increase the contribution of renewable energy to the electricity supply mix. RPS programs often utilize tradable renewable energy certificates (RECs) to increase the flexibility and reduce the cost of compliance with the purchase mandate, and to facilitate a purely financial product that can be traded separately from the underlying electricity generation. These actions have created a relatively stable market for the purchase and sale of RECs, enhancing their value in a number of state markets. REC transactions create a supplemental revenue stream for renewable generators and allow retail suppliers to demonstrate compliance with the RPS by purchasing RECs in lieu of directly purchasing renewable electricity.

The concept of RPS was developed in California in 1995, although not implemented there until 2003; other states began enacting RPS in the late 1990s. As of November 2015, 29 states and the District of Columbia have RPS mandates, as shown in Exhibit 2-1.

Exhibit 2-1: States with RPS



RPS mandates created strong demand for renewable power. It is estimated that 58% of all renewable capacity in the U.S. installed from 1998 to 2014 is being used to meet RPS targets (excluding hydropower).[15] RPS mandates require that at least 8% of the U.S. power supply

[15] Wiser et al, "A Retrospective Analysis of the Benefits and Impacts of U.S. Renewable Portfolio Standards," published by National Renewable Energy Laboratory, January 2016.

will be met by renewables in 2025, equivalent to 106 GW of capacity.[16] From 2010-2013, wholesale power buyers (generally utilities) tended to pay a premium (under long-term power purchase agreements) over prevailing "brown power" rates, as high as 4.8¢ per kWh for some utilities, to purchase renewables for RPS purposes over other generation options. The incremental cost of complying with RPS, net of the avoided cost of alternative generation, ranged from 2% to 4% of retail rates in eight states, and was below 2% in 17 states.[17]

2.2 ENERGY POLICY ACT OF 2005

The Federal government's effort to increase the use of energy from renewable sources began in earnest with the requirements included in EPAct.[18] Given high oil and natural gas prices that prevailed around 2001, the Bush Administration supported policies which targeted the development of a long-term, comprehensive strategy to lessen the impact of energy price volatility and supply uncertainty. This led to several years of policy discussion around "energy security" as a national priority. In 2005, the U.S. Congress enacted the EPAct, which reflected the Administration's goals by creating programs and policies aimed at increasing and diversifying domestic energy production. EPAct included key provisions to help diversify domestic energy production through the development of new sources of fuel and electricity supply. This included incentives for nuclear power plants, coal, and renewables.

For renewable energy, EPAct included financial incentives, which were later enhanced in subsequent legislation and demand mandates related to the energy consumption by Federal facilities. Tax incentives, which are examined in the following section, included production tax credits, investment tax credits, and accelerated depreciation treatment for qualifying renewable energy projects. Also, EPAct set specific renewable energy purchase targets for all Federal agencies:

- 3% of all electricity by 2007;
- 5% by 2010; and

[16] Wiser et al, "A Retrospective Analysis of the Benefits and Impacts of U.S. Renewable Portfolio Standards," published by National Renewable Energy Laboratory, January 2016.
[17] Heeter at al, "A Survey of State-Level Cost and Benefit Estimates of Renewable Portfolio Standards," published by National Renewable Energy Laboratory, May 2014.
[18] *Energy Policy Act of 2005*, Pub.L. 109-58, Aug. 8, 2005, 42 U.S.C. §§ 13201, et. seq.

- 7.5% by 2013.[19]

The Administrator of General Services (GSA) was required to establish a photovoltaic purchasing program for the acquisition and installation of solar electric systems for new and existing buildings.[20] DOE was authorized to establish a renewable energy rebate for the installation of renewable energy systems in residential and small business properties.[21] And the Secretary of Interior (DOI) was directed to approve non-hydropower renewable energy projects located on public lands with a generation capacity of at least 10,000 megawatts of electricity by 2015.[22]

The goals included in EPAct were intensified by Congress as applied to the Department of Defense (DoD) in the 2007 National Defense Authorization Act (NDAA), which required DoD to "produce or procure not less than 25 percent of the total quantity of electric energy it consumes within its facilities and in its activities during fiscal year 2025 and each fiscal year thereafter from renewable energy sources" and "to produce or procure electric energy from renewable energy sources whenever the use of such renewable energy sources is consistent with the energy performance goals and energy performance plan for the Department."[23]

Section 1703 of Title XVII of EPAct of 2005 created the DOE's Loan Guarantee Program. Under Section 1703, DOE is authorized to issue loan guarantees for projects with high technology risks that "avoid, reduce or sequester air pollutants or anthropogenic emissions of greenhouse gases; and employ new or significantly improved technologies as compared to commercial technologies in service in the United States at the time the guarantee is issued." Loan guarantees are intended to encourage early commercial use of new or significantly improved technologies in energy projects. The loan guarantee program generally does not support research and development projects. During the Obama Administration, DOE issued new supplemental guidance for Renewable Energy and Efficient Energy (REEE) projects that added $500 million of loan guarantee authority, making the total available approximately $4.5 billion.

The loan guarantee program was reauthorized and revised by the American Recovery and Reinvestment Act (ARRA) of 2009 by adding Section 1705 to EPAct. The 1705 Program was retired in September 2011, and loan guarantees are no longer available under that authority.

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[19] Section 203 of EPAct, 42 U.S.C. § 15852.
[20] Section 204 of EPAct, 40 U.S.C. § 3177.
[21] Section 206(c) of EPAct, 42 U.S.C. § 15853.
[22] Section 211 of EPAct.
[23] *National Defense Authorization Act of 2007*, October 17, 2006, Pub.L. 109-364, § 2852.

DOE, however, still has authority to issue loan guarantees under the old Section 1703 Program.

2.3 RECOVERY ACT BOOST TO FUNDING RENEWABLE ENERGY PROJECTS

Nearly 10% of the ARRA[24], which included over $787 billion in economic stimulus measures, focused on funding and tax credits for green-energy related projects including renewables, energy efficiency, transmission, and weatherization. No funding was provided for nuclear related programs.

In 2009, ARRA significantly increased Federal investment and spending on renewable energy. ARRA included $16.8 billion for the DOE's Office of Energy Efficiency and Renewable Energy (EERE). The funding was a nearly tenfold increase for EERE, which received $1.7 billion in fiscal year 2008. The bulk of the new EERE funding supported direct grants and rebates while $2.5 billion supported EERE's applied research, development, and deployment activities, mainly for renewable technologies.[25]

ARRA also provided $3.2 billion in block grants to assist local governments in implementing energy efficiency and conservation programs authorized under subtitle E of title V of the Energy Independence and Security Act of 2007[26]. These funds could be used for a number of activities, including establishing financial incentive programs for energy efficiency improvements (e.g., loan programs, rebate programs, waive permit fees); developing, implementing, or installing on or in any government building onsite renewable energy technology that generates electricity from renewable resources (solar and wind energy, fuel cells, and biomass); implementing energy distribution technologies; and purchasing/implementing technologies to reduce and capture methane and other greenhouse gases generated by landfills or similar sources.

ARRA included a $3.1 billion appropriation to DOE's State Energy Program (SEP) authorized under part D of title III of the Energy Policy and Conservation Act (42 U.S.C. 6321). SEP dollars are used to provide grants and funding to state energy offices for energy efficiency and renewable energy programs. The Act also appropriated $6 billion for the cost of guaranteed loans authorized by section 1705 of the Energy Policy Act of 2005, as noted above. The Act authorized the DOE Loan Guarantee Program for projects that involved renewable energy, electric transmission, or leading-edge biofuel technologies. The $6 billion in appropriated funds was expected to support more than $60 billion in loans for these projects.

[24] Pub. L. 111-5, February 17, 2009; 123 Stat. 115.

[25] Included in the $2.5 billion were $800 million for projects related to biomass and $400 million for geothermal activities and projects.

[26] 42 U.S.C. 17151, et seq.

Through ARRA, Congress provided $280 million for the military departments, of which $100 million was for energy conservation and alternative energy projects. $120 million was allocated for the Energy Conservation Investment Program (ECIP). ECIP improves the energy and water efficiency of existing Military Services' facilities, promoting energy conservation and investment in renewable energy resources including wind, solar, geothermal, waste-to-energy, and biomass at U.S. military installations.

In addition to these direct appropriations, ARRA also provided tax incentives supportive of renewable energy uses. For example, the creation of a 30% tax credit for certain investments with respect to qualifying advanced energy products, including manufacturing facilities for the production of renewable energy products, electric grids to support the transmission of intermittent sources of renewable energy, and property designed to refine or blend renewable fuels or to produce energy conservation technologies. ARRA also extended and expanded credits available to qualified facilities producing energy from renewable resources, credits worth approximately $13 billion. Income tax credits for the production of electricity from qualified energy resources were also included. The qualified energy resources were comprised of wind, closed loop biomass, open loop biomass, geothermal energy, solar energy, small irrigation power, municipal solid waste, qualified hydropower production, and marine and hydrokinetic renewable energy.

ARRA also provided incentives to residential energy users by extending a credit of 30% for residential solar electric, solar water heating, small wind energy and geothermal heat pump property expenditures, and removing previous caps on residential solar electric, solar water heating, small wind energy, and geothermal heat pump property expenditures.

2.4 ENERGY INDEPENDENCE AND SECURITY ACT OF 2007

The Energy Independence and Security Act of 2007 (EISA) built on many of the policy objectives and goals included in EPAct. [27] For example, Section 431 established new energy reduction goals for Federal facilities, increasing each year up to 30% reduction by 2015. Section 432 established energy management scorecards for Federal agencies and required metering and other evaluative tools in order to identify and implement energy and water efficiency projects, and to establish benchmarks for all metered buildings in the Federal inventory. Section 433 required all new Federal buildings, or buildings undergoing major modernizations (those requiring GSA to submit a prospectus to Congress or over $2.5 million) to reduce fossil fuel use compared to a similar building use in FY 2003. The percentage reduction in fossil fuel use was set at 55% for 2010 and increased to 100% by

[27] Energy Independence and Security Act of 2007. Pub. L. No. 110-140. 121 Stat. 1492 (2007).

2030. Within 3 years of enactment of EISA, as provided in Section 435, Federal agencies were prohibited from executing any lease with the private sector for space that had not earned an EnergyStar label. Title V of EISA included a number of provisions to encourage the use of ESPCs, which had been authorized in EPAct, by addressing policy or procedural obstacles that had been encountered by Federal agencies in implementing the authority.

2.5 EXECUTIVE ORDERS ON RENEWABLE ENERGY USE BY FEDERAL AGENCIES

President Bush, by Executive Order (E.O.) in 2007, required Federal agencies to reduce their energy usage by 30% by 2015, and ensure that at least half of their renewable goals under EPAct were achieved using new renewable sources, located on Federal agency property to the extent feasible.[28] Later that same year, Congress passed the Energy Independence and Security Act (EISA), which required all new Federal buildings and all Federal buildings undergoing major renovation to reduce fossil fuel-generated energy consumption, as compared to 2003 usage by similar buildings, by 55% by 2010, 65% by 2015, 80% by 2020, 90% by 2025, and 100% by 2030.[29] Federal agencies were also required, where lifecycle cost-effective, as compared to other reasonably available technologies, to ensure that not less than 30% of the hot water demand for each new Federal building or Federal building undergoing a major renovation be met through the installation and use of solar hot water heaters.[30]

President Bush also signed E.O. 13514, Federal Leadership in Environmental, Energy and Economic Performance, which encouraged Federal agencies to increase the use of renewable energy and to implement renewable energy generation projects on agency property.[31] Following up on that executive order, President Obama issued a Presidential Memorandum in 2011, requiring Federal agencies to implement all energy conservation measures in Federal buildings with a payback time of less than 10 years.[32] President Obama also established a 2 year goal for all Federal agencies to enter into a minimum of $2 billion in performance-based contracts, primarily through the ESPC and UESC contracts that had been authorized in EPAct.

[28] E.O. 13423, January 26, 2007.

[29] *Energy Information and Security Act*, Pub.L. 110-140, December 19, 2007, Section 433, 42 U.S.C. § 6834(a)(3).

[30] Section 523 of EISA, 42 U.S.C. 6834(a)(3)(A)(iii).

[31] E.O. 13514, October 8, 2009, Section 2(a)(ii) and (f).

[32] Presidential Memorandum, *Implementation of Energy Savings Projects and Performance-Based Contracting for Energy Savings*, December 2, 2011.

President Obama, on December 5, 2013, signed a Presidential Memorandum directing the Federal government to consume 20% of its electricity from renewable sources by 2020, more than double the then current level of about 7% renewable energy use.[33] The Presidential Memorandum implemented the goal the President outlined in his June 2013 Climate Action Plan that challenged Federal agencies to more than double their renewable electricity consumption by 2020.[34] As part of this effort, agencies were encouraged to identify formerly contaminated lands, landfills, and mine sites to target for renewable energy projects, providing valuable opportunities to return those lands to productive use. To improve agencies' ability to manage energy consumption and reduce costs, the Memorandum directs them to use Green Button, a tool developed by industry in response to a White House call-to-action that provides utility customers easy and secure access to their energy usage information in a consumer-friendly format.

President Obama then doubled the original $2 billion goal for performance-based contracting by the Federal agencies to $4 billion total.[35]

In 2015, President Obama launched the Clean Energy Investment Initiative through DOE.[36] The initiative set a goal of catalyzing $2 billion in private sector investment in solutions to climate change, particularly through the development of low-carbon energy technologies. By June of that same year, the President announced that the objective had already reached more than $4 billion in commitments, over double the initial goal.[37] Before leaving office, President Obama announced that the goal had been exceeded as a result of Federal agency initiatives.[38]

2.6 DEPARTMENT OF DEFENSE IMPLEMENTATION OF RENEWABLE ENERGY GOALS

In addition to goals established by statute and executive order, additional renewable energy goals have been established by Federal agency policies. For example, in 2012, President Obama directed DoD to install 3 GWs of renewable energy capacity on or around its bases by 2025. This directive was built on a commitment President Obama made during the State

[33] Presidential Memorandum, *Federal Leadership on Energy Management*, December 5, 2013.
[34] https://obamawhitehouse.archives.gov/sites/default/files/image/president27sclimateactionplan.pdf
[35] See, https://obamawhitehouse.archives.gov/the-press-office/2014/05/09/fact-sheet-president-obama-announces-commitments-and-executive-actions-a; https://obamawhitehouse.archives.gov/blog/2014/05/09/leading-example-reduce-carbon-pollution-and-waste-less-energy
[36] Presidential Memoranda,
[37] *Fact Sheet: Obama Administration Announces More Than $4 billion in Private Sector Commitments and Executive Actions to Scale up Investment in Clean Energy Innovation*, June 16, 2015.
[38] https://obamawhitehouse.archives.gov/blog/2016/12/28/Federal-government-exceeds-goal-renewable-energy-and-energy-efficiency-investments

of the Union that year to develop 1 GW of renewable energy on Navy installations by 2020. As a result, the Air Force established a goal of obtaining 1 GW by 2016 and the Army set a goal of obtaining 1 GW of capacity by 2025.[39]

In order to implement these renewable energy goals, DoD's Office of the Assistant Secretary of Operational Energy Plans and Programs was established to coordinate energy issues in 2010. In 2011, DoD published its Operational Energy Strategy to set the overall direction for operational energy security for the agency.[40] DoD and DOE published a Memorandum of Understanding (MOU) in July 2010, to facilitate cooperation to accelerate the research, development, and deployment of energy efficiency and renewable energy technologies.[41]

Each of the services also established new energy offices in order to carry out the renewable energy objectives. In 2009, the Army issued the Army Energy Security Implementation Strategy, which requires at least five installations meet "net-zero" energy goals by 2020 and deploy 1 GW of renewable energy on their installations by 2025.[42] In 2011, the Secretary of the Army established the Energy Initiatives Office Task Force (EITF) as a part of the Office of the Assistant Secretary of the Army for Installations, Energy and Environment (ASA IE&E). The EITF served as the central managing office for the development of large-scale Army renewable energy projects intended to help the Army achieve the previously established goals. In 2014 the EITF became an enduring organization, the Office of Energy Initiatives (OEI), which now serves as the central management office for implementing large-scale renewable and alternative energy projects.

The Deputy Assistant Secretary of the Navy (Energy) office was established in March 2010, in order to develop and oversee Department of the Navy policy on matters pertaining to operational and shore energy initiatives for the Secretary of the Navy. In 2012, the Navy issued its Strategy for Renewable Energy to guide the Department of the Navy in accomplishing two of the energy goals established in 2009: to obtain half of the Department's energy from alternative sources; and to produce at least half the shore-based energy requirements from renewable sources, such as solar, wind, and geothermal by 2020.[43]

[39] See https://obamawhitehouse.archives.gov/the-press-office/2012/04/11/fact-sheet-obama-administration-announces-additional-steps-increase-ener
[40] The 2011 Report, and annual reports thereafter, can be found at https://www.acq.osd.mil/eie/OE/OE_library.html
[41] See https://www.acq.osd.mil/dpap/cpic/cp/docs/Memorandum_of_Agreement_with_DoE.pdf
[42] http://www.asaie.army.mil/Public/Partnerships/doc/AESIS_13JAN09_Approved%204-03-09.pdf
[43] http://www.secnav.navy.mil/eie/Documents/DoNStrategyforRenewableEnergy.pdf

In May 2010, the Air Force published its Air Force Energy Plan with the vision: To "make energy a consideration in all we do."[44] Renewable energy initiatives, as well as other energy programs, were managed by the Air Force Facility Energy Center. In 2016, the Air Force established the Air Force Office of Energy Assurance (OEA), which develops an integrated facility energy portfolio and manages the progression of all energy initiatives for the service. Also in 2016, the Air Force and the Army signed an interagency agreement to partner and share resources in pursuing the fruition of their energy initiatives and renewable energy goals.[45] In addition to the goal of producing 1 GW of renewable energy to support on-site capacity by 2016, the Air Force is also pushing toward ensuring all new buildings are designed to achieve zero-net-energy by 2030, beginning in 2020.

2.7 DEPARTMENT OF ENERGY, GENERAL SERVICES ADMINISTRATION AND OTHER FEDERAL AGENCY IMPLEMENTATION OF GOALS

2.7.1. Department of Energy Initiatives

Even before the creation of the Office of Energy Efficiency & Renewable Energy (EERE) in 1993, DOE had been focused on the development and use of renewable energy and had launched initiatives in support of renewable energy. After the passage of EPAct in 2005, DOE created the Solar America Initiative (SAI) in 2006 as part of President Bush's Advanced Energy Initiative. The SAI's goal was to make solar energy cost competitive by 2015.[46] EERE and the State of Hawaii signed a Memorandum of Understanding in 2008, establishing the Hawaii Clean Energy Initiative, a long-term partnership designed to transform Hawaii's energy system to one that uses renewable energy and energy efficient technologies for a significant portion (60-70%) of its energy needs.[47] In response to the ARRA, DOE created the Energy Efficiency and Conservation Block Grant Program to provide $3.2 billion in block grants to cities, communities, states, U.S. territories, and Indian tribes to develop, promote, implement, and manage energy efficiency and conservation projects.

DOE's Solar Energy Technology Office (SETO) launched the SunShot Initiative in 2011 with the objective of making solar electricity costs competitive with other generation sources by 2020, without subsidies.[48] In September 2017, SETO announced the utility-scale solar goal

[44] http://www.acc.af.mil/Portals/92/Docs/AFD-100930-035.pdf
[45] https://www.army.mil/e2/c/downloads/429902.pdf
[46] https://www.nrel.gov/docs/fy07osti/40936.pdf
[47] http://www.hawaiicleanenergyinitiative.org/wp-content/uploads/2015/02/HCEI_FactSheet_Feb2017.pdf
[48] https://www.energy.gov/eere/solar/articles/doe-pursues-sunshot-initiative-achieve-cost-competitive-solar-energy-2020

had been met three years ahead of schedule.[49] SETO has stated that they will continue to work to lower the cost of solar energy and has established a goal to halve the cost of solar energy by 2030, committing up to $82 million in supportive funding to that end.[50]

In addition to the SunShot Initiative, DOE also released the National Offshore Wind Strategy in 2011, a strategic plan for accelerating the responsible deployment of offshore wind energy in the United States. This publication serves as a blueprint to achieve 54 GW of deployed offshore wind generating capacity by 2030.[51] The program expected to build from the more than $90 million provided in ARRA and FY 2009 and FY 2010 appropriations provided to DOE for wind initiatives. EERE launched the Clean Energy Manufacturing Initiative (CEMI) in 2013, a new DOE initiative focused on growing American manufacturing of clean energy products and boosting U.S. competitiveness through major improvements in manufacturing energy productivity.[52] Since initiating the program, DOE has issued $150 million in Advanced Energy Manufacturing tax credits and supported state energy and economic development offices to create state strategies for clean energy manufacturing and economic development. Then in 2016, DOE's Wind and Water Power Technologies Office released Hydropower Vision, a roadmap by which U.S. hydropower could grow from 101 GW of capacity in 2015 to nearly 150 GW by 2050.[53]

DOE continues to provide significant support for renewable energy sources and technology. In fact, DOE Secretary Perry just announced it is providing $105.5 million in funding for several solar initiatives in partnership with the private sector, funding approximately 70 projects.[54] An additional $20 million is being provided to assist innovative solar technologies intended to drive down the cost of solar production.[55]

DOE also supports other agencies in increasing their acquisition of energy from renewable sources. For example, the Federal Energy Management Program (FEMP) established the Renewable Energy Procurement (REP) Program to provide training for Federal employees, as well as acquisition assistance to Federal contracting offices in the procurement of renewable energy.[56]

[49] https://www.energy.gov/articles/energy-department-announces-achievement-sunshot-goal-new-focus-solar-energy-office
[50] Ibid.
[51] https://www1.eere.energy.gov/wind/pdfs/national_offshore_wind_strategy.pdf
[52] https://www.energy.gov/clean-energy-manufacturing-initiative
[53] https://www.energy.gov/eere/water/articles/hydropower-vision-new-chapter-america-s-1st-renewable-electricity-source
[54] https://www.energy.gov/articles/us-secretary-energy-rick-perry-announces-105-million-new-funding-advance-solar-technologies
[55] https://www.energy.gov/articles/department-energy-announces-20-million-new-projects-lower-cost-power-electronics-solar
[56] https://www.energy.gov/eere/femp/renewable-energy-procurement-Federal-agencies

2.7.2. General Services Administration Initiatives

ARRA provided $5.55 billion to the General Services Administration (GSA) Federal Buildings Fund of which no less than $4.5 billion was to be used to convert GSA facilities to High-Performance Green buildings as defined in P.L. 110-140. An additional $4 million was provided for the Office of Federal High-Performance Green Buildings, authorized in the Energy Independence and Security Act of 2007. While this funding was largely targeted at energy efficiency, this initiative also led to GSA's commitment to increase its renewable energy production and procurement by 30% by FY20.

