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Wind and Solar Data and Projections from the U.S. Energy Information Administration: Past Performance and Ongoing Enhancements

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Introduction

Several articles, papers, and comments over the past year offered critical views regarding renewable electricity data and projections prepared by the U.S. Energy Information Administration (EIA). Although particular details vary from source to source, several critiques have involved claims along the following lines:

- EIA data do not accurately track wind and solar generation or capacity, particularly distributed solar photovoltaics (PV)[1]
- EIA projections "consistently" and "significantly" underestimate additions of wind and solar capacity[2,3]
- EIA estimates for the cost of renewable capacity such as wind and solar are out-of-date and not representative of current market costs[4]

Wind and solar electricity capacity, the latter including both utility-scale solar and distributed photovoltaic (PV), has experienced rapid growth in recent years, increasing by more than 100% and slightly over 900%, respectively, between 2009 and 2015. Wind and solar capacity growth represents about half of gross capacity additions over the same period, although the wind and solar shares of total capacity in 2015 remain modest, at 6.7% and 2.0% respectively. Wind and solar generation shares in 2015 were 4.7% and 0.9%, respectively; somewhat below their capacity shares as a result of the intermittent availability of these resources.

Given the recent growth rates in wind and solar capacity and generation, EIA follows these technologies closely and is committed to assuring