For example, in 2014, GSA awarded a competitive power supply contract to a commercial wind developer for the purchase of 140 megawatts (MW) of wind energy.[57] The energy will come from the Walnut Ridge Wind Farm, which is currently in development in northwest Illinois, and will add more than 500,000 megawatt-hours (MWhs) of electricity to the power grid annually. The ten-year contract was awarded to MG2 Tribal Energy – a joint venture between the Mesa Grande Band of Mission Indians, a Federally-recognized Native American tribe, and Geronimo Energy, a commercial wind developer – and is the largest wind energy purchase from a single source in Federal contracting history.

GSA has also initiated programs to implement other Administration objections, such as a Net Zero program to achieve the goal of 100% use of renewable energy by 2030 established in EISA.[58]

2.7.3. Department of Veterans Affairs

In response to the renewable purchase goal of 7.5% of consumed energy by 2013 set for Federal agencies in EPAct, the Department of Veterans Affairs (VA) actually doubled that goal for itself to 15%. In order to reach this goal, the VA initiated a number of renewable energy projects, including a $78 million solar project in Phoenix, AZ, a 455 Kw solar project in Philadelphia, PA[59], and both a wind turbine and a ground source heat pump generation project in St. Cloud, MN.[60] In 2010 alone, the VA awarded $78 million in solar projects nationwide.[61] In 2011, the VA awarded another $56 million in contracts for solar energy.[62] By 2016, the VA reported that 30% of their facilities' electrical use came from renewable sources.[63]

[57] See, https://www.gsa.gov/node/78816
[58] See, https://www.gsa.gov/cdnstatic/RMI_white_paper_-_GSA_NZE-_2015-10-21.pdf
[59] http://vabenefitblog.com/the-va-tackles-renewable-energy/
[60] https://www.stcloud.va.gov/features/Wind_Turbine.asp
[61]https://obamawhitehouse.archives.gov/blog/2010/10/22/leading-example-va-funds-solar-energy-projects-hospitals-clinics-cemeteries
[62] https://www.pv-tech.org/news/us_department_of_veterans_affairs_grants_us56.7m_for_solar_installations_on
[63] https://www.sustainability.gov/pdfs/va_scorecard_fy2016.pdf

2.7.4. Department of Labor

The Department of Labor (DOL) received $750 million from ARRA for a program of competitive grants for worker training and placement in high growth and emerging industry sectors. Within the amount provided, $500 million was designated for projects that prepare workers for careers in energy efficiency and renewable energy as described in the Green Jobs Act of 2007. ARRA also appropriated $250 million for the DOL Job Corps Centers, of which up to $37.5 million was made available for the operational needs of the Job Corps program, including activities to provide additional training for careers in energy efficiency, renewable energy, and environmental protection industries.

2.8 SUMMARY

Although there had been earlier attempts to promote the use of renewable energy, progress was slow until the galvanizing impacts of Federal support through mandating the acquisition and generation of renewable energy by Federal agencies, and Federal tax and credit incentives to increase the affordability of renewable energy. These initiatives were matched, and in some cases exceeded, by State programs which also mandated renewable energy production and use by public utilities, and provided consumers with tax incentives for renewable purchasing. As discussed in the sections that follow, this multipronged strategy was effective and the combination of incentives meaningfully impacted the solar and wind sectors in the United States.

CHAPTER 3: PROJECT LEVEL EFFECTS OF FINANCIAL INCENTIVES

The financial incentives introduced by EPAct and subsequent legislation addressed several financing challenges being faced at the time: first, renewable energy projects had a limited track record of commercial deployment, particularly with the newer technologies being introduced at the time; and second, for several years the financial markets were recovering from the 2008-2009 economic downturn, limiting the availability of low cost, long term debt. The financing tools introduced by the Federal government made renewable energy projects financially feasible.

This section of the report describes these financial incentives and quantifies the impact of incentives at the project level. Importantly, many of the financial incentives can be used in combination, providing a cumulative benefit as reflected in the LCOE. This section is organized as follows:

- Introduction and Description of Financial Incentives; and
- Project Level Financial Analysis.

For the analysis of financial incentives, solar and wind generation are examined as these sources of renewable energy posted the largest gains over the period 2005 through 2015.

3.1 FINANCIAL INCENTIVES OFFERED TO RENEWABLES SINCE 2005

The financial incentives introduced or extended by EPAct and subsequent legislation can be broadly categorized into two types: tax-based incentives and credit-based incentives. Tax-based incentives encourage investment by providing a means of lowering an investor's taxable income while credit-based incentives increase the availability of debt capital and/or lower borrowing cost. Each of these categories is described below.

3.1.1. Tax-Based Incentives

Tax-based incentives offer the benefit of being relatively easy to introduce and administer. Once enacted, investors will realize the value of tax incentives by claiming credits or deductions on their tax filings. To convert the benefit of tax incentives to facilitate project development, project developers often collaborate with specialized financing entities who have larger income, and thus a larger appetite for tax reductions. These specialized entities are willing to trade cash "tax equity" for a stream of tax benefits. Tax equity represents a source of capital for projects qualifying for tax incentives and reduces the amount of funding required from conventional debt and equity sources. Third-party tax equity investors tend to be large, sophisticated institutional investors, and in 2016 funded approximately $13 billion in tax equity investments, largely in the renewable energy sector.[64]

The tax incentives utilized in the renewable sector are described below.

Investment Tax Credits (ITCs)

ITCs give a business a tax credit for a specified percentage of capital expenditures for qualifying energy projects. ITCs are an investment-based subsidy as they provide upfront financial support for the construction of a project which is expected to deliver a specified good or service in the future (renewable energy in this case). The ITCs for renewable energy property were established by EPAct 2005 and then modified by several subsequent laws: The Energy Improvement and Extension Act of 2008, ARRA, and most recently the Consolidated Appropriations Act of December 2015. The Tax Cut and Jobs Act of 2017 did not change the status quo ITC offerings. Projects qualify for ITCs in the year they begin construction, and receive ITCs when they are placed in service; projects can spread ITC benefits over multiple years by "carrying forward" the unused amount. From 2005 to 2015, ITCs were offered in an amount equal to 30% of qualifying investment costs. Since the value of ITCs for individual projects often exceeds tax obligations, tax equity investors are commonly used to fully realizing the benefit of ITCs.

Production Tax Credits (PTCs)

PTCs give a taxpaying entity a tax credit for power output, in terms of a fixed dollar amount per unit of output. A PTC can thus be considered a form of results-based subsidy, in that it is only paid out when the intended product (renewable energy in this case) is delivered.[65] PTCs have been offered for a specified number of years of production generally less than the full operational life of power projects; since 2005, PTCs have been offered for eight years of production for nuclear projects and 10 years for other technologies. PTCs for renewable energy were first authorized by the Energy Policy Act of 1992, and then have been modified or extended several times since then, including most recently EPAct 2005, ARRA in 2009, the American Taxpayer Relief Act of 2012, the Tax Increase Prevention Act of 2014, and the Consolidated Appropriations Act of 2016.[66] The Tax Cut and Jobs Act of 2017 did not change the status quo PTC offerings. PTC payments were scaled up to adjust for inflation each year.

[64] Tax Equity Update 2017. Bloomberg New Energy Finance. March 7, 2017.

[65] Results-based subsidies, also commonly referred to as results-based financing (RBF) in international development, have been used to support investment in renewables and other infrastructure. https://openknowledge.worldbank.org/handle/10986/17481

[66] https://www.awea.org/production-tax-credit

As with the ITCs described previously, power projects often use tax equity financing to realize the full benefit of PTCs.

Accelerated Depreciation

Accelerated depreciation—formally Modified Accelerated Cost Recovery System (MACRS)—is a long-standing business tax incentive which is offered to renewable power projects and a wide range of other business assets. Standard depreciation creates an annual expense over many years for a capital asset by simply dividing the total capital expenditure by the expected years of operating life (straight-line depreciation). The Tax Code of 1986 authorized MACRS as a way for businesses to realize higher depreciation expenses, and in turn, lower tax liabilities, earlier in the life of an asset while still incurring the same total depreciation.

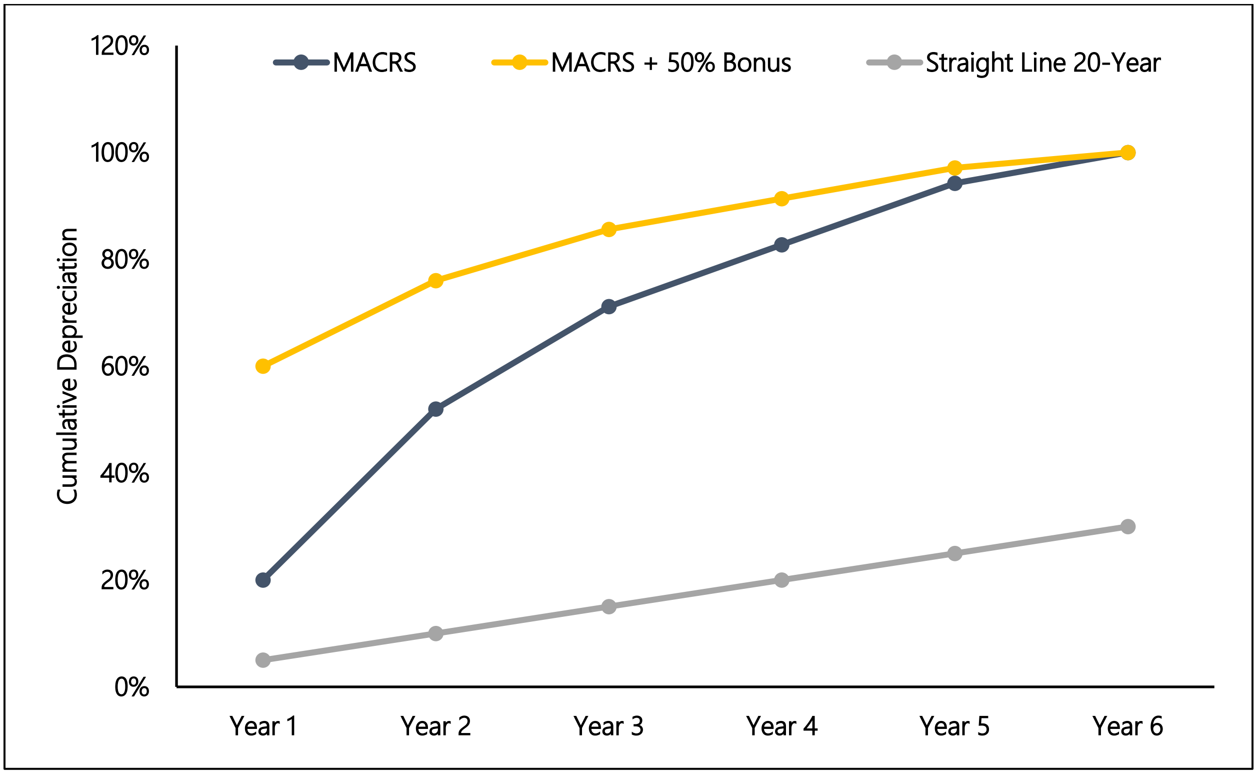
MACRS effectively enhances the value of depreciation to taxpayers because early depreciation is worth more than later depreciation, due to the time value of money. Businesses which use MACRs will face a higher annual tax burden in later years than under straight-line depreciation, because no depreciation is realized in later years and the tax expense is correspondingly higher.[67] Different asset classes have different schedules for accelerated depreciation under MACRS. Each asset class has a set "recovery period" which defines the number of years over which depreciation is spread, and a "recovery method" which determines how depreciation is spread over the recovery period. MACRS has generally allowed a five-year recovery period for renewable energy property since 1986. MACRS depreciation is generally not spread evenly over each year of the recovery period.[68]

The Economic Stimulus Act of 2008 and ARRA of 2009 each offered "bonus depreciation" which further accelerated the MACRS schedule by allowing an additional 50% of an asset's value to be depreciated in the first year of operating life while maintaining the original recovery period. The Tax Relief, Unemployment Compensation Reauthorization, and Job Creation Act of 2010 temporarily allowed 100% depreciation to be realized in the first year. The Protecting Americans from Tax Hikes Act of 2015 extended bonus depreciation for another five years with a phase-out schedule: 50% bonus from 2015 to 2017, 40% in 2018, 30% in 2019, and none thereafter.[69]

67 US PREF, "MACRS Depreciation and Renewable Energy Finance."
68 US PREF, "MACRS Depreciation and Renewable Energy Finance."
69 US PREF, "MACRS Depreciation and Renewable Energy Finance."

Exhibit 3-1 illustrates total depreciation under straight-line depreciation, MACRS, and MACRS with 50% bonus depreciation. Six years are shown since projects are assumed to become operational in mid-year by convention, which causes the five-year recovery period to span all or part of six calendar years.

Exhibit 3-1: Cumulative Depreciation[70]



As seen in Exhibit 3-1, MACRS front-loads depreciation such that a significantly higher amount is realized in the early years of a project than under conventional straight-line depreciation. MACRS with a bonus further increases first-year depreciation, although cumulative depreciation in subsequent years is closer to regular MACRS.

Section 1603 Cash Grant

The Federal government briefly offered cash grants to developers of renewable energy projects as an alternative to ITCs, in response to a decline in tax equity financing during the 2008-2009 economic downturn which stifled development of renewable power projects.[71] Before the downturn, about 20 tax equity investors were investing in new projects; in 2009,

[70] This exhibit assumes that the project is placed into service mid-way through the first year. Thus, application of MACRS for five years runs into the sixth year of project life.

[71] Tax equity financing is explained in the previous discussion of investment tax credits.

this number fell to only five. Section 1603 of ARRA offered cash payments to developers equal to, and in lieu of, the existing ITC (30% of qualifying investment). This allowed developers to receive a benefit equivalent to the ITC without relying on a tax equity investor. The grant payments were offered to qualifying renewable energy projects which began construction from 2009 to 2011.[72] The 1603 Cash Grants effectively extended ITCs to wind projects, by providing grants equal to 30% of investment to wind projects in lieu of PTCs.

3.1.2. Credit-Based Incentives

As discussed previously, Section 1703 of EPAct established the DOE's loan program targeted at projects employing innovative technology. The program was subsequently modified by the Energy Independence and Security Act (ESIA) of 2007 and ARRA of 2009.[73] Credit support under the project can take two forms:

- **Direct Loan:** Under the program, DOE provides a direct loan through the Federal Financing Bank (FFB), which serves as the lender.[74] FFB charges interest slightly above U.S. Treasury rates. DOE then guarantees 100% of the FFB loan.
- **Partial Loan Guarantees:** DOE guarantees loans provided by commercial lenders. DOE's guarantee amount is capped at 80% of principal for a given loan, thus requiring the lender to hold at least 20% of credit exposure.

Credit-based incentives provide budgetary advantages to the government as compared to tax incentives and grants. Loans and loan guarantees are budgeted per the Federal Credit Reform Act (FCRA) of 1990, which results in the budgetary impact of a given credit transaction being less than the total value of the loan or loan guarantee provided. Broadly, the subsidy costs are the difference between (1) the present value of expected cash flows paid out by the government (loan disbursements or loan guarantee claims), and (2) the present value of expected cash flows paid to the government (loan repayment or guarantee fees). Thus, the subsidy cost is approximately the present value of the expected loss on a

[73] "DOE Loan Programs: Current Estimated Net Costs Include $2.2 Billion in Credit Subsidy, Plus Administrative Expenses" by the U.S. Government Accountability Office, April 2015.

[74] Strictly speaking, this is a guarantee, but functions as a direct loan from DOE in all material respect given that DOE bears all of the credit risk.

loan; for well underwritten loans, the expected loss is very low compared to the loan's total principal.

DOE's loan program has supported many successful projects at a low cost to the Federal government including 18 operational power plants (11 solar plants, four wind plants, and three geothermal plants), and a new nuclear plant at the Vogtle site in Georgia. DOE has also supported one storage project, one transmission project, one biofuel production project, and three solar manufacturing projects.

The total loan values and subsidy costs for wind and solar are summarized in Exhibit 3-2.[75] The appropriated subsidy costs are notably small relative to the total loans.

Exhibit 3-2: DOE Credit Support[76]

	Total Capacity (MW)	Total Loans (2015 $M)	Total Appropriated Subsidy Costs (2015 $M)*	Total Appropriated Subsidy Costs per MW (2015 $M)
Solar Generation	2,783	10,056	1,220	0.44
Wind Generation	1,025	1,656	47	0.05
Total Generation	**3,808**	**11,712**	**1,267**	**0.33**

As of November 21, 2014
Source: "DOE Loan Programs: Current Estimated Net Costs..." by the GAO, April 2015
*Subsidy costs can change over time if the outlook on the performance of a loan changes.

3.2 EFFECT OF INCENTIVES ON INDIVIDUAL PROJECTS

The incentives discussed previously in Section 3.1 help to reduce the cost of power from different generation technologies, thus enhancing their competitiveness against other power sources. Tax credits, accelerated depreciation, and credit support enable significant cost reductions when applied together, and enable power to be purchased by customers at a lower price.

This section presents an analysis of the effects of certain incentives on the cost of power from indicative generation projects. Costs are analyzed in terms of estimated LCOE of each

75 All raw data other than MW were sourced from "DOE Loan Programs: Current Estimated Net Costs…" by the GAO, 2015. Data on MW were taken from https://energy.gov/lpo/portfolio/portfolio-projects.
76 All raw data other than MW were sourced from "DOE Loan Programs: Current Estimated Net Costs…" by the GAO, 2015. Data on MW were taken from https://energy.gov/lpo/portfolio/portfolio-projects.

technology, which takes all lifetime costs of a generation facility (including construction, operations and maintenance, financing, and others), and spreads them across the generation facility's total lifetime power production to estimate a cost per unit of power, typically in terms of cents per kilowatt-hour (¢/kWh).[77,78] LCOE is often used to make generalized comparisons of the costs of different generation technologies, while bearing in mind that individual projects' costs can sometimes differ significantly from LCOE due to differences in projects' location, technical design, and other characteristics.[79]

3.2.1. Solar LCOE

Solar projects were significant beneficiaries of ITCs, receiving tax credits equal to 30% of qualifying capital investment costs. Since power projects typically sell power for many years, the value of the ITC often exceeds a project's tax obligation in any individual year. Thus, tax equity investors are often required to realize the full benefit of ITCs, as discussed in Section 3.1.1. Solar projects were also the primary beneficiary of DOE's power generation support through Section 1705, with solar comprising 75% of total loan value and 70% of installed generation capacity under the program.[80]

LCOE for solar was analyzed using the Stanford Graduate School of Business Sustainability Initiative's LCOE Calculator. [81] The solar project was assumed to be utility scale and located in an area with mid-range solar resources. These characteristics along with other project assumptions related to useful life, incentives and financing were entered into the calculator to derive a LCOE for a project under varying levels of incentives.[82] The results of this analysis are presented in Exhibit 3-3 which shows the LCOE incremental benefit to an indicative solar project of adding multiple incentives on top of each other.

[77] DOE Office of Indian Energy, "Levelized Cost of Energy (LCOE), accessed May 11, 2018 (https://www.energy.gov/sites/prod/files/2015/08/f25/LCOE.pdf)

[78] The Stanford Graduate School of Business Sustainability Initiative's LCOE Calculator was used for the calculations (http://stanford.edu/dept/gsb_circle/cgi-bin/sustainableEnergy/LCOE.py)

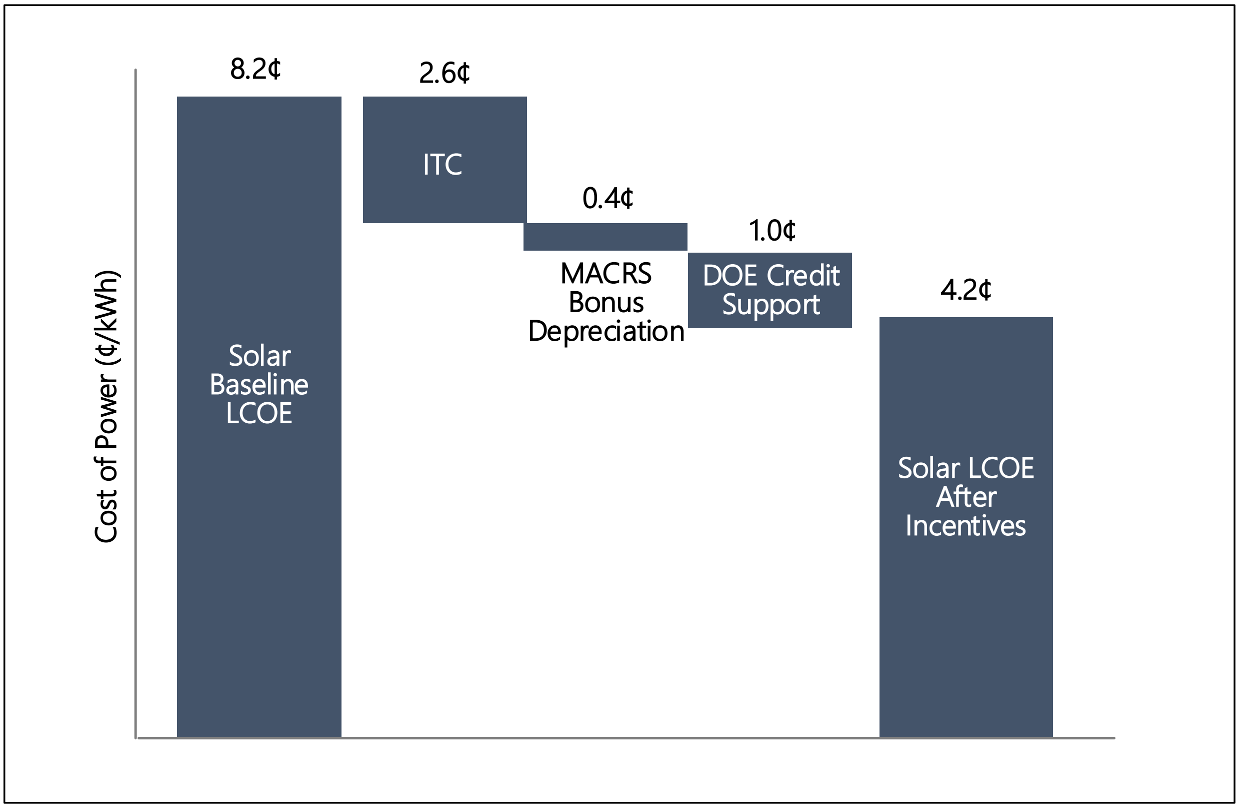
[79] The full assumptions for solar and wind LCOE calculations can be found in Sections 3.2.1 and 3.2.2.

[80] Government Accountability Office, "DOE Loan Programs: Current Estimated Net Costs...," April 2015. Note that the Section 1705 total loan value also includes manufacturing, transmission, and storage, as well as renewable generation.

[81] Stanford Graduate School of Business Sustainability Initiative, "LCOE Calculator," (http://stanford.edu/dept/gsb_circle/cgi-bin/sustainableEnergy/LCOE.py), accessed May 16, 2018

[82] See. Appendix A-1 for detailed assumptions.

Exhibit 3-3: LCOE of Solar Project[83]



Adding an investment tax credit reduces the cost of solar power by 32%. Bonus depreciation makes a much smaller reduction, and DOE credit support brings the cost down by another 1.0¢, or 12% of the baseline cost. DOE loans offer interest at the Treasury rate plus a premium of 0.25%; this results in a cost of debt of 3.3% for a 20-year DOE loan.[84] All together, these incentives reduce the cost of power by 3.9¢, or 48% of the baseline cost.

3.2.2. Wind LCOE

Wind power projects primarily benefitted from PTCs. As described in Section 3.1.1, PTCs have been offered since well before EPAct 2005, and were typically available for 10 years of a

[83] Stanford Graduate School of Business Sustainability Initiative, "LCOE Calculator," (http://stanford.edu/dept/gsb_circle/cgi-bin/sustainableEnergy/LCOE.py), accessed May 16, 2018.
[84] Based on Treasury rates found at https://www.bloomberg.com/markets/rates-bonds/government-bonds/us, accessed May 9, 2018.

project's operating life, thus reducing tax expense and increasing revenue for a significant portion of a project's operating life. ITCs were largely unavailable to wind projects.[85]

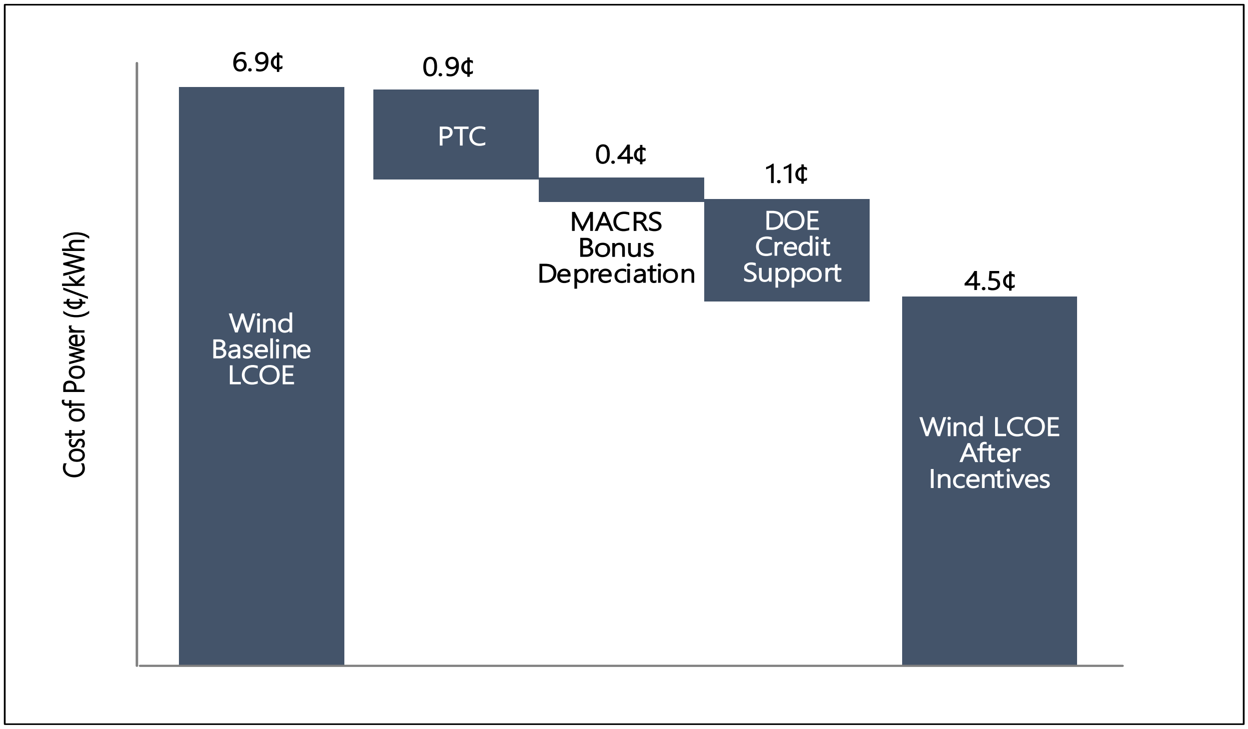
As with solar, the LCOE for wind was analyzed using the Stanford LCOE Calculator.[86] The wind project was assumed to be utility scale and located in an area with average mid-range wind resources. These characteristics along with other project assumptions related to useful life, incentives and financing were entered into the calculator to derive a LCOE for a project under varying levels of incentives.[87] Exhibit 3-4 illustrates the benefit of various incentives on an indicative wind power project.

[85] The 1603 Cash Grant Program awarded grants to wind projects in lieu of PTCs. These grants to wind projects were structured in the same way as the grants in lieu of ITCs offered to solar projects. Thus, wind projects could receive a benefit effectively equivalent to ITCs during the 1603 Cash Grant Program's life. Wind projects were the largest beneficiary of 1603 Cash Grants in dollar terms, receiving a total of $13.90 billion. See U.S. Treasury, "Final Overview of the Section 1603 Program," March 1, 2018.

[86] Stanford Graduate School of Business Sustainability Initiative, "LCOE Calculator," (http://stanford.edu/dept/gsb_circle/cgi-bin/sustainableEnergy/LCOE.py), accessed May 16, 2018

[87] See. Appendix A-2 for detailed assumptions.

Exhibit 3-4: LCOE of Wind Project[88,89]



As with solar power, adding incentives to a wind power project result in significant cost reductions. A production tax credit reduces the cost of wind power by 13%. Bonus depreciation makes a much smaller reduction, and DOE credit support brings the cost down by another 1.1¢, or 16% of the baseline cost. DOE loans offer interest at the Treasury rate plus a premium of 0.25%; this results in a cost of debt of 3.3% for a 20-year DOE loan.[90] All together, these incentives reduce the cost of power by 2.4¢, or 35% of the baseline cost.

3.3 SUMMARY

Tax credits and credit support for renewable power generation projects can enable significant reductions in the cost of electricity. Applying several incentives together reduces costs more, indicating that a comprehensive incentive policy should consider how multiple offerings work together. The combination of tax credits, accelerated depreciation, and credit support is estimated to reduce the cost of power by 48% for solar power, and 35% for wind.

[88] The Stanford Graduate School of Business LCOE Calculator was used for the calculations, with the indicative project being located in Wyoming. The project thus has costs, capacity factors, and state taxation reflecting Wyoming. (http://stanford.edu/dept/gsb_circle/cgi-bin/sustainableEnergy/LCOE.py).
[89] Wind projects could receive 1603 Cash Grants which were valued at 30% of qualifying capital expenditure and were effectively equivalent to receiving an ITC.
[90] Based on Treasury rates found at https://www.bloomberg.com/markets/rates-bonds/government-bonds/us, accessed May 9, 2018.

CHAPTER 4: COSTS AND ECONOMIC BENEFITS OF SUPPORT PROGRAMS FOR RENEWABLES

Chapter 2 of this report described the multi-pronged strategy deployed at the Federal and State level to increase the demand and in turn commercial deployment of renewable energy in the U.S. power sector. Chapter 3 provided illustrative examples of how these incentives reduced the cost of power at the power level. By all accounts, this strategy has been successful. From 2005 through 2015, renewable energy penetration in the power mix has increased from 9% to 16% with the most significant gains coming from solar and wind generation sources. In addition to energy generation, the government financial assistance have led to industry evolution, driving down costs, demonstrating technologies, creating jobs, and lowering prices.

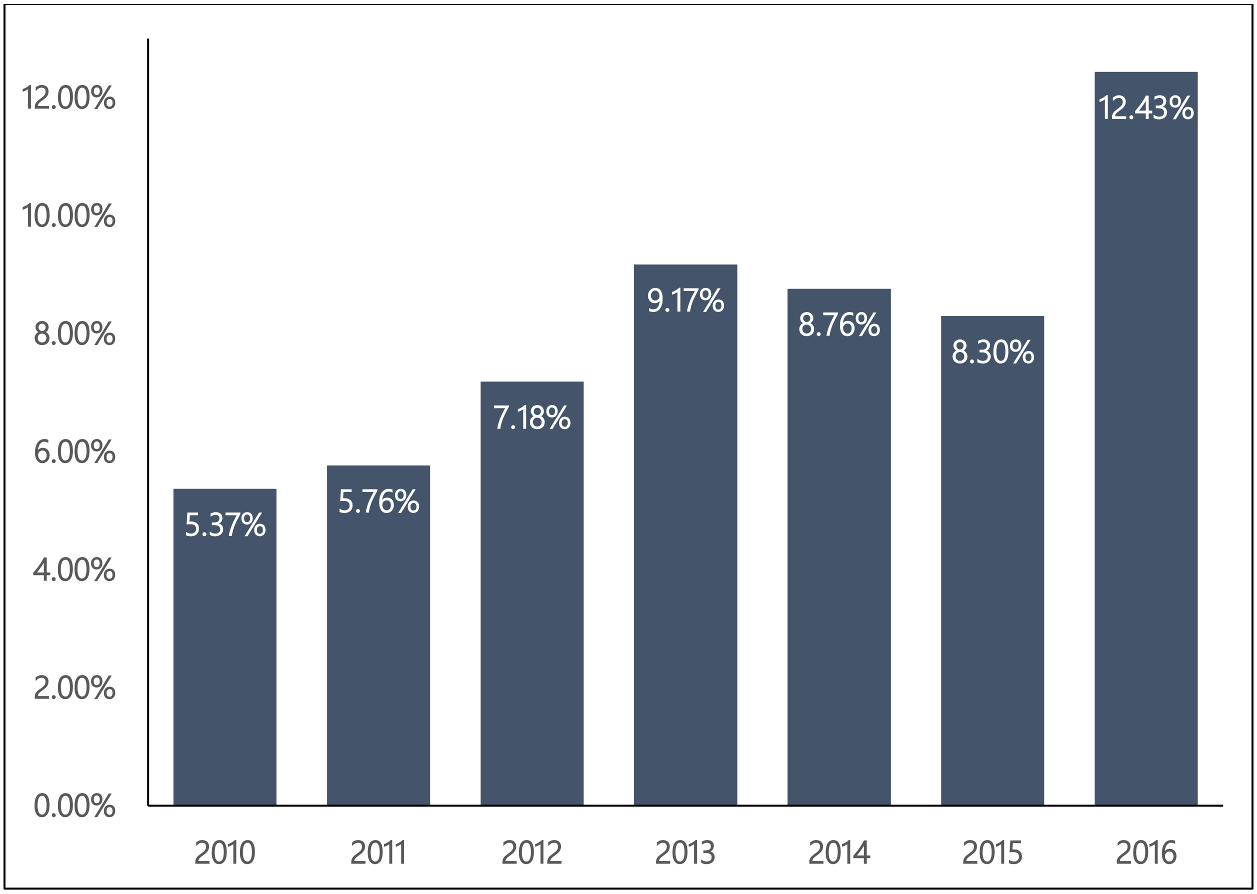
This chapter of the report attempts to quantify the level of investment made by the Federal government in the renewable sector over the 2005 through 2015 period and the associated impacts on market penetration and industry evolution. The analysis focuses on the solar and wind sectors as these technologies posted the strongest gains over the period examined. This chapter analyzes the total investment by the Federal government in solar and wind and then examines the industry gains posted in terms capacity installed, generation, and job growth.

4.1 COSTS OF INCENTIVE PROGRAMS

Growth in the solar and wind power industries was supported by a combination of Federal spending on supply-side incentives (tax incentives, credit support, and R&D), and demand mandates by the Federal and state governments. To quantify the cost of incentive programs, this report examines the revenue loss associated with tax incentives, the appropriated credit subsidy associated with credit incentives, and the direct spending associated with research and development initiatives.

Demand mandates were also an important component of the incentive strategy. As shown in Exhibit 4-1, the share of energy consumption comprised of renewables more than doubled from 2008 to 2016, reaching 12.4%.

Exhibit 4-1: Renewables as a Share of Federal Energy Consumption



State RPS mandates have and will contribute more significantly to demand growth and will require an average annual capacity addition of 4 GW to reach 2030 targets.[91]

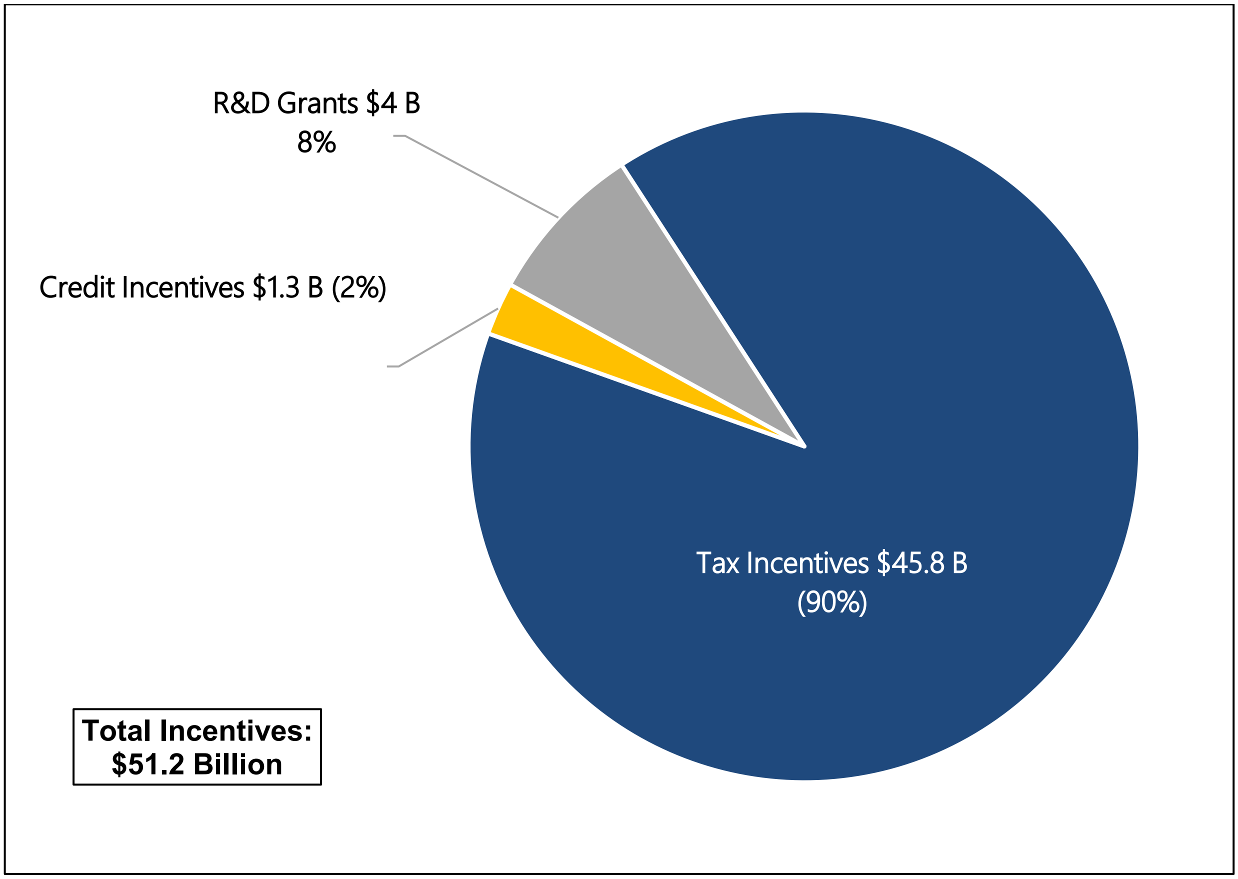
Despite the importance of demand mandates to driving industry growth, measuring the cost to the government represents a challenge. The cost of demand mandates is not total spending on renewable power, but rather the additional cost of renewable power over the term of a power purchase agreement. This type of avoided cost analysis is subject to significant uncertainty, is project-specific, and cannot be meaningfully aggregated. Also, some organizations, like the U.S. Army, seek to procure renewable power at or below prevailing grid energy prices. Other agencies purchased Renewable Energy Credits (RECs)

[91] Barbose, "U.S. Renewables Portfolio Standards: 2017 Annual Status Report," July 2017.

as an alternative to entering into long-term power purchase agreements. Given these challenges, this section does not attempt to quantify the cost of demand mandates.

As illustrated in Exhibit 4-2, based on a review of incentives for solar and wind from 2005 to 2015, it is estimated that the Federal government spent $51.2 billion, with tax incentives accounting for 90% of the total.

Exhibit 4-2: Total Incentives for Wind and Solar[92],[93]



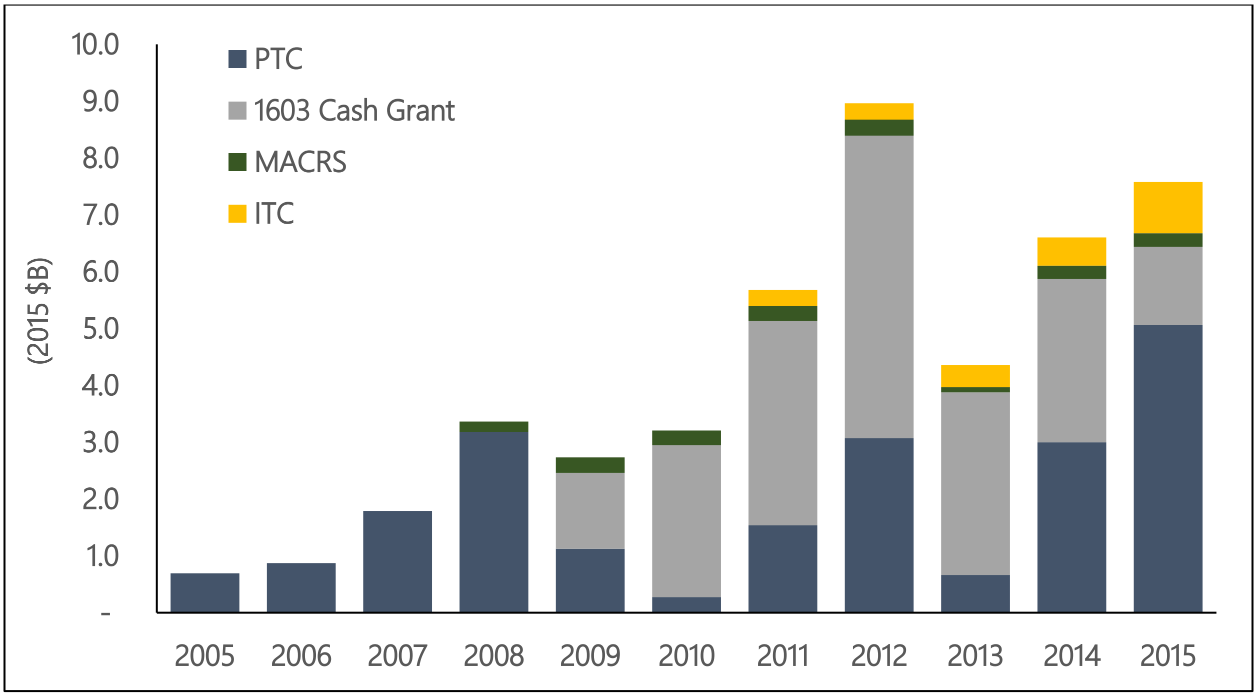
Each component of these incentives is examined below.

[92] Based on Scully Capital analysis discussed throughout this section.
[93] Chart shows $51.1 billion instead of $51.2 B of total incentives; slight difference due to rounding.

4.1.1. Tax-Based Incentives

The Federal government incurred significant tax expenditure to subsidize solar and wind—tax expenditure is defined as the amount of tax revenue the Federal government loses through special tax credits and other incentives which reduce tax obligations.[94] The Federal government spent a total of $45.8 billion on tax incentives for solar and wind from 2005 to 2015. Of this, production tax credits comprised 46.4%, or $21.3 billion. Spending on 1603 Cash Grants comprised $20.4 billion, or 44.5% of the total. This was followed by investment tax credits of $2.4 billion, or $5.13% of the total; it is worth noting that 1603 Cash Grants were effectively a substitute for ITCs, so investment-based subsidies were in fact very large if ITCs and 1603 Cash Grants are considered together. Lastly, MACRS incentives were worth $1.8 billion, or 3.97% of the total. This is summarized in Exhibit 4-3.

Exhibit 4-3: Summary of Tax-Based Incentives in 2015 Billions of U.S. Dollars



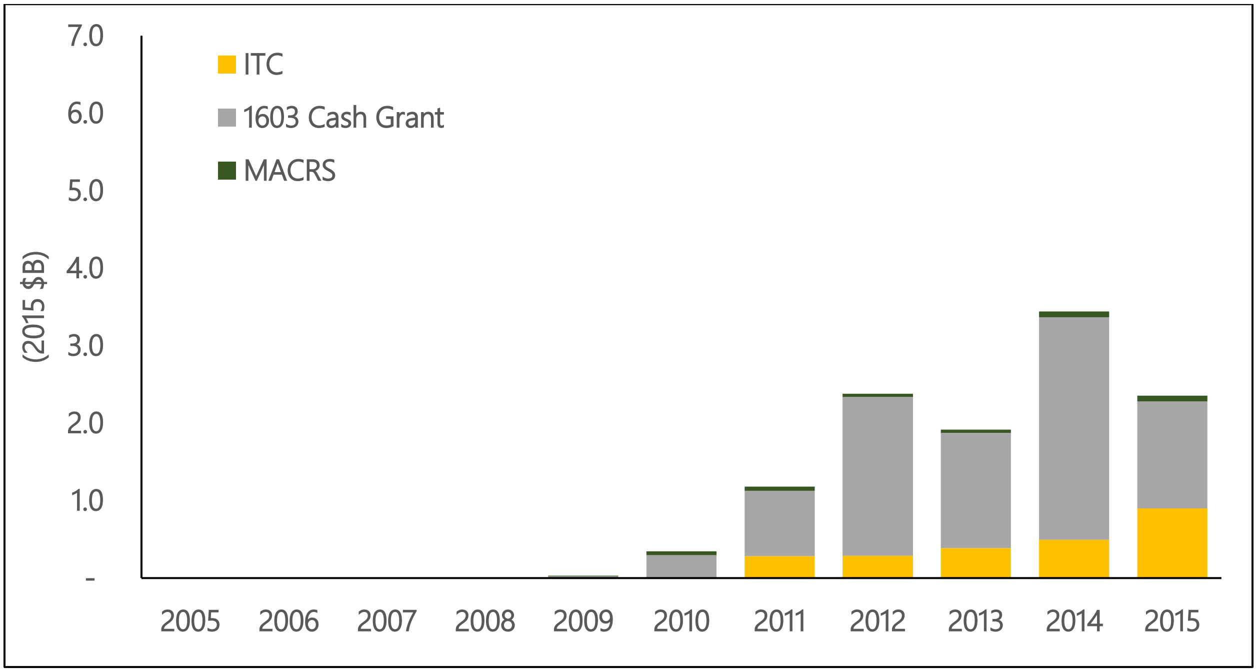
The details on tax incentives for solar and wind are presented below.

[94] Tax Policy Center, "Tax Policy Center Briefing Book," accessed May 20 (https://www.taxpolicycenter.org/briefing-book/what-are-tax-expenditures-and-how-are-they-structured).

Tax Incentives for Solar Generation

As shown in Exhibit 4-4, tax expenditure for solar became significant from 2010 onwards, totaling $11.6 billion. Before then, tax expenditure for solar never exceeded the Joint Committee on Taxation (JCT) reporting threshold of $5 million in a given year, and thus was not reported.[95]

Exhibit 4-4: Tax Incentive Spending for Solar



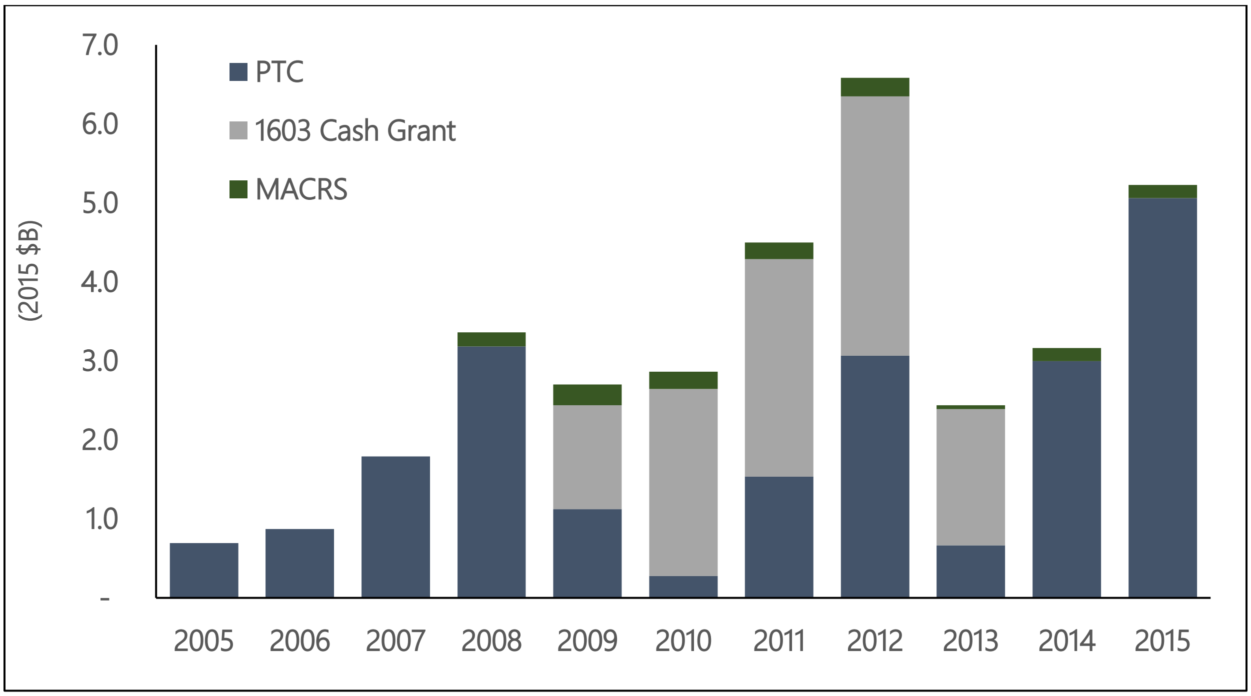
The 1603 Cash Grant comprises the vast majority of tax incentives for solar ($8.9 billion); as the 1603 Cash Grants were given to solar projects in lieu of ITCs, they are reported here along with the other tax incentives. ITC expenditure totaled $11.4 billion over the period. However, as the name would imply, 1603 Cash Grants were cash disbursements and thus not measured in terms of revenue loss.[96] MACRS comprised a small share of tax incentive spending for solar, totaling just $300 million.[97] PTCs for solar power never exceeded the JTC reporting threshold.

[95] PTCs were available for solar projects not claiming the ITC, but never exceeded the JCT reporting threshold.
[96] 1603 Cash Grants were not recorded in the Joint Committee on Taxation's "Estimates of Federal Tax Expenditure…"
[97] Detailed tables with data on solar tax incentives for each year and the relevant sources can be found in Appendix B.

Tax Incentives for Wind Generation

Total tax expenditure for wind, as shown in Exhibit 4-5, was relatively large at $34.2 billion. This was around three times more than for solar, reflecting the fact that wind power had significantly higher capacity growth (in terms of MW coming on the grid) than did solar from 2005 to 2015 (see Chapter 4.2). It is also important to note that this report takes an approach to estimating PTC expenditure which results in higher expenditure than government reporting; this report counts all PTCs for a given project as being expensed in the first year that the project receives PTCs, rather than spreading them over a project's 10-year life. This reflects the fact that investment decisions are made around the expectation of PTCs over many years, as projects are built and financed around confidence in PTCs being realized in the future. Details on the methodology for estimating wind tax expenditure can be found in the Appendix.

Exhibit 4-5: Tax Incentive Spending for Wind



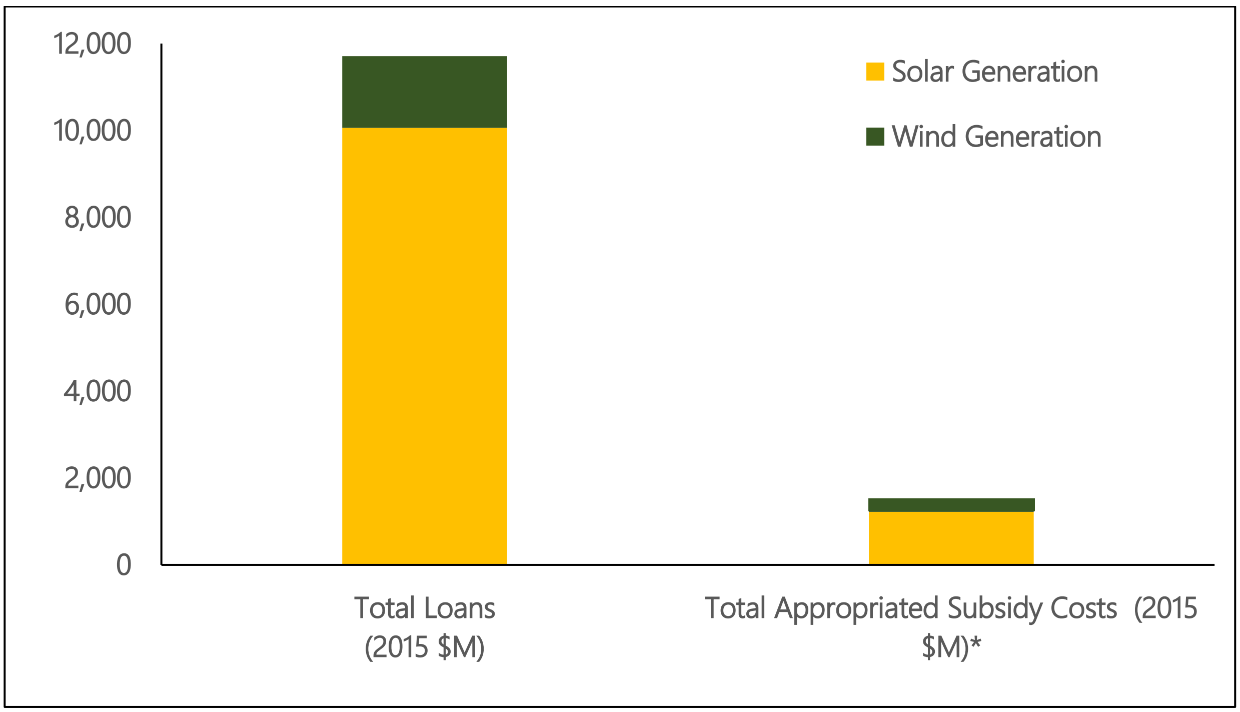
PTCs comprised the largest part of wind tax expenditure at $21.3 billion. ITCs were generally not offered for wind power projects; however, wind projects could claim 1603 Cash Grants in lieu of tax credits. Wind projects also received significant support from 1603 Cash Grants, totaling $11.4 billion. 1603 Cash Grants were offered for 30% of qualifying investment for wind, thus being equivalent to a 30% ITC. As with the previous discussion of solar, 1603 Cash

Grants were not a tax expenditure, but are included here since they were offered in lieu of tax credits. MACRs comprised a small share of tax incentives for wind, totaling $1.5 billion.[98]

4.1.2. Credit-Based Incentives

The Federal government offered significant credit support in the form of loans and loan guarantees for wind and solar through DOE's lending authority. In total, DOE provided $11.7 billion in credit assistance to 3,808 MW of solar and wind projects. Although the loans supported by DOE totaled $11.7 billion, the appropriated subsidy costs were only $1.3 billion, reflecting the use of credit subsidy in budgeting. Thus, the Federal government carried only 11% of the total cost of loans or $332,711 per MW.[99]

Exhibit 4-6: LPO Credit Incentive Spending for Wind and Solar[100]



Solar generation received the vast majority of DOE support, with $10.1 billion of loans supporting 2,783 MW; this incurred subsidy costs of just $1.2 billion. Total Federal costs for

[98] Detailed tables with data on wind tax incentives for each year and the relevant sources can be found in the Appendix.
[99] Government Accountability Office, "DOE Loan Programs: Current Estimated Net Costs…," April 2015. The cost per MW was calculated for this report by dividing the total appropriated subsidy costs by the MW supported.
[100] Government Accountability Office, "DOE Loan Programs: Current Estimated Net Costs…," April 2015.

solar were just 12% of the total loans. A total of 1,025 MW of wind projects were built, with $1.7 billion of loans and a subsidy cost of just $47 million. Total Federal subsidy costs for wind were just 2.8% of loans. The budgeted cost for solar was nearly 24 times larger than the budgeted cost for wind. [101]

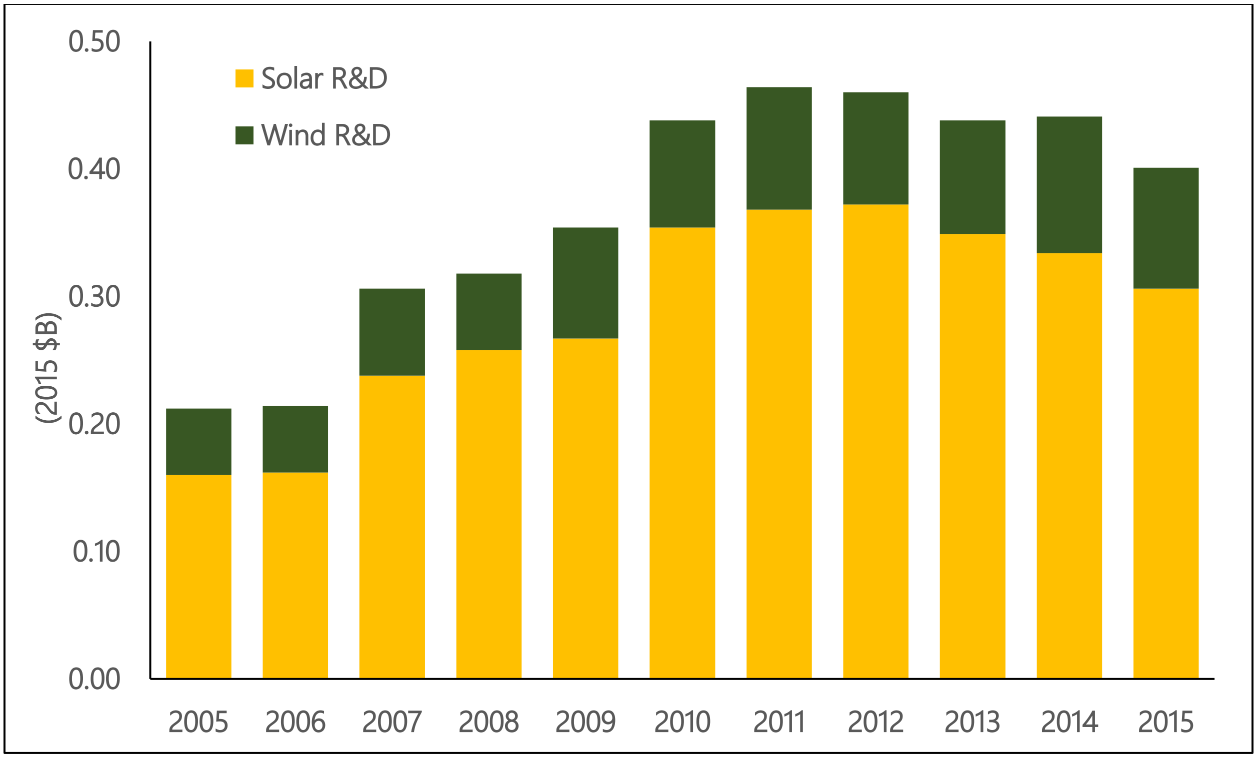
Research and Development Expenditures

Federal R&D spending on solar power totaled $3.2 billion from 2005 to 2015 and totaled $880 million for wind power over same period. Three quarters of solar spending came from DOE; the remainder came from the U.S. Department of Agriculture (USDA) and the National Aeronautics and Space Administration (NASA). R&D spending is summarized in Exhibit 4-7.[102]

[101] Government Accountability Office, "DOE Loan Programs: Current Estimated Net Costs…," April 2015. The source document did not break out spending by year or by individual project, to protect confidentiality of individual projects' credit subsidies and other data.

[102] Managed Information Services, Inc., "Two Thirds of a Century and $1 Trillion+ U.S Energy Incentives," published by the Nuclear Energy Institute, May 2017.

Exhibit 4-7: R&D Spending for Solar and Wind[103]



As seen in Exhibit 4-7, solar R&D spending was significantly higher from 2010 onwards. This reflects, in part, DOE's SunShot Initiative, which aimed to reduce the cost of solar power. SunShot has supported a range of initiatives in design of solar panels, integrating solar power with the grid, and encouraging commercialization of new technologies and business models.[104,105]

4.2 BENEFITS OF INCENTIVE PROGRAMS

While the Federal government's $51.2 billion investment in solar and wind represents a large commitment, the impact on the industry and U.S. generation mix has been significant. Strong government support resulted in meaningful growth in generation capacity and power production for solar and wind, and stimulated related employment.

The incentive programs discussed in Section 3.1 stimulated growth in the solar and wind power industries. Deployment of solar and generation capacity, and the resulting electricity,

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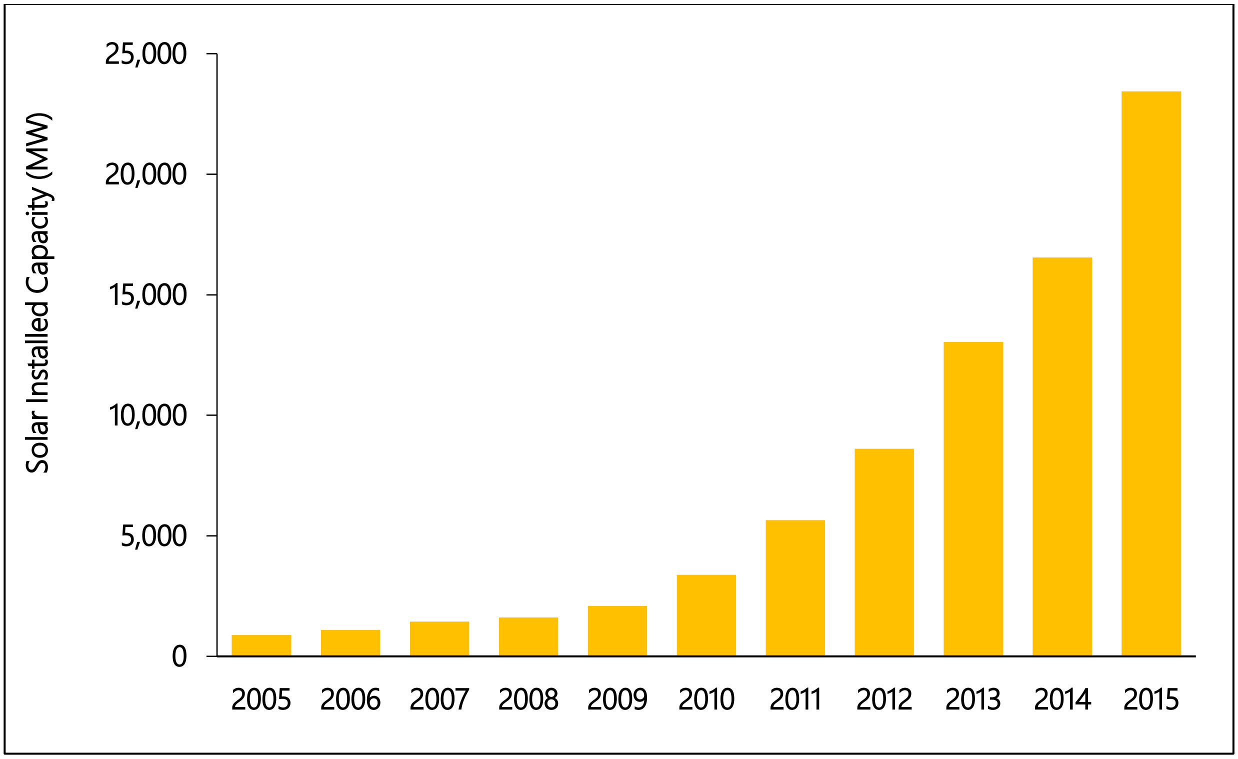
[103] Managed Information Services, Inc., "Two Thirds of a Century and $1 Trillion+ U.S Energy Incentives," published by the Nuclear Energy Institute, May 2017.
[104] U.S. Department of Energy, "The SunShot Initiative's 2030 Goal…," December 2016.
[105] U.S. Department of Energy, "Technology to Market," February 2016.

have grown sharply since 2005. Power production has become more efficient, and costs have fallen, for both technologies. Industry growth has also brought benefits to the American economy in terms of employment. This section first discusses developments in the solar power industry, and then discusses wind.

4.2.1. Solar Energy Market Penetration and Industry Development

The solar power industry has realized dramatic growth from 2005 to 2015, with installed capacity of 23,440 MW in 2015 being over 26 times larger than installed capacity in 2005. From 2010 to 2016, solar was the fastest growing utility-scale generation source in the U.S.[106] This growth is summarized in Exhibit 4-8.

Exhibit 4-8: Growth in Solar Capacity[107]

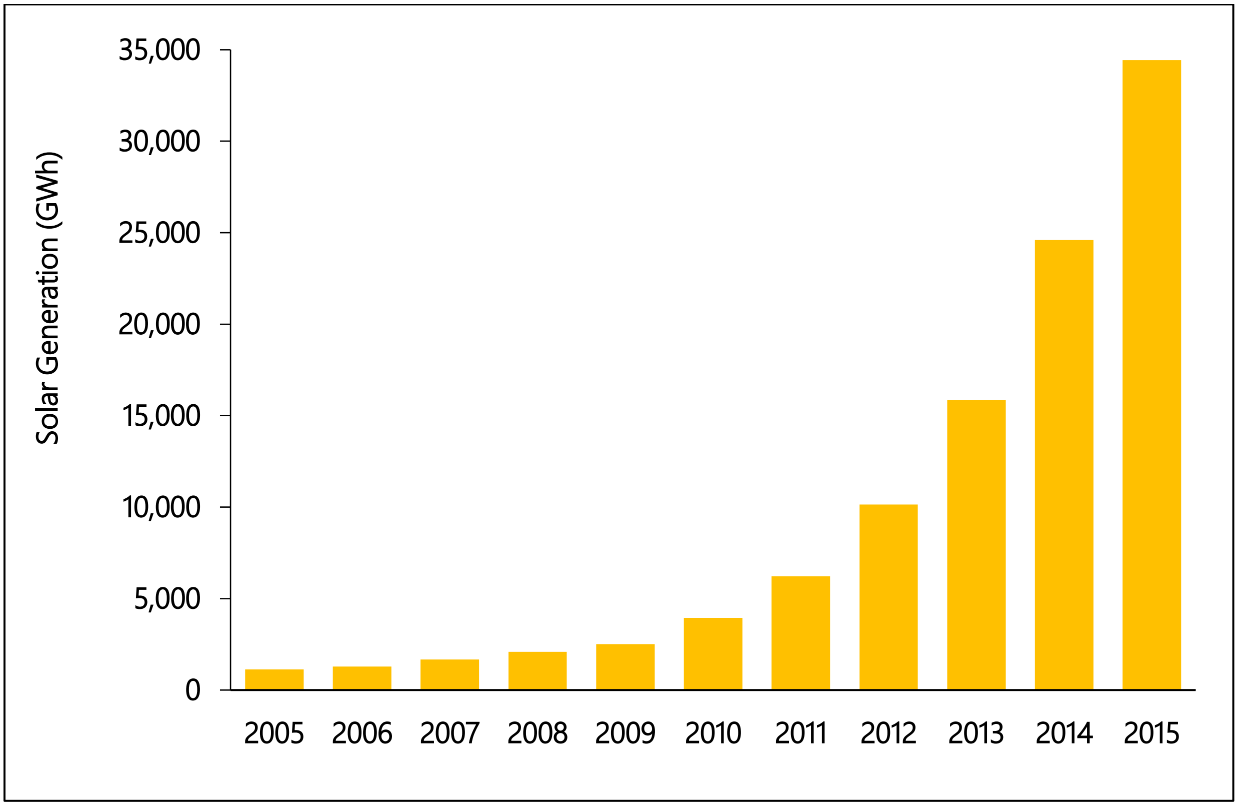


[106] U.S. Energy Information Administration, "Utility-Scale Solar Has Grown Rapidly Over the Past Five Years," accessed May 22, 2018 (https://www.eia.gov/todayinenergy/detail.php?id=31072)

[107] International Renewable Energy Agency, "Data and Statistics," accessed April 17, 2018 (http://resourceirena.irena.org/gateway/dashboard/)

Since 2005, solar has risen from a relatively minor source of power to comprising 30% of additional capacity brought online in the U.S. in 2017.[108] Growth in solar power was driven by growth in installed capacity and was also influenced by an overall improvement in capacity factors for solar generation (the ratio of actual output to maximum potential output in a given time period).[109] This led to significant increases in solar power generation as reflected in Exhibit 4-9.

Exhibit 4-9: Growth in Solar Generation



Solar capacity factors improved due to many influences, including selection of project sites with better solar resource quality, use of solar panel designs which track the sun's movement, and improved inverters.[110,111] The dramatic growth in solar capacity and generation has been

[108] Solar Energy Industries Association, "Solar Market Insight Report 2017 Year in Review," accessed May 22, 2018 (https://www.seia.org/research-resources/solar-market-insight-report-2017-year-review)

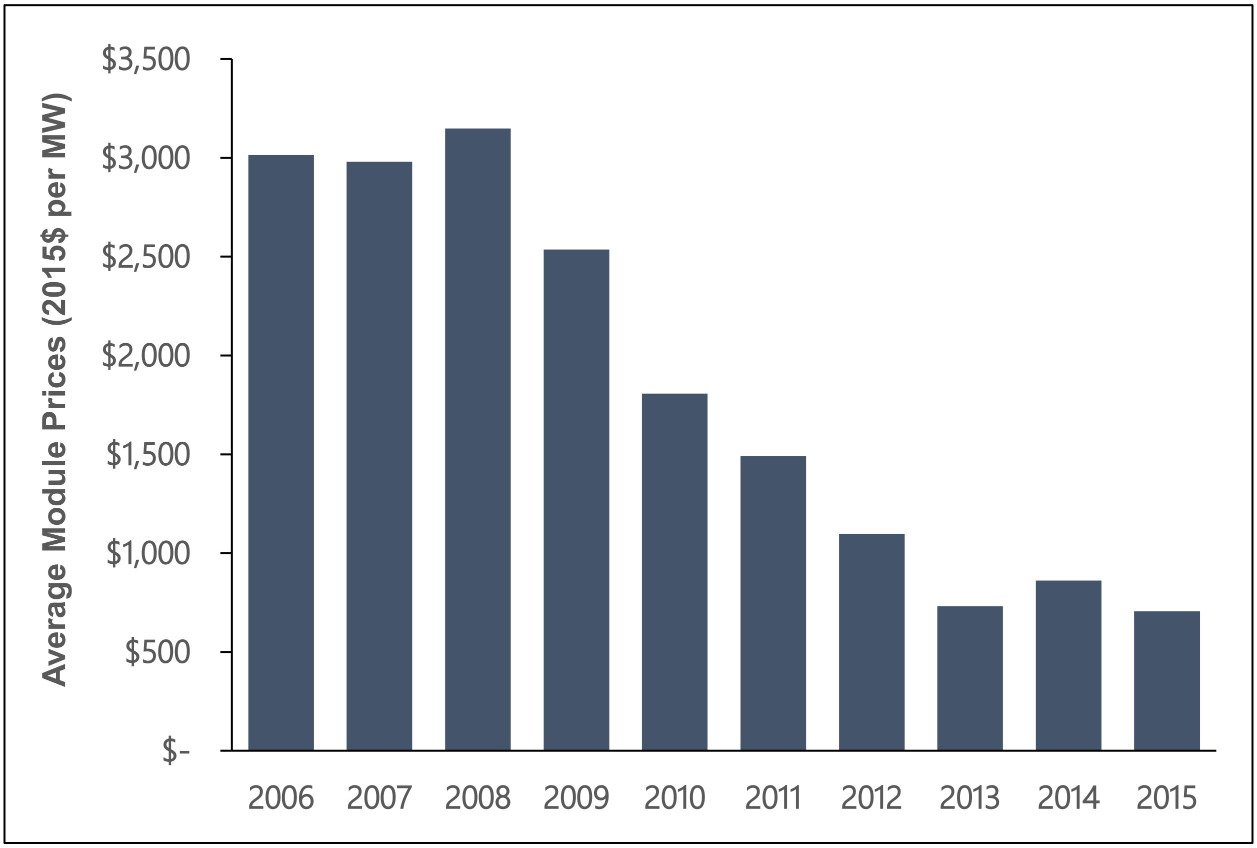
[109] Bolinger et al, "Utility Scale Solar 2016," published by Lawrence Berkeley national Laboratory, September 2017.

[110] Bolinger et al, "Utility Scale Solar 2016," published by Lawrence Berkeley national Laboratory, September 2017.

[111] Inverters convert electricity generated by sunlight striking solar modules (direct current) into electricity which is more easily used in the power grid (alternating current). See https://www.sunrun.com/go-solar-center/solar-articles/what-is-a-solar-inverter-and-how-does-it-work.

supported by declining costs for solar power. From 2006 to 2015, average solar module prices declined by 77% in real terms, falling from $3,014 per MW to $705 per MW.[112] This is shown in Exhibit 4-10.

Exhibit 4-10: Real Prices for Solar Modules[113]



Module prices have fallen largely due to efficiency gains in manufacturing and global competition, especially due to pressure from Chinese manufactures. The number of module manufacturing facilities in the U.S. fell from 51 in 2011 to 38 in 2013.[114] China has been the world's largest producer of modules since 2007, and also leads across other stages of the PV supply chain (silicon, silicon wafers, solar cells). China's share of world module output

[112] U.S. Energy Information Administration, Form EIA-63B, "Annual Photovoltaic Cell/Module Shipments Report," accessed May 4, 2018 (https://www.eia.gov/renewable/annual/solar_photo/pdf/table4.pdf). Data were not available for 2005.
[113] U.S. Energy Information Administration, Form EIA-63B, "Annual Photovoltaic Cell/Module Shipments Report," accessed May 4, 2018 (https://www.eia.gov/renewable/annual/solar_photo/pdf/table4.pdf). Data were not available for 2005.
[114] "U.S. Solar Photovoltaic Manufacturing…" by Platzer, CRS, January 2015.

grew from 61% in 2011 to 74% in 2016.[115] Solar manufacturing in China has also experienced consolidation; from 2011 to 2015 the number of PV module and cell manufacturers in China dropped by over 300 to under 100.[116] Foreign solar manufacturers may move some production to the U.S. in response to recently implemented tariffs; Jinko Solar of China plans to investment $50 million in a factory in Florida.[117]

While Chinese manufacturers have played a major part in the global market for solar equipment, American firms have also been successful. In particular, First Solar, Inc. of Arizona stands out as a global cost leader, with over 17 GW of capacity installed worldwide, and sales in Asia, Europe, Latin America, the Middle East, and the United States. The company was the world's seventh-largest module supplier in 2016.[118] First Solar's cost competitiveness has been enabled by strong investment in R&D, investing more in R&D than all other competitors; its cumulative R&D spending is expected to surpass $1 billion in 2016.[119,120] The company gains significant competitive advantages through innovative production processes, product designs which reduce the amount of silicon required for modules, and other means. First Solar's financial statements state that the company has benefitted from tax credits and other subsidies for renewable power in the U.S. and foreign markets.[121]

As would be expected from strong growth in solar installed capacity and generation, employment in solar energy has grown quickly in recent years and is expected to continue growing quickly. Solar jobs are estimated to have grown at 11.82% CAGR from 2003 to 2010.[122] In 2016, solar power was estimated to have employed 374,000 people. Solar jobs were estimated to have grown by 25% in 2016.[123]

Notably, the Bureau of Labor Statistics estimates that solar PV installers will be the fastest growing job from 2016 to 2026, with an expected annual growth rate of 7.41% which far outpaces the forecast 0.71% annual growth for total employment in the U.S.[124] Outside of

[115] "PVPS Annual Report" by International Energy Agency, 2017.
[116] "U.S. Solar Photovoltaic Manufacturing…" by Platzer, CRS, January 2015.
[117] St. John, "Jinko Solar Confirms $50M Investment in US Factory," Greentech Media, March 30, 2018; accessed May 22, 2018 (https://www.greentechmedia.com/articles/read/jinkosolar-confirms-410m-investment-in-u-s-factory-to-make-tariff-free#gs.EBedfFA).
"[118] "Top-10 Solar Module Suppliers in 2016," PVTech, accessed May 4, 2018 (https://www.pv-tech.org/editors-blog/top-10-solar-module-suppliers-in-2016).
[119] First Solar 10-K Filing for 2016.
[120] "First Solar to Surpass US$1 Billion in Cumulative R&D Spending in 2016," PVTech, accessed May 4, 2018 (https://www.pv-tech.org/editors-blog/top-10-solar-module-suppliers-in-2016).
[121] First Solar 10-K filing, 2016.
[122] Muro et al, "Sizing the Clean Economy," Brookings Institution, 2011.
[123] Department of Energy, "U.S. Energy and Employment Report," January 2017.
[124] Bureau of Labor Statistics, "News Release: Employment Projections 2016-2026," October 24, 2017.

manufacturing, the solar power industry creates jobs in many other areas, such as system design (including IT specialists and power system engineers), project development (including utility procurement specialists and solar site assessors), and installation and operations (including project managers and installation instructors).[125]

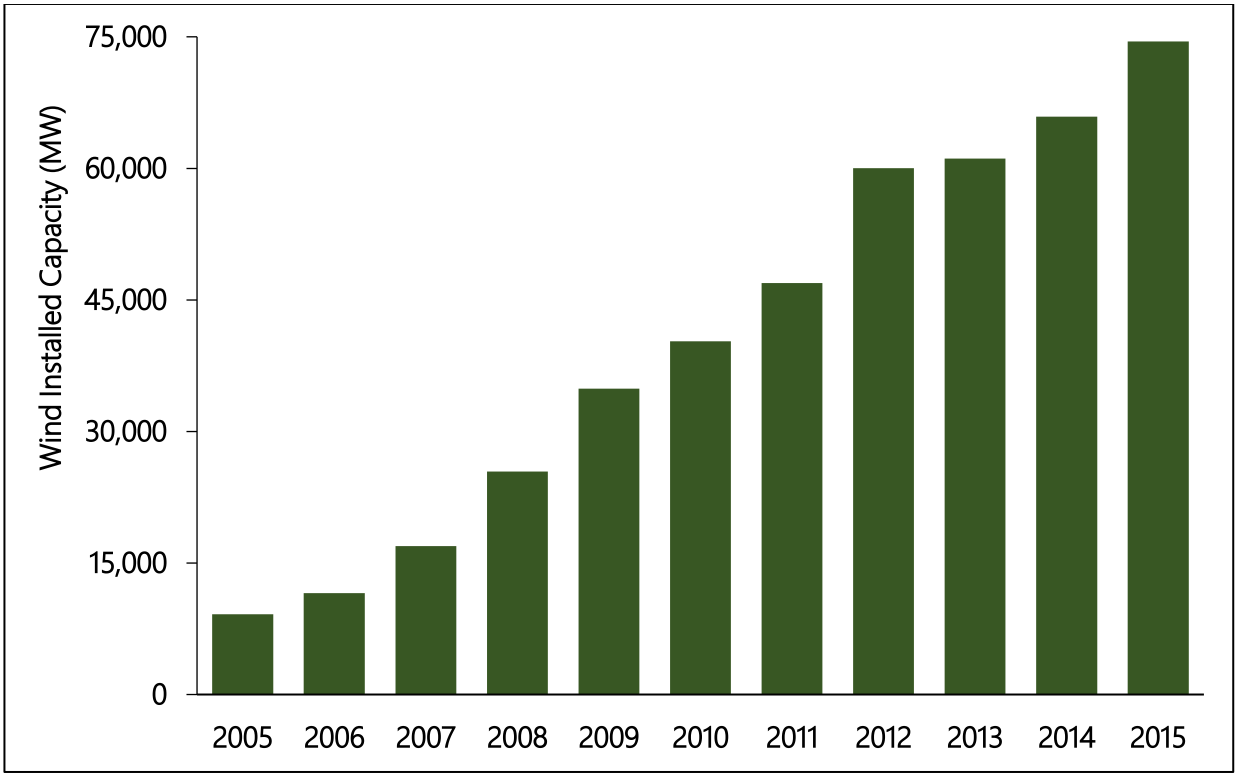
The solar industry is a significant contributor to the wider economy. The Solar Foundation estimates that the solar industry added $84 billion to U.S. GDP in 2016. The industry also generated approximately $50 billion in labor income, $11.6 billion in Federal taxes, and $6.5 billion in state and local taxes. One dollar of spending on solar power was estimated to generate an additional $1.46 in spending elsewhere in the economy.[126]

4.2.2. Industry and Job Development for Wind

The wind power industry has realized strong growth from 2005 to 2015, with installed capacity of 74,470 MW in 2015 being over eight times larger than installed capacity in 2005. Wind comprised 31% of capacity additions in the U.S. from 2006 to 2016.[127] This growth is summarized in Exhibit 4-11.

[125] IREC, "Solar Career Map," referenced May 8, 2018 (http://irecsolarcareermap.org/).
[126] Solar Foundation, "U.S. Solar Industry Added $84 Billion to U.S. G.D.P. in 2016," accessed May 22, 2018 (http://www.thesolarfoundation.org/wp-content/uploads/2017/04/2016-Census-Economic-Impacts_Final.pdf).
[127] Wiser et al, "2016 Wind Technologies market Report: Summary," U.S. Department of Energy, 2017.

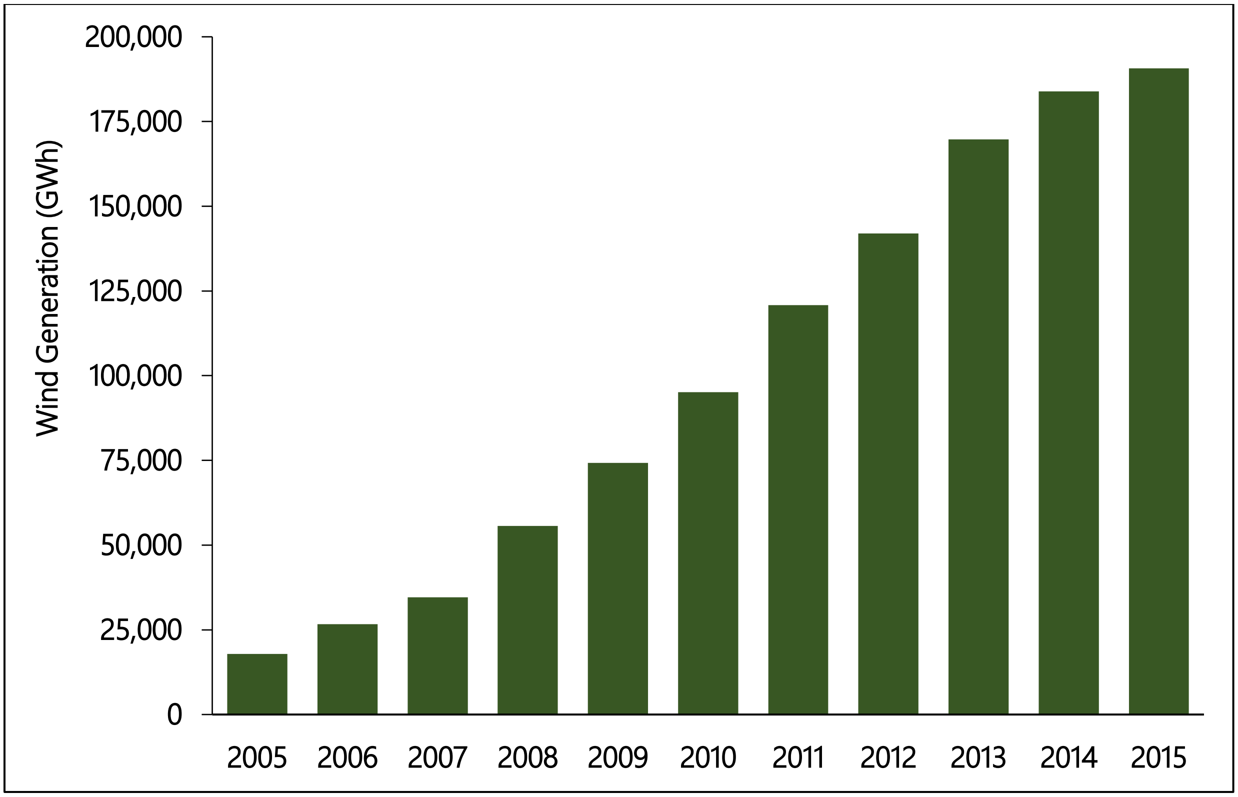
Exhibit 4-11: Growth in Wind Capacity[128]



In 2016, the U.S. realized the second largest wind capacity additions worldwide and had the second largest installed wind capacity.[129] Wind generation has realized similarly strong growth, as shown in Exhibit 4-12. Growth in generation was driven by growth in installed capacity and was also influenced by an overall improvement in capacity factors for wind generation (the ratio of actual output to maximum potential output in a given time period).[130]

[128] International Renewable Energy Agency, "Data and Statistics," accessed April 17, 2018 (http://resourceirena.irena.org/gateway/dashboard/).
[129] Wiser et al, "2016 Wind Technologies Market Report: Summary," U.S. Department of Energy, 2017.
[130] U.S. Department of Energy, "2016 Wind Technologies Market Report," 2018.

Exhibit 4-12: Growth in Wind Generation[131]

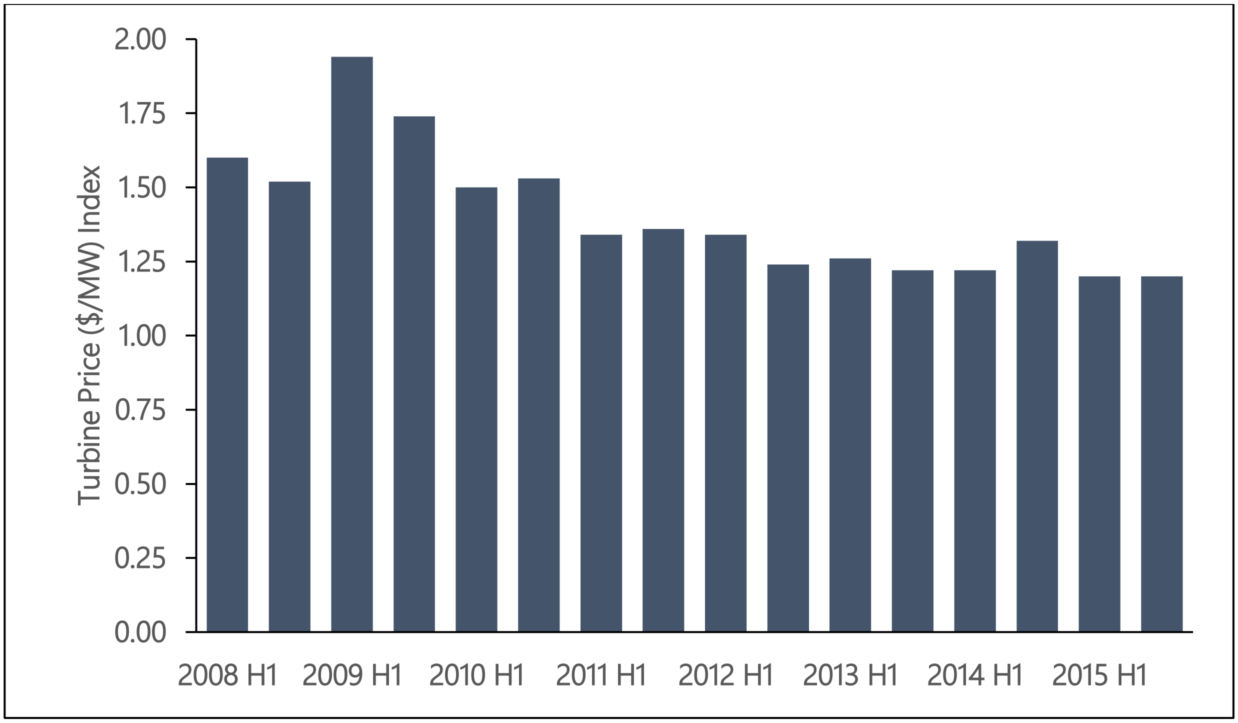


The U.S. Energy Information Administration expects that wind power's strong growth will result in wind surpassing hydropower as the largest source of renewable generation in 2018.[132] Wind generation growth has also been influenced by improvements in capacity factors. Newer wind facilities have generally had higher capacity factors than older ones, due to improvements in turbine designs and higher quality wind resource sites.[133]

The dramatic growth in wind capacity and generation has been supported by declining costs for wind power. From the first half of 2008 to the second half of 2015, average turbine prices declined by 25% according to a global price index from Bloomberg New Energy Finance.[134] This is shown in Exhibit 4-13.

[131] International Renewable Energy Agency, "Data and Statistics," accessed April 17, 2018 (http://resourceirena.irena.org/gateway/dashboard/).
[132] U.S. Energy Information Administration, "Wind Expected to Surpass Hydro as Largest Renewable Electricity Generation Source," January 24, 2018; accessed May 22, 2018 (https://www.eia.gov/todayinenergy/detail.php?id=34652#).
[133] U.S. Department of Energy, "2016 Wind Technologies Market Report," 2018.
[134] Data were not available before 2008.

Exhibit 4-13: Turbine Price Index[135]



Turbine prices have generally fallen worldwide in recent years due to cost competition among turbine suppliers and cost-cutting initiatives among component suppliers, and by declining prices of commodity inputs to manufacturing (such as energy and metals). Purchasers have also received more favorable sales terms in recent years, including reduced time to delivery and stronger performance guarantees.[136,137] Wind power prices are expected to be generally competitive with natural gas through 2050.[138]

As would be expected from strong growth in wind installed capacity and generation, employment in wind energy has grown quickly in recent years and is expected to continue growing quickly. Wind jobs are estimated to have grown at 14.9% CAGR from 2003 to 2010.[139] Wind power is estimated to have employed 101,738 workers in 2016. More recently, wind jobs grew by 32.0% in 2016.[140] Notably, the Bureau of Labor Statistics estimates that

[135] Data from: Bloomberg New Energy Finance "H2 2016 Wind Turbine Price Index," January 4, 2017. The index does not show actual prices, but rather uses an index to compare prices worldwide at different times.
[136] U.S. Department of Energy, "2016 Wind Technologies Market Report," 2018.
[137] Moné et al, "2015 Cost of Wind Energy Review," published by NREL, 2017.
[138] Wiser et al, "2016 Wind Technologies Market Report: Summary," U.S. Department of Energy, 2017.
[139] Muro et al, "Sizing the Clean Economy," Brookings Institution, 2011.
[140] Department of Energy, "U.S. Energy and Employment Report," January 2017.

wind turbine technicians will be the second-fastest growing job from 2016 to 2026, with an expected annual growth rate of 6.99% which far outpaces the forecast 0.71% annual growth for total employment in the U.S.; only solar PV installers will grow faster.[141] The wind industry employs workers in all 50 states.[142]

Although the U.S. is a net importer of wind power equipment, there is significant manufacturing of wind turbine parts in the U.S. There are over 500 wind-related manufacturing facilities in the U.S. across 43 states.[143] In 2016, domestic content in wind towers ranged from 65%-80%, and from 50%-70% for blades and hubs. However, nacelles often have domestic content of under 20%.[144] Globally, General Electric (GE) is the second-largest manufacturer of wind turbines, following Vestas of Denmark. [145] GE was also the second-largest provider of wind turbines for the U.S. market in 2016 with a 42% share, just behind Vestas at 43%. Domestic jobs are also found at wind power manufacturing facilities owned by foreign firms. Vestas, ABB, Siemens, Vest-Fiber, and other foreign firms manufacture components in the U.S. Besides manufacturing, the wind power industry creates jobs in project development (including attorneys and land acquisition specialists), construction (including engineers and construction tradesmen), operations (including asset managers and meteorological technicians), and education, training, and research (including scientists and technical instructors).[146]

Wind power also contributes to the wider economy. Wind power projects pay more than $245 million annually in lease payments to access land for generation sites. The industry is expected to provide $8 billion in tax payments and to have a total economic impact of $85 billion from 2018 to 2020. Wind power is also expected to create 102,000 induced jobs in other sectors in the same period.[147]

4.3 SUMMARY

The Federal government spent significant amounts on solar and wind power from 2005 to 2015 through several channels. In total, this spending amounted to $51.2 billion, of which

[141] Bureau of Labor Statistics, "News Release: Employment Projections 2016-2026," October 24, 2017.
[142] American Wind Energy Association, "Wind Brings Job and Economic Development to All 50 States," March 9, 2017.
[143] American Wind Energy Association, "Wind Brings Job and Economic Development to All 50 States," March 9, 2017.
[144] According to DOE's "2016 Wind Technologies Market Report," nacelle domestic content has been rated as above 90% by some approaches, but this does not capture most parts internal to nacelles. When more internal parts are considering, the domestic content drops considerably.
[145] Department of Energy, "2016 Wind Technologies Market Report," 2018.
[146] U.S. Department of Energy, "Wind Career Map," referenced May 8, 2018 (https://www.energy.gov/eere/wind/wind-career-map).
[147] American Wind Energy Association, "Wind Brings Job and Economic Development to All 50 States," March 9, 2017.

$16 billion (31%) went to solar, and $35 billion (69%) went to wind. Spending through tax incentives, credit incentives, and R&D is summarized in Exhibit 4-14.

Exhibit 4-14: Total Incentive Spending for Solar and Wind

Incentive	Solar Expenditures (2015 $B)	Wind Expenditures (2015 $B)	Total Expenditures (2015 $B)
Tax Incentives	$ 11.65	$ 34.19	$ 45.84
Credit Incentives	1.22	0.05	1.27
R&D	3.17	0.88	4.05
Total	**$ 16.04**	**$ 35.11**	**$ 51.15**

Tax incentives comprised the vast majority of total incentive spending at $45.84 billion, or 90% of the total. Credit incentives and R&D provided the remainder. Credit incentives provided significant opportunities for leveraging financial support, as appropriated subsidy costs for Federal loans and loan guarantees were significantly lower than the total loans received by supported projects.

Significant spending on solar and wind resulted in significant growth in both industries. From 2005 to 2015, solar capacity grew by 77,794 MW, with $206,000 of Federal support per MW. Wind capacity grew by 446,548 MW, with $79,000 of Federal support per MW. This also facilitated growth of employment in solar and wind jobs, such that those industries are expected to provide the two fastest growing occupations through 2026. Both industries make strong contributions to the wider economy, including stimulating growth in other sectors and making significant tax payments.

CHAPTER 5: APPLICATION TO SMRS

Electric utilities in the United States currently operate in a rapidly evolving market environment which has challenged conventional notions of how electric power is generated and delivered to customers, presenting uncertainty for electric utilities facing long-term investment decisions. Nevertheless, capital will continue to be deployed in power production assets that can reliably provide energy, capacity, and flexibility. As the nation's traditional baseload generation assets, largely consisting of large coal and nuclear power plants, are phased out, utilities will seek opportunities to replace these assets with more resilient energy systems that recognize the long-term impacts of distributed energy resources (DERs) while at the same time provide for safe, reliable, and resilient grid performance over the long term.

This section provides an overview of current U.S. electric market conditions and how the industry has evolved over time, describes how SMRs can address emerging concerns in the power sector, and proposes models of incentives to support SMR commercial deployment.

5.1 EVOLUTION OF THE U.S. ELECTRICITY MARKET

Since the late 1970s, the power sector has moved towards increasingly competitive and integrated markets, especially in wholesale power. The Public Utility Regulatory Policies Act of 1978 (PURPA) aimed to support investment in cogeneration and small renewable power plants (called Qualifying Facilities or QFs). This stimulated the market for development of privately-financed generation facilities which sell power to utilities or end-users and are not part of integrated utilities (Independent Power Producers, or IPPs).[148]

Transmission grids were opened up to unrestricted access by the Energy Policy Act of 1992, which allowed FERC to grant access to transmission lines upon request. FERC then enacted Order No. 888, which mandated open transmission access to all transmission lines and extended open access to municipal, cooperative, and Federal utilities. This facilitated competition in generation by allowing power to flow more freely across the grid, effectively connecting a wider range of generators and utilities.

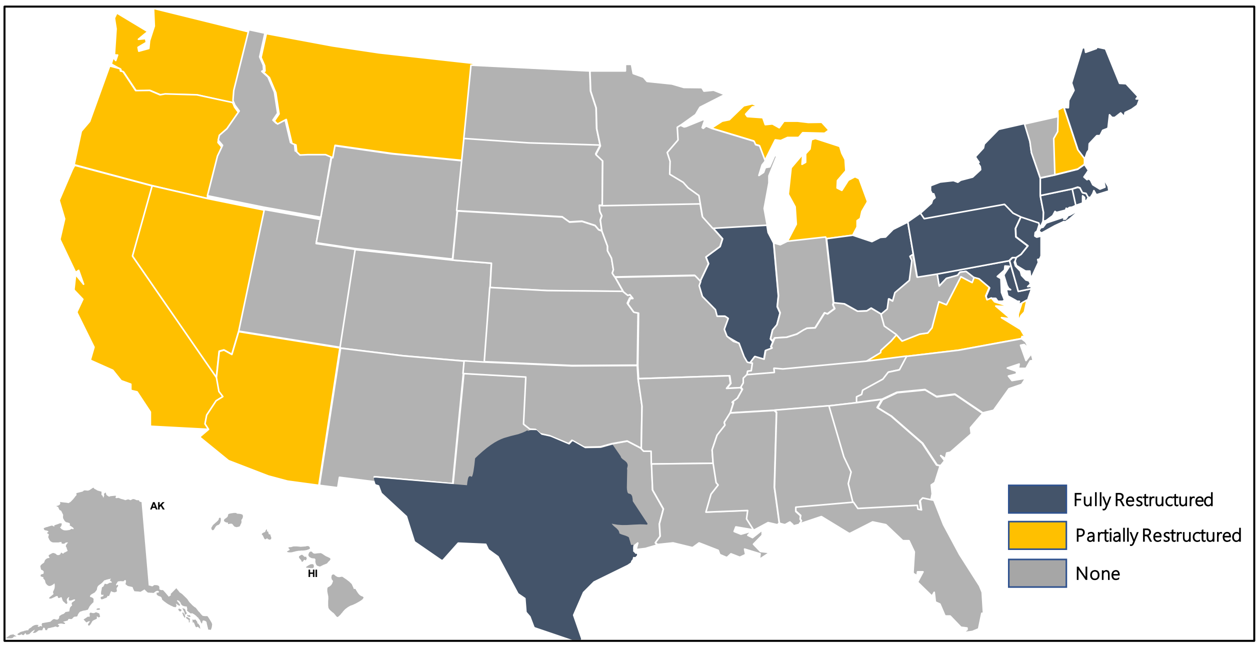
Order No. 888 also supported the creation of independent system operators (ISOs), which are non-profit organizations charged with operating the transmission grid to ensure open access and managing competitive electricity markets in their territories. FERC Order No.

[148] Up until then, the power sector largely consisted of integrated utilities which included generation, transmission, and distribution in one entity. IPPS are also sometimes called NUGs.

2000 helped further the goals of the Energy Policy Act of 1992 by refining the role of ISOs as a type of RTO. Private transmission companies can also become RTOs, although thus far all RTOs have taken the non-profit ISO form.

From 1998 to 2006, 23 states and the District of Columbia enacted legislation to effect deregulation.[149] However, after the 2000-2001 energy crisis in California, seven states halted progress towards deregulation. This includes California, which was already relatively deregulated, but has little retail competition. As of 2015, 15 states and the District of Columbia are deregulated.[150] Now, about two thirds of electricity customers are served by markets in which wholesale prices are set in a competitive market. The states' progress towards deregulation is shown in Exhibit 5-1.

Exhibit 5-1: States' Progress Towards Deregulation[151]



The introduction of competitive forces in the electric power sector has challenged the conventional vertically-integrated electric utility business model. In many markets, competitive generation has been split away from transmission and distribution utilities, creating wholesale power markets. Some state regulators have also allowed for retail

[149] Department of Energy, "Staff Report on Electricity Markets and Reliability," August 2017.
[150] Claire Lim, "U.S. Electric Utilities and Deregulation: Trends, States' Choice, and Political Environments," Cornell University, 30 August 2016, https://lim.economics.cornell.edu/deregulation_main.pdf.
[151] Department of Energy, "Staff Report on Electricity Markets and Reliability," August 2017.

competition, in which companies can compete with utilities for sales to customers; however, non-utility retailers still pay utilities to deliver power over distribution lines.

5.2 EXISTING CHALLENGES INFLUENCING U.S. ELECTRIC SUPPLY

The rise of competitive markets has exposed generators to greater risks from supply and demand dynamics. Several forces have influenced the U.S. electricity market in recent years which have challenges the conventional electric utility model while at the same time presenting opportunities for new sources of power such as SMRs. In recent years, demand growth has slowed, while prices have fallen for natural gas and renewable power supply.

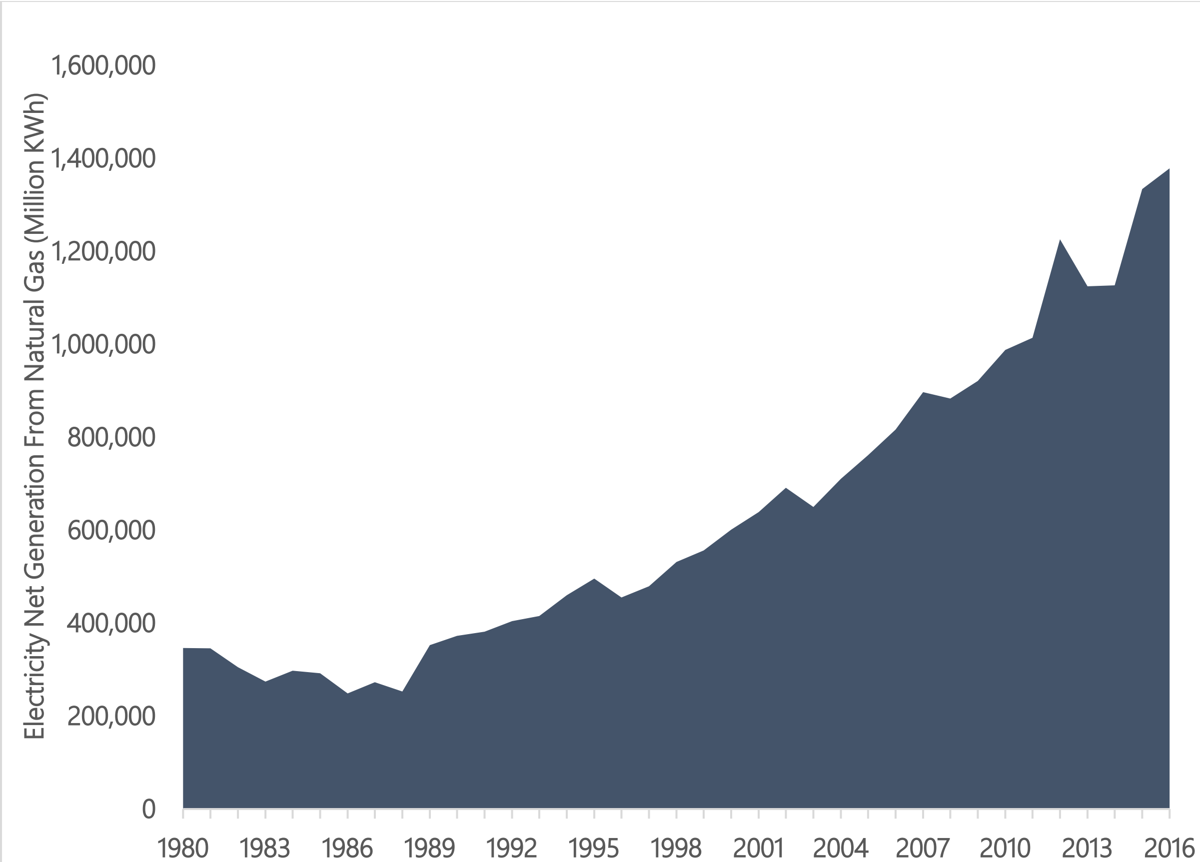
Historically, electricity demand (load) grew in line with economic growth, but this relationship began to change after 2000. From 2005 to 2015, generation grew at a CAGR of 0.05, noticeably slower than the 1.3% per year growth in GDP over the same period.[152] The Energy Information Administration (EIA) attributes this decline in the demand growth rate to several factors, including the cumulative impact of energy efficiency programs, standards, and codes; technology improvements in appliances, lighting, and other end-use equipment; and broader structural changes, such as a shift toward less electricity-intensive industries as well as slower population growth.[153]

The significant development in shale gas production, which expanded the availability of natural gas and lowered its cost across the United States, has also exerted significant influence in the electricity markets in recent years. Before the widespread use of horizontal drilling techniques in the past decade, U.S. natural gas prices averaged more than $7 per MMBtu between 2003 and 2008 and approached $14/MMBtu in several short periods. Hydraulic fracturing practices spread and made previously inaccessible gas sources economic, causing natural gas prices to fall, averaging less than $3.20/MMBtu between 2012 and 2016.

Low gas prices and other factors have contributed to the continuous growth of natural gas-fired generation since the since the late 1980s, as illustrated in Exhibit 5-2.

[152] Department of Energy, "Staff Report on Electricity Markets and Reliability," August 2017.
[153] U.S. Energy Information Administration, "Annual Energy Outlook to 201," January 5, 2017.

Exhibit 5-2: Grown in Natural Gas Generation[154]



While natural gas units have been used for intermediate and peak loads rather than baseload, the sustained low natural gas prices and the operational flexibility of gas generation units have enabled them to be used for baseload power. As a result, some coal plants have been pushed higher on the merit order (i.e., cheaper power plants are being dispatched ahead of coal), which reduces their average capacity factors, negatively impacts their economics, and can ultimately lead to retirements. Similarly, retirement of nuclear plants has been driven by falling wholesale market prices rather than increasing costs of generation.[155]

Another factor influencing the market is the penetration of renewable energy in power markets. Regions with significant renewable generation require greater flexibility from conventional generation sources to address fluctuations in renewable generation. In addition, significant "behind-the-meter" solar generation causes "peak load" to occur later in the day when insolation is lower and customers with on-site solar capacity need to draw

[154] U.S. Energy Information Administration, "Monthly Energy Review," July 2017,
[155] U.S. Energy Information Administration, "Annual Energy Outlook to 201," January 5, 2017.

more power from the grid. Therefore, while the low marginal cost of renewables generation may displace conventional sources of power, the need for conventional sources of power remains.

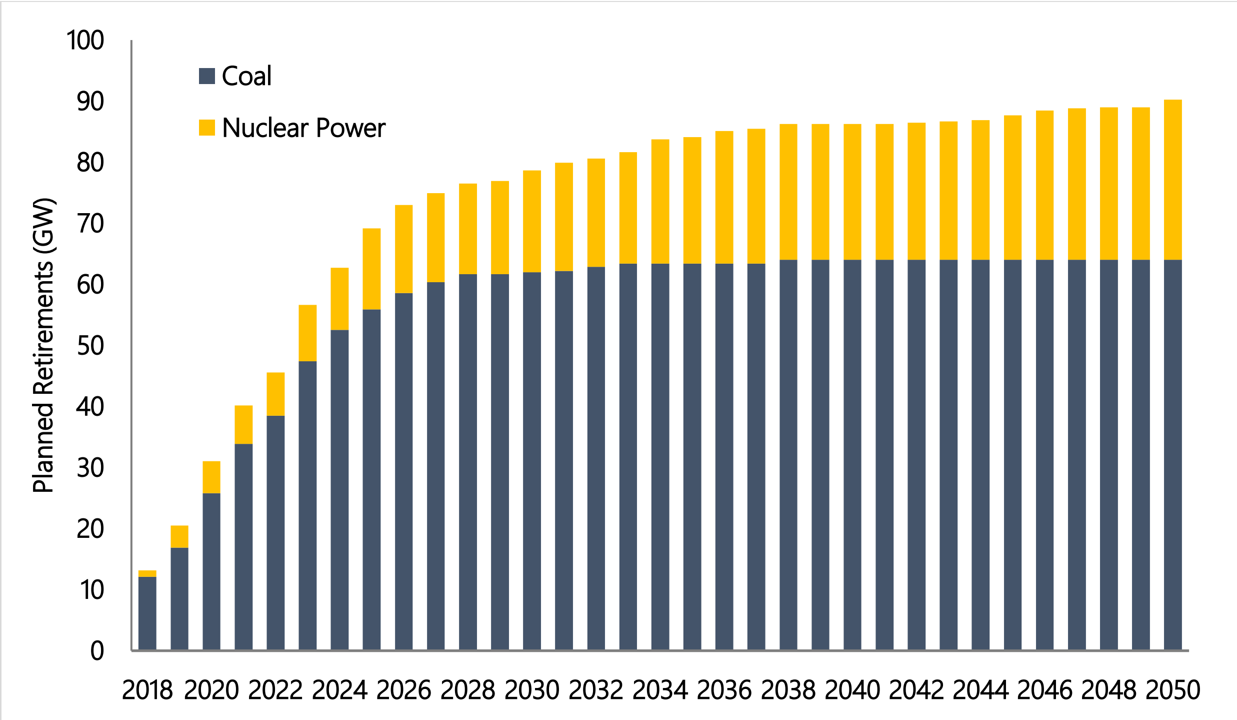
Finally, Federal and state financial assistance such as those discussed in Chapter 2 along with policy and regulatory uncertainty introduce additional challenges to industry participants. While previous Federal policy pushed utilities toward lower carbon energy systems, current rules related to carbon emissions are under review or being rescinded. Given the forty plus year time horizon associated with power plant investments, utilities in the U.S. may be hesitant to invest in such technologies.

The combination of the rising use of natural gas and renewables, slower demand growth, and various state and Federal demand mandates and other policies has driven decisions to retire coal and nuclear power plants in recent years. Declining gas prices began forcing retirements of smaller, older coal plants starting in 2009. Coal retirements became larger from 2011 onwards, as plant owners chose to shut down plants rather than bear the cost of compliance with net environmental regulations (particularly the Mercury and Air Toxics Standards, or MATS, rule), and lower natural gas prices and slow demand growth were increasingly viewed as secular trends. Nuclear plants have also been retiring, with little replacement expected outside of the construction of new capacity at the Vogtle plant in Georgia. From 2002-2016, 4,666 MW of nuclear capacity was announced as retiring, amounting to 4.7% of total nuclear capacity; since then, another 7,167 MW have been slated for retirement, amounting to 7.2% of nuclear capacity. Most nuclear retirements have been driven by concerns over market conditions, although some plants have closed due to technical challenges or other reasons. [156]

Retirements are expected to accelerate in the near future in the U.S. Information Administration's Reference Case in the 2018 Annual Energy Outlook, as summarized in Exhibit 5-3. Most of the retirements are expected to occur by 2030, with cumulative retirements from 2018 to 2030 for coal and nuclear combined reaching 79 GW. By 2050, another 11 GW is excepted to be retired.[157]

[156] U.S. Energy Information Administration, "Annual Energy Outlook 2017," January 5, 2017.
[157] U.S. Energy Information Administration, "Annual Energy Outlook 2018: Table: Electricity Generating Capacity," Accessed May 23, 2018 (https://www.eia.gov/outlooks/aeo/data/browser/#/?id=9-AEO2018&cases=ref2018&sourcekey=0).

Exhibit 5-3: Cumulative Coal and Nuclear Retirements[158]



As with recent historical retirements, future retirements of coal and nuclear are expected to be driven by price competition with natural gas, as well as older plants reaching the end of their operating life. An alternative scenario with stronger carbon emission regulation envisions more retirements, with coal retirements being 29% higher through 2050 than in the scenario shown in Exhibit 5-3, while nuclear plant retirements remain largely unaffected.[159]

5.3 THE MARKET OPPORTUNITY FOR SMRS

Rising use and affordability of renewables, and significant retirements of coal and nuclear generation assets raise fundamental questions about what kind of generation is needed on

[158] U.S. Energy Information Administration, "Annual Energy Outlook 2018: Table: Electricity Generating Capacity," Accessed May 23, 2018 (https://www.eia.gov/outlooks/aeo/data/browser/#/?id=9-AEO2018&cases=ref2018&sourcekey=0).

[159] U.S. Energy Information Administration, "Annual Energy Outlook 2018: Table: Electricity Generating Capacity," Accessed May 23, 2018 (https://www.eia.gov/outlooks/aeo/data/browser/#/?id=9-AEO2018&cases=ref2018&sourcekey=0).

the grid. Natural gas is increasingly seen as an important balancing resource for renewables; it is cheap (as long as commodity markets favor low gas prices), and natural gas plants can be ramped up and down quickly to compensate for variation in renewable generation. Some voices in the energy industry argue that reliance on flexible gas plants, along with increasing use of dispatchable energy storage and demand-side management, will effectively eliminate the need for traditional, always-on baseload power in markets with high renewable supply. This perspective values flexibility of energy sources, which enables them to compensate for variations in intermittent renewable generation.[160]

While the power market may not require the levels of baseload generation prevalent decades ago, the grid is not ready to be free of baseload entirely. Energy storage shows much promise, but it is not yet being used on a wide scale—certainly not widely enough to be a substitute for baseload at this time. As of May 2017, only 540 MW of batteries were installed in the U.S.; this is small compared to the 25 GW of utility-scale renewable capacity added to the grid in 2017, let alone total renewable capacity. [161,162] Furthermore, the North American Electric Reliability Corporation (NERC) indicated in its 2017 Long-Term Reliability Assessment that fuel assurance is a significant concern in planning for adequate reserve margins, especially for markets with high renewable penetration and significant reliability on natural gas.[163]

The current trends in the electric power sector present opportunities for SMR development as a flexible, carbon-free baseload generation resource which can be built on a smaller scale than traditional nuclear plants. SMRs have many beneficial attributes, including:[164]

- **Flexible Output:** NuScale states that its SMRs are designed to ramp generation up or down quickly. [165] This feature could enable an SMR to provide flexible power in response to variations in output from renewables.
- **Clean Source of Baseload Power:** SMRs have zero marginal carbon emissions from power production, unlike coal or natural gas baseload alternatives. SMRs can also serve as steady baseload when required, perhaps meeting smaller baseload

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[160] Chang et al, "Advancing Past "Baseload to a Flexible Grid," NRDC and The Brattle Group, June 26, 2017.

[161] U.S. Energy Information Administration, "Energy Storage and Renewables Beyond…," accessed May 23, 2018 (https://www.eia.gov/todayinenergy/detail.php?id=31372).

[162] U.S. Energy Information Administration, "Nearly Half of Utility-Scale Capacity Installed in 2017…," accessed May 23, 2018 (https://www.eia.gov/todayinenergy/detail.php?id=34472).

[163] North American Electric Reliability Corporation, "2017 Long-Term Reliability Assessment," March 2018.

[164] Kutak Rock and Scully Capital, "Small Modular Reactors: Adding to Resilience at Federal Facilities," published by U.S. Department of Energy, December 2017.

[165] Marcinkiewicz, "NuScale Small Modular Reactors; Advanced, Scalable, Flexible, Economic," presentation to PNWER Energy Working Group, July 25, 2017 (http://www.pnwer.org/uploads/2/3/2/9/23295822/charles_mercinkiewicz-_energy_session.pdf).

requirements than traditional nuclear plants have historically. The need for baseload may be higher in the longer term in states whose regulatory environments are less supportive of renewables.

- **Scalability:** Plant owners can add more reactor modules to a given site over time as the need for capacity grows. Adding reactor modules can compensate for capacity lost from baseload plant retirements.
- **Cost:** SMRs require less total capital expenditure than conventional nuclear plants, especially if the number of modules at a site is gradually increased over time.
- **Fuel Diversification:** SMRs do not rely on natural gas or coal, thus avoiding potential volatility in those commodity markets. Significant amounts of fuel could be stored on-site, reducing exposure to supply chain challenges.
- **Modularity:** Reactors can be manufactured in a factory and delivered to plant sites, thus limiting on-site construction, and allowing for manufacturing of standardized modules to be used at many sites.
- **Export Opportunities:** Companies which produce SMRs or related service and goods could have foreign sales opportunities. EIA estimates that global electricity generation will increase by 69% from 2012 to 2040.[166]

5.4 ADDRESSING CHALLENGES THROUGH FEDERAL ASSISTANCE

As a new and complex technology, SMRs will have to address several challenges to commercial deployment, in order to capture the benefits. These challenges include:

- **Development of Manufacturing Ecosystem:** A working SMR has yet to be built. Producing SMRs at scale to reap the benefits of modularity will require to construction of module manufacturing facilities. Producing standardized SMR components may be challenging. Historical experience with attempts at standardizing manufacture of larger reactors indicate that realizing NOAK cost reductions may be challenging.[167]

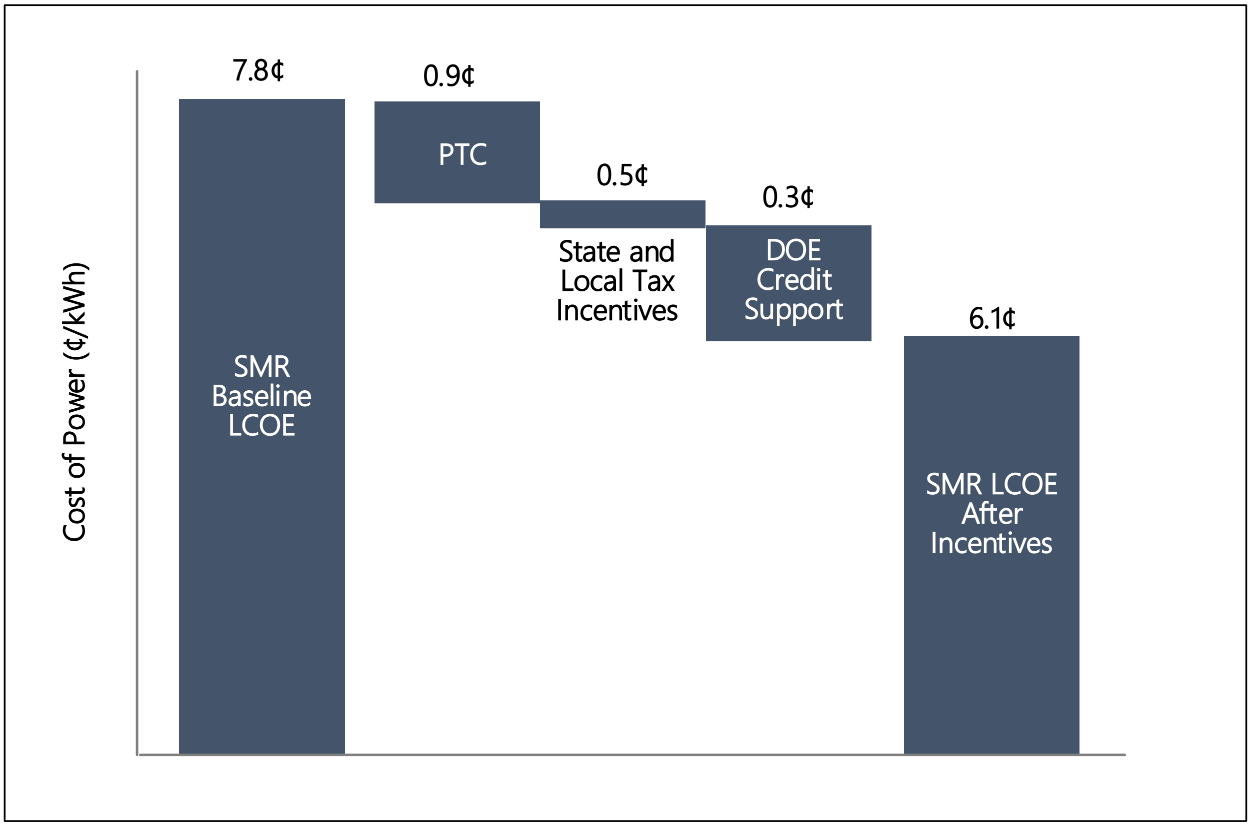
[166] U.S. Energy Information Administration, "International Energy Outlook 2016: Chapter 5. Electricity," May 11, 2016.
[167] U.S. Government Accountability Office, "Nuclear Reactors: Status and Challenges in Development and Deployment of New Commercial Concepts," July 2015.

- **Licensing Risk:** Developing and certifying a reactor design can cost up to $2 billion dollars. This is a significant investment, which also faces regulatory uncertainty.[168]
- **Development Timeline:** Designing a reactor can require up to 10 or more years of design work, followed by 7.5 or more years of licensing, and then 3 or 4 years of construction. Some SMRs, noticeably those designed by NuScale, have made significant progress to date; the SMR under development at TVA could come online by 2027, without significant delays.[169] Ideally an SMR would come online before 2030, when the pace of coal and nuclear retirements is expected to slow.
- **First of a Kind (FOAK) Costs:** FOAK SMRs are expected to cost more than nth-of-a-kind (NOAK) SMRs which benefit from economies of scale in production; SMR Start, as industry trade organization consisting of potential customers and vendors investing in the development of SMR's, estimates that FOAK SMRs will be 12% more costly in terms of overnight capital costs.[170] Another study estimated that the cost of power from an SMR would be 27% higher from a FOAK reactor than from NOAK.[171]
- **Uncertainty in Long-Term Energy Markets:** As previously discussed in this report, power markets are evolving and subject to competitive uncertainty. Markets may shift to provide more competitive challenges for SMRs by the time they become operational.[172]

Federal financial assistance can help address these challenges. Tax and credit incentives clearly contribute to significant reductions in the cost of electricity. Such incentives could also potentially be applied to support the development of SMRs; in February 2018, Congress voted to extend the eligibility period for PTCs for nuclear power.[173] Exhibit 5-4 illustrates SMR Start's estimate of the potential savings to an SMR's LCOE based on the application of tax and credit incentives. As described in a previous DOE report, extending nuclear PTCs to municipal SMRs could further encourage competitiveness against other technologies.[174]

[168] U.S. Government Accountability Office, "Nuclear Reactors: Status and Challenges in Development and Deployment of New Commercial Concepts," July 2015.
[169] Kutak Rock and Scully Capital, "Small Modular Reactors: Adding to Resilience at Federal Facilities," published by U.S. Department of Energy, December 2017.
[170] SMR Start, "The Economics of Small Modular Reactors," September 14, 2017.
[171] Rosner et al, "Small Modular Reactors – Key to Nuclear Power Generation in the U.S.," The Harris School, July 14, 2011 (https://epic.uchicago.edu/sites/default/files/SMR_Final_White_Paper_7-11.pdf).
[172] U.S. Government Accountability Office, "Nuclear Reactors: Status and Challenges in Development and Deployment of New Commercial Concepts," July 2015.
[173] "US Extends Tax Credit for Nuclear New Build…,"
[174] Kutak Rock and Scully Capital, "Purchasing Power Produced by Small Modular Reactors: Federal Agency Options," January 2017. The two most advanced SMR projects in the U.S. are both being developed by government-owned generators (UAMPS and TVA).

Exhibit 5-4: LCOE of SMR[175]



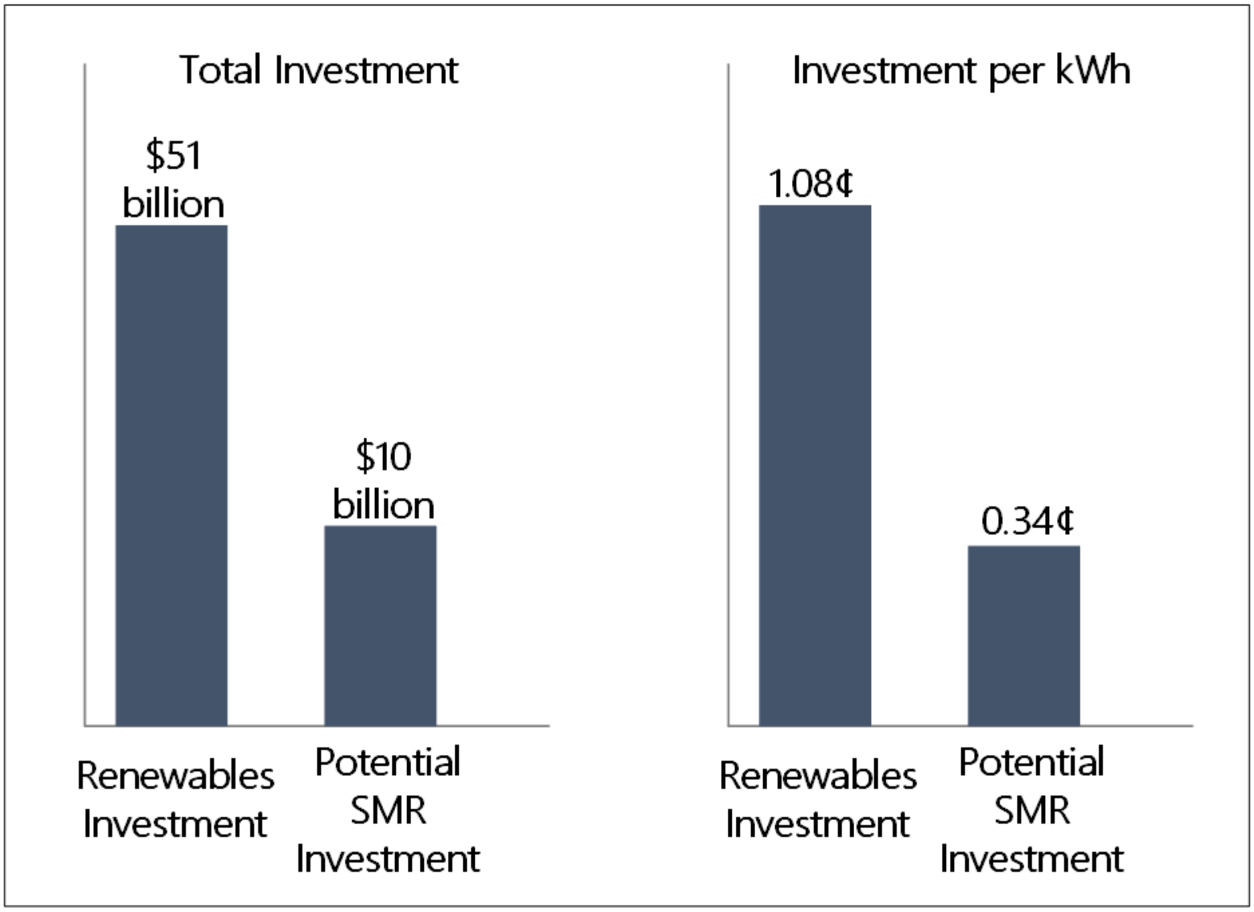
SMR Start estimates that allowing municipal SMRs to receive PTCs would reduce the cost of power by just under 1¢ per kWh. Loan guarantees are estimated to reduce the cost of power by another 0.3¢. State and local tax incentives, such as sales and use tax exemptions and property tax abatements, could further reduce costs by 0.5¢. Altogether, these would reduce the cost of power by 22%.[176]

To meaningfully impact commercial deployment, these incentives would need to be applied to several SMRs in combination with demand mandates to assure off-take. Construction of 6 GW of SMR capacity by 2035 would comprise about 5% of total capacity additions through that year. This would amount to 15 SMR projects with capacity of 400 MW each. The total cost to the Federal government of supporting 15 such SMR projects with PTCs and DOE credit support is estimated to cost approximately $11 billion. While this level of support is

[175] SMR Start, "The Economics of Small Modular Reactors," September 14, 2017.
[176] SMR Start, "The Economics of Small Modular Reactors," September 14, 2017.

significant relative to the capacity deployed, the high capacity factors and long operating lives of SMRs support an attractive return on the government's investment. Specifically, the $10 billion assistance estimate equates to approximately $0.0034/kWh. By comparison, the investments in wind and solar equaled approximately $0.0108/kWh.[177] This comparison is presented in Exhibit 5-5.

Exhibit 5-5: Investment to Support SMR Generation



As illustrated above, when viewed in terms of spending per unit of power produced (cents per kWh), the proposed support for SMRs compares favorably against the historic support for solar or wind. This is because SMRs are expected to realize capacity factors of 92.1% or above and have very long operating lives. Nevertheless, important questions remain regarding the cost of commercially deploying SMRs and whether 6 GW of induced capacity

[177] Scully Capital calculations, see Appendix C.

would be sufficient to develop the industrial capabilities necessary to support the industry over the long-term.

5.5 SUMMARY

Recent developments in power markets have created challenges for baseload power supply from coal and conventional nuclear generation. Demand for power is growing at slower rates, due to improvements in energy efficiency and shifts in the economy towards less energy-intensive activities. Furthermore, falling costs of natural gas and renewable power have made coal and conventional nuclear plants less competitive, leading plant owners to retire assets; environmental regulation has further encouraged retirement of coal plants.

To accelerate commercial deployment of SMRs and address an emerging business need, Federal financial assistance similar to the kinds of support provided to the renewables sector could enable the development of several SMRs and facilitate the development of necessary industrial infrastructure and supply chains. SMRs present an opportunity to flexibly respond to intermittent renewables and deliver carbon-free baseload power while relying on modular plant designs which will not require extraordinary up-front capital expenditures associated with conventional nuclear plants. Financial incentives, such as tax credits and credit support, would enhance the economic competitiveness of SMRs and potentially allow this generation source to meet emerging generation market needs.

CHAPTER 6: NEXT STEPS FOR SUPPORTING COMMERCIAL DEPLOYMENT OF SMRS

The Federal government has made large strides since 2005 in supporting the widespread commercial adoption of renewable power generation, in particular solar and wind power. Since the enactment of EPAct 2005, the Federal government has provided various tax incentives and credit support to facilitate renewable power project development, as well as research and development grants, amounting to a total of $51 billion. This supply-side support helped meet growing demand for renewable power, which was strongly stimulated by state RPS mandates, and Federal purchase mandates as well.

Given significant recent retirements of coal and conventional nuclear plants, and significant retirements expected in coming years, an opportunity exists for SMRs to enter the market and meaningfully contribute to the country's need for energy security and energy resilience. However, SMRs face significant challenges in commercial deployment, including the need to develop a manufacturing ecosystem for a new technology, significant work remaining to license and develop a working generation facility, and costs which may be high relative to other energy sources in competitive and quickly evolving power markets.

The success of Federal financial incentives for renewables presents a promising model of financial support for power project development, which could be applied to other innovative power technologies, including SMRs. Federal expenditure for SMRs could be impactful even if on a smaller scale than the $51 billion spent on solar and wind from 2005 to 2015. As mentioned in Chapter 5, Federal tax and credit incentives, as well as state and local tax incentives, could reduce the cost of power from SMRs and facilitate their adoption as a cost-competitive generation source.

The Federal government has made progress in facilitating SMR projects' access to Federal incentives. DOE currently has an open solicitation for loan guarantees for nuclear projects including SMRs.[178] Congress also voted to extend nuclear PTCs past the planned expiration in 2020, which would enable projects completed after 2020 to benefit from them.[179] While those actions could be helpful for SMRs, other steps would further help SMRs to commercialization:

[178] https://www.energy.gov/lpo/advanced-nuclear-energy-projects-solicitation.
[179] https://www.nei.org/news/2018/congress-passes-nuclear-production-tax-credit.

- **Examine Potential Market Associated with SMRs:** In order to establish a business case for Federal financial assistance, the potential of SMRs as a source of power generation and as a commercial enterprise should be analyzed, and if possible, quantified. This should include consideration of financial, legal, regulatory, and technical issues related to SMRs' integration into the power system, including consideration of the entire value chain, cost competitiveness, and other matters. The objective of this undertaking would be fourfold:
  - Confirm the suitability of SMRs to address the baseload power replacements which will be driven by coal and conventional nuclear retirements;
  - Identify how the SMR supply chain will need to develop in order to achieve the n^{th}-of-a-kind cost targets;
  - Validate or refine the 6 GW estimate of SMR commercial deployments required to establish SMRs as a viable baseload option; and
  - Develop an order of magnitude estimate of technology export value based on the U.S. experience with conventional nuclear power plants.

- **Create Project-Level Business Case:** Analyses of the impact of financial incentives have focused on LCOE, which is a useful metric for comparing costs of different technologies or considering an indicative project. To further DOE's understanding, a project-level business case that contemplates the site-specific costs, load profiles, and financial structure is warranted. This feasibility analysis would seek to identify the cost of service of a proposed SMR and would measure the impact of incentives and the uncertainties that could increase costs, identify key risks and mitigants, and integrate financial, legal, regulatory, and technical considerations.

  While the analysis could draw upon conceptual design data, site-specific costs, infrastructure requirements and customers would be examined with the objective of refining DOE's understanding of the financial feasibility of one or two "first movers." Additionally, the analysis would consider the host utility's ownership, the proposed credit structure of the project and the economic objectives and constraints of the host utility's customer base. This effort would result is assessment the opportunities and challenges to SMR commercial deployment and would inform the design of incentives around specific market conditions and other constraints.

- **Identify Obstacles that Require Legislative Action:** Enhancing Federal support for SMRs will require Congress to pass legislation. To facilitate the eventual enactment of new incentives, key initiatives should be identified for development into law. This would be informed by the findings of the project-level business case analysis, and could focus on matters such as identifying appropriate existing legal authorities for supporting Federal power purchase agreements, finding ways to modify or extend existing incentives, creating budget scoring alternatives or developing roadmaps for implementing new programs or legislation.

APPENDIX A: ASSUMPTIONS FOR LCOE ANALYSES

The LCOE for solar was analyzed using the Stanford LCOE Calculator. Inputs to the calculator are shown below.

Exhibit A-1: Assumptions for Solar LCOE Analysis

Solar Inputs	Units	Baseline	+ ITC	+ MACRS Bonus	+ LPO
Useful Life (Economic)	Years	30	30	30	30
System Price	$/W	0.9800	0.9800	0.9800	0.9800
Investment Tax Credit	Percent	0.00%	30.00%	30.00%	30.00%
Production Tax Credit	$/kWh	0.0000	0.0000	0.0000	0.0000
Capacity Factor	Percent	17.54%	17.54%	17.54%	17.54%
System Degradation Factor	Percent	99.50%	99.50%	99.50%	99.50%
Fixed O&M Cost	$/kW - yr	13.2800	13.2800	13.2800	13.2800
Variable O&M Cost	$/kWh	0.0010	0.0010	0.0010	0.0010
Fuel Cost	$/kWh	0.0000	0.0000	0.0000	0.0000
Carbon Cost	($/tCO2e)	0.0000	0.0000	0.0000	0.0000
Emissions Performance	kg CO2e/kWh	0.0000	0.0000	0.0000	0.0000
Cost of Equity*	Percent	12.80%	12.80%	12.80%	12.80%
Cost of Debt*	Percent	6.00%	6.00%	6.00%	3.33%
Ratio of Equity to Capital	Decimal	0.4000	0.4000	0.4000	0.30
Ratio of Debt to Capital	Decimal	0.6000	0.6000	0.6000	0.70
Cost of Capital*	Percent	8.72%	8.72%	8.72%	6.17%
Federal Tax Rate	Percent	35.00%	35.00%	35.00%	35.00%
State Tax Rate	Percent	3.00%	3.00%	3.00%	3.00%
Federal Depreciation Method	Tax Method	5-year MACRS	5-year MACRS	100% Bonus Depreciation	100% Bonus Depreciation
State Depreciation Method	Tax Method	20-year 150% Declining Balance	20-year 150% Declining Balance	20-year 150% Declining Balance	20-year 150% Declining Balance
LCOE	$/kWh	0.0818	0.0557	0.0521	0.0424

* The LCOE calculator uses a cost of capital which excludes the tax shield, and instead accounts for the benefit of the tax shield by applying a tax factor. Thus the cost of capital here is just the ratio of debt to capital times the cost of debt, plus the ratio of equity to capital times the cost of equity. See the User Guide at http://stanford.edu/dept/gsb_circle/cgi-bin/sustainableEnergy/GSB_LCOE_User%20Guide_0517.pdf.

The LCOE for wind was analyzed using the Stanford LCOE Calculator. Inputs to the calculator are shown below.

Exhibit A-2: Assumptions for Wind LCOE Analysis

Wind Inputs	Units	Baseline	+ PTC	+ MACRS Bonus	+ LPO
Useful Life (Economic)	Years	30	30	30	30
System Price	$/W	1.5995	1.5995	1.5995	1.5995
Investment Tax Credit	Percent	0.00%	0.00%	0.00%	0.00%
Production Tax Credit	$/kWh	0.0000	0.0144	0.0144	0.0144
Capacity Factor	Percent	35.00%	35.00%	35.00%	35.00%
System Degradation Factor	Percent	99.20%	99.20%	99.20%	99.20%
Fixed O&M Cost	$/kW - yr	23.7700	23.7700	23.7700	23.7700
Variable O&M Cost	$/kWh	0.0016	0.0016	0.0016	0.0016
Fuel Cost	$/kWh	0.0000	0.0000	0.0000	0.0000
Carbon Cost	$/tCO2e	0.0000	0.0000	0.0000	0.0000
Emissions Performance	kg CO2e/kWh	0.0000	0.0000	0.0000	0.0000
Cost of Equity*	Percent	12.80%	12.80%	12.80%	12.80%
Cost of Debt*	Percent	6.00%	6.00%	6.00%	3.33%
Ratio of Equity to Capital	Decimal	0.4000	0.4000	0.4000	0.30
Ratio of Debt to Capital	Decimal	0.6000	0.6000	0.6000	0.70
Cost of Capital*	Percent	8.72%	8.72%	8.72%	6.17%
Federal Tax Rate	Percent	35.00%	35.00%	35.00%	35.00%
State Tax Rate	Percent	0.00%	0.00%	0.00%	0.00%
Federal Depreciation Method	Tax Method	5-year MACRS	5-year MACRS	100% Bonus Depreciation	100% Bonus Depreciation
State Depreciation Method	Tax Method	20-year 150% Declining Balance	20-year 150% Declining Balance	20-year 150% Declining Balance	20-year 150% Declining Balance
LCOE	**$/kWh**	**0.0693**	**0.0601**	**0.0565**	**0.0454**

* The LCOE calculator uses a cost of capital which excludes the tax shield, and instead accounts for the benefit of the tax shield by applying a tax factor. Thus the cost of capital here is just the ratio of debt to capital times the cost of debt, plus the ratio of equity to capital times the cost of equity. See the User Guide at http://stanford.edu/dept/gsb_circle/cgi-bin/sustainableEnergy/GSB_LCOE_User%20Guide_0517.pdf.

APPENDIX B: TAX EXPENDITURE CALCULATIONS

This appendix summarizes the approach used to calculate tax expenditure for solar and wind power. The approach used to calculate wind tax expenditure is presented first, as it was more complex. This is followed by a discussion of the approach to solar tax expenditure. All units are shown in constant 2015 dollars; nominal dollars were converted to constant dollars using GDP deflators.[180]

B.1 WIND POWER

Wind power benefitted from PTCs, 1603 cash grants, and to a lesser extent, MACRS. The approach used to estimate PTC expenditure in this report is unusual in that it did not rely on reports of Federal spending on PTCs from sources such as the Joint Committee on Taxation (JCT) Estimates of Federal Tax Expenditure. JCT data presented total spending on PTCs by the Federal government each year; however, this would necessarily include wind projects which came online outside the 2005 to 2015 period, because projects receive PTC benefits for ten years. For example, a wind project which came online in 2002 would receive PTC benefits in 2006, and these benefits would be part of the JCT's reporting of 2006 PTC expenditure. Since this report focuses on growth in generation from 2005 to 2015, an alternative approach was used to capture spending for plants which entered into service from 2005 to 2015 and excludes plants which entered into service outside that period.

This analysis also considered all PTCs paid to a project over ten years; for example, a project entering into service in 2013 would receive PTC benefits until 2022, including several years outside the 2005 to 2015 window. In developing this estimate, the capacity factors applied was based on aggregate output and installed capacity each year in the U.S. and does not apply a degradation profile. Total PTC expenditure for capacity entered into service in a given year was counted in the first year of service. This approach also combined all PTC benefits received over ten years into one benefit in the first year of service. This was done to capture all relevant PTC spending, including benefits received after 2015, and to reflect the fact that the expectation of a stream of PTCs over time was an important factor in development and financing decisions.

[180] Federal Reserve Bank of St. Louis, "Gross Domestic Product: Implicit Price Deflator, Percent Change from Preceding Period, Annual, Not Seasonally Adjsuted," accessed May 10, 2018 (https://fred.stlouisfed.org).

The analysis began by identifying installed capacity in the U.S. each year from 2005 to 2015, and estimating capacity entered into service by taking the difference in capacity between two years. For example, capacity in 2006 was subtracted from capacity in 2007 to find capacity entered into service in 2007. Capacity factors for wind prevailing on the grid each year were calculated using total installed capacity and total generation from wind power.[181] These steps are presented in Exhibit B-1.

[181]Calculated by dividing total capacity (MW) by total output (MWh) times 24 times 365. See https://ucdenver.instructure.com/courses/342680/files/3776710/download.

Exhibit B-1: Wind Capacity and Generation[182, 183]

Wind Power	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Capacity (MW)	9,147	11,575	16,907	25,410	34,863	40,267	46,916	60,005	61,107	65,880	74,471
Capacity Entered Into Service (MW)	2,424	2,428	5,332	8,503	9,453	5,404	6,649	13,089	1,102	4,773	8,591
Output (MWh)	17,881,500	26,675,700	34,602,800	55,696,200	74,225,900	95,148,300	120,854,500	141,921,700	169,712,500	183,891,800	190,719,200
Capacity Factor (%)	22.3%	26.3%	23.4%	25.0%	24.3%	27.0%	29.4%	27.0%	31.7%	31.9%	29.2%

[182] U.S. Department of Energy, "U.S. Installed and Potential Wind Power Capacity and Generation," accessed May 10, 2018 (https://windexchange.energy.gov/maps-data/321).
[183] International Renewable Energy Agency, "Query Tool," accessed May 10, 2018 (http://resourceirena.irena.org/gateway/dashboard/?topic=4&subTopic=16).

The next step in the analysis was to identify capacity entered into service which benefitted from PTCs. In some years, wind projects benefitted from 1603 Cash Grants and were thus ineligible for PTCs. Capacity benefitting from 1603 Cash Grants was subtracted from capacity entered into service to find capacity eligible for PTCs. Having identified capacity eligible for PTCs, annual power production from that capacity was then by calculated by applying the capacity factors which were previously discussed. This is summarized in Exhibit B-2.

Exhibit B-2: Wind Power Production Eligible for PTCs[184]

Wind Power	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Capacity Entered Into Service (MW)	2,424	2,428	5,332	8,503	9,453	5,404	6,649	13,089	1,102	4,773	8,591
Less: Capacity Entered Into Service w/ 1603 Cash Grant Support	0	0	0	0	6,549	4,776	3,576	6,643	0	0	0
Less: Capacity Receiving ITC	0	0	0	0	0	0	0	0	0	0	0
Capacity Entered Into Service: Eligible for PTC	2,424	2,428	5,332	8,503	2,904	628	3,073	6,446	1,102	4,773	8,591
Capacity Factor (%)	22.3%	26.3%	23.4%	25.0%	24.3%	27.0%	29.4%	27.0%	31.7%	31.9%	29.2%
Power Production from Capacity Entered into Service Eligible for PTC (MWh)**	4,738,685	5,595,559	10,912,766	18,637,733	6,182,997	1,483,609	7,915,130	15,245,029	3,060,585	13,322,944	22,001,432

[184] Data on wind capacity benefitting from 1603 Cash Grants was provided by staff at the National Renewable Energy Laboratory (NREL).

Next, the total power production eligible for PTCs in each year was estimated. This was done by identifying output from plants entered into service each year; and then these numbers were aggregated to find total production for each year. For example, total production eligible for PTCs in 2008 would include PTCs for capacity entered into service in 2006. This is summarized in Exhibit B-3.

Exhibit B-3: Power Production Eligible for PTCs

Wind Capacity Eligible for PTCs				Power Production Eligible for PTCs (GWh)																				
Year Entered Into Service	Capacity (MW)	Capacity Factor	Annual Production (MWh)	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2005-2024
2005	2,424	22.3%	4,738,685	4,739	4,739	4,739	4,739	4,739	4,739	4,739	4,739	4,739	4,739	0	0	0	0	0	0	0	0	0	0	47,387
2006	2,428	26.3%	5,595,559	0	5,596	5,596	5,596	5,596	5,596	5,596	5,596	5,596	5,596	5,596	0	0	0	0	0	0	0	0	0	55,956
2007	5,332	23.4%	10,912,766	0	0	10,913	10,913	10,913	10,913	10,913	10,913	10,913	10,913	10,913	10,913	0	0	0	0	0	0	0	0	109,128
2008	8,503	25.0%	18,637,733	0	0	0	18,638	18,638	18,638	18,638	18,638	18,638	18,638	18,638	18,638	18,638	0	0	0	0	0	0	0	186,377
2009	2,904	24.3%	6,182,997	0	0	0	0	6,183	6,183	6,183	6,183	6,183	6,183	6,183	6,183	6,183	6,183	0	0	0	0	0	0	61,830
2010	628	27.0%	1,483,609	0	0	0	0	0	1,484	1,484	1,484	1,484	1,484	1,484	1,484	1,484	1,484	1,484	0	0	0	0	0	14,836
2011	3,073	29.4%	7,915,130	0	0	0	0	0	0	7,915	7,915	7,915	7,915	7,915	7,915	7,915	7,915	7,915	7,915	0	0	0	0	79,151
2012	6,446	27.0%	15,245,029	0	0	0	0	0	0	0	15,245	15,245	15,245	15,245	15,245	15,245	15,245	15,245	15,245	15,245	0	0	0	152,450
2013	1,102	31.7%	3,060,585	0	0	0	0	0	0	0	0	3,061	3,061	3,061	3,061	3,061	3,061	3,061	3,061	3,061	3,061	0	0	30,606
2014	4,773	31.9%	13,322,944	0	0	0	0	0	0	0	0	0	13,323	13,323	13,323	13,323	13,323	13,323	13,323	13,323	13,323	13,323	0	133,229
2015	8,591	29.2%	22,001,432	0	0	0	0	0	0	0	0	0	0	22,001	22,001	22,001	22,001	22,001	22,001	22,001	22,001	22,001	22,001	220,014
Total	**46,203**	**n/a**	**109,096,470**	**4,739**	**10,334**	**21,247**	**39,885**	**46,068**	**47,551**	**55,466**	**70,712**	**73,772**	**87,095**	**104,358**	**98,762**	**87,849**	**69,212**	**63,029**	**61,545**	**53,630**	**38,385**	**35,324**	**22,001**	**1,090,965**

Then, total PTC expenditure was calculated. As previously mentioned, all PTCs received by capacity entered into service were counted as expenditure in the first year of service. This approach effectively pulled a stream of PTCs over 10 years into a single benefit in the first year. This approach is summarized in Exhibit B-4. The rightmost column shows total PTCs for each year; for example, the number $0.69 billion in the top of the rightmost column reflects total PTC benefits for projects which entered into service in 2005.

Exhibit B-4: Power Production Eligible for PTCs

Wind Production Eligible for PTC				PTC Expenditure (2015 $B)																				
Year Entered Into Service	Annual Production (MWh)	PTC ($/MWh, $2015)	Annual PTC (2015 $B)	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2005-2024
2005	4,738,685	14.65	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	-	-	-	-	-	-	-	-	-	-	0.69
2006	5,595,559	15.57	0.09	-	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	-	-	-	-	-	-	-	-	-	0.87
2007	10,912,766	16.42	0.18	-	-	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	-	-	-	-	-	-	-	-	1.79
2008	18,637,733	17.08	0.32	-	-	-	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	-	-	-	-	-	-	-	3.18
2009	6,182,997	18.19	0.11	-	-	-	-	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	-	-	-	-	-	-	1.12
2010	1,483,609	18.62	0.03	-	-	-	-	-	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	-	-	-	-	-	0.28
2011	7,915,130	19.42	0.15	-	-	-	-	-	-	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	-	-	-	-	1.54
2012	15,245,029	20.12	0.31	-	-	-	-	-	-	-	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	-	-	-	3.07
2013	3,060,585	21.71	0.07	-	-	-	-	-	-	-	-	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	-	-	0.66
2014	13,322,944	22.50	0.30	-	-	-	-	-	-	-	-	-	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	-	3.00
2015	22,001,432	23.00	0.51	-	-	-	-	-	-	-	-	-	-	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	5.06
Total	**109,096,470**	**n/a**	**2.13**	**0.07**	**0.16**	**0.34**	**0.65**	**0.77**	**0.79**	**0.95**	**1.25**	**1.32**	**1.62**	**2.06**	**1.97**	**1.79**	**1.47**	**1.36**	**1.33**	**1.18**	**0.87**	**0.81**	**0.51**	**21.27**

Identifying other tax expenditure was relatively straight forward. Spending on 1603 Cash Grants was found in a spreadsheet on the Department of the Treasury's website.[185] Spending on MACRS was apportioned to wind by taking total MACRS spending from the JCT, and apportioning it to wind based on wind's relative share of capacity entered into service each year. ITCs for wind power never exceeded the JCT's minimum reporting threshold, and were thus not reported.[186] Total tax expenditure for wind is summarized in Exhibit B-5.

[185] U.S. Department of the Treasury, "1603 Program: Payments for Specified Energy Property in Lieu of Tax Credits," accessed May 10, 2018 (https://www.treasury.gov/initiatives/recovery/Pages/1603.aspx). See the link "List of Awards."

[186] Joint Committee on Taxation, "Publications on Tax Expenditures," accessed May 10, 2018 (https://www.jct.gov/publications.html.). See links to Estimates of Federal Tax Expenditures covering the period 2005 to 2015.

Exhibit B-5: Total Tax Expenditure for Wind[187]

Tax Expenditure for Wind (2015 $B)*	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2005-2024
PTC	0.7	0.9	1.8	3.2	1.1	0.3	1.5	3.1	0.7	3.0	5.1	21.3
ITC	-	-	-	-	-	-	-	-	-	-	-	-
1603 Cash Grant	-	-	-	-	1.3	2.4	2.8	3.3	1.7	0.0	0.0	11.4
MACRS	-	-	-	0.2	0.3	0.2	0.2	0.2	0.0	0.2	0.2	1.5
Total	**0.7**	**0.9**	**1.8**	**3.4**	**2.7**	**2.9**	**4.5**	**6.6**	**2.4**	**3.2**	**5.2**	**34.2**

[187] See preceding paragraph for reference to sources.

B.2 SOLAR POWER

The approach to estimating tax expenditure for solar power was much simpler because solar power never received enough PTCs for expenditure to be reported by JCT. Data on ITC expenditure for solar was taken directly from the JCT; ITC benefits as reported by JCT were assumed to have been received in the year of entering into service.[188] Data for 1603 Cash Grant expenditure for solar was taken from the Treasury website, as for wind.[189] Spending on MACRS was apportioned to wind by taking total MACRS spending from the JCT, and apportioning it to wind based on wind's relative share of capacity entered into service each year. [190] Total tax expenditure for solar is summarized in Exhibit B-6.

[188] Joint Committee on Taxation, "Publications on Tax Expenditures," accessed May 10, 2018. (https://www.jct.gov/publications.html.). See links to Estimates of Federal Tax Expenditures covering the period 2005 to 2015.

[189] U.S. Department of the Treasury, "1603 Program: Payments for Specified Energy Property in Lieu of Tax Credits," accessed May 10, 2018 (https://www.treasury.gov/initiatives/recovery/Pages/1603.aspx). See the link "List of Awards."

[190] Joint Committee on Taxation, "Publications on Tax Expenditures," accessed May 10, 2018. (https://www.jct.gov/publications.html.). See links to Estimates of Federal Tax Expenditures covering the period 2005 to 2015.

Exhibit B-6: Total Tax Expenditure for Solar[191]

Tax Expenditure for Solar (2015 $B)*	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2005-2024
PTC	-	-	-	-	-	-	-	-	-	-	-	-
ITC	-	-	-	-	-	-	0.3	0.3	0.4	0.5	0.9	2.4
1603 Cash Grant	-	-	-	-	0.0	0.3	0.8	2.0	1.5	2.9	1.4	8.9
MACRS	-	-	-	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.3
Total	**-**	**-**	**-**	**0.0**	**0.0**	**0.3**	**1.2**	**2.4**	**1.9**	**3.4**	**2.4**	**11.6**

[191] See preceding paragraph for reference to sources.

APPENDIX C: ANALYIS OF PROPOSED SMR ASSISTANCE

This appendix summarizes the analysis supporting the cost comparisons of the proposed SMR assistance against the historic investment in wind and solar. For each technology, the amount of generation was projected based on publicly-available information cited in this report. Assumptions for SMRs were sourced from SMR Start while solar and wind were derived from the historical capacity additions reported by the U.S. Department of Energy and the International Renewable Energy Agency ("IRENA"). Notably, the demonstrated improvements in capacity factors are reflected in the data as is the varying resource quality experienced by solar and wind installations around the country. We did not attempt to adjust for solar and wind degradation profiles and acknowledge that this may result in lifetime production being moderately overestimated. Finally, a 60 year operating life was assumed for SMRs based on data from SMR Start and found to be reasonable given the experience with light water reactors in the United States. A 25 year operating life was assumed for solar and wind. This was based on warranty periods for solar panels and a range of operating life estimates for wind projects found in an NREL report on the cost of wind power.[192]

These data and calculations are presented in the sections that follow.

[192] Moné et al, "2015 Cost of Wind Energy Review," published by NREL, 2017.

C.1 SMRS

Exhibit C-1: SMR Incentives

	Incentive		SMR Project
	Installed Capacity (MW) [A]		400
	Capacity Factor (%) [B]		92.1%
=[A]x[B]x365x24	Annual Production (MWh) [C]		3,227,184
	PTC per kWh (2015 $) [D]	$	0.017
	Years of PTC Benefit [E]		10
=[C]x[D]x[E]x1,000/1,000,000	Total Federal Investment from PTC (2015 $ M) [F]	$	563
	Capital Cost (2015 $ M) [G]	$	1,998
	Debt to Capital [H]		50%
=[G]x[H]	Total Debt (2015 $ M) [I]	$	999
	Average Federal Subsidy Rate [J]		10%
=[I]x[J]	Federal Subsidy Cost (2015 $ M) [K]	$	99.88
=[F]+[K]	**Total Federal Investment per SMR (2015 $ M) [L]**	**$**	**663**
	Operating Life (years) [M]		60
=[C]x[M]x1,000	Lifetime Production (kWh) [N]		193,631,040,000
=[L]x1,000,000/[N]	Total Lifetime Federal Investment per kWh (2015 $) [O]	$	0.0034
=[O]X100	**Total Lifetime Federal Investment per kWh (2015 ¢)**	**¢**	**0.34**
	Number of SMRs Required for 6 GW of Capacity [P]		15
=[L]x[P]	**Total Federal Investment Required (2015 $ M)**	**$**	**9,947.69**

C.2 SOLAR

Exhibit C-2: Solar Capacity Improvements

Solar Capacity Added					
Year Entered Into Service	Capacity (MW)	Capacity Factor	Annual Production (MWh)	Opearting Life (Years)	Total production (MWh)
2005	130	14.5%	165,252	25	4,131,300
2006	218	13.4%	255,371	25	6,384,286
2007	340	13.3%	395,407	25	9,885,163
2008	179	14.8%	231,505	25	5,787,630
2009	468	13.8%	564,337	25	14,108,428
2010	1,296	13.3%	1,510,327	25	37,758,167
2011	2,262	12.6%	2,490,845	25	62,271,129
2012	2,969	13.4%	3,496,926	25	87,423,141
2013	4,432	13.9%	5,392,261	25	134,806,525
2014	3,500	17.0%	5,204,645	25	130,116,123
2015	6,897	16.8%	10,133,104	25	253,327,609
Total	22,691	n/a	29,839,980	n/a	745,999,500

Exhibit C-3: Solar Incentives

Incentive		Solar Investment
Federal Investment (2015 $ B)		
Tax Incentives	$	11.65
Credit Incentives		1.22
R&D		3.17
Total Investment	**$**	**16.04**
Federal Investment per kWh (2015 $)		
Solar Lifetime Production (kWh)		745,999,499,658
Total Investment per kWh	**$**	**0.021**

C.3 WIND

Exhibit C-4: Wind Capacity Improvements

Wind Capacity Added					
Year Entered Into Service	Capacity (MW)	Capacity Factor	Annual Production (MWh)	Opearting Life (Years)	Total Lifetime Production (MWh)
2005	2,424	22.3%	4,738,685	25	118,467,137
2006	2,428	26.3%	5,595,559	25	139,888,984
2007	5,332	23.4%	10,912,766	25	272,819,142
2008	8,503	25.0%	18,637,733	25	465,943,318
2009	9,453	24.3%	20,126,135	25	503,153,367
2010	5,404	27.0%	12,769,300	25	319,232,506
2011	6,649	29.4%	17,127,666	25	428,191,646
2012	13,089	27.0%	30,957,639	25	773,940,976
2013	1,102	31.7%	3,060,585	25	76,514,628
2014	4,773	31.9%	13,322,944	25	333,073,604
2015	8,591	29.2%	22,001,432	25	550,035,802
Total	67,748	n/a	159,250,444	n/a	3,981,261,110

Exhibit C-5: Wind Incentives

Incentive		Wind Investment
Federal Investment (2015 $ B)		
Tax Incentives	$	34.19
Credit Incentives	$	0.05
R&D	$	0.88
Total Investment	**$**	**35.11**
Federal Investment per kWh (2015 $)		
Wind Lifetime Production (kWh)		3,981,261,110,075
Total Investment per kWh	**$**	**0.009**

C.4 COMBINED

Exhibit C-6: Combined Incentives

	Incentive		Solar Investment		Wind Investment		Combined
	Federal Investment (2015 $ B)						
	Tax Incentives [A]	$	11.65	$	34.19	$	45.84
	Credit Incentives [B]		1.22		0.05		1.27
	R&D [C]		3.17		0.88		4.05
=[A]+[B]+[C]	**Total Investment [D]**		16.04		35.11		51.15
	Lifetime Production (kWh) [E]		745,999,499,658		3,981,261,110,075		4,727,260,609,733
=[E]/[D]	Total Investment per kWh (2015 $) [F]	$	0.021	$	0.009	$	0.011
=[F]x100	**Total Investment per kWh (2015 $)**	**¢**	**2.15**	**¢**	**0.88**	**¢**	**1.08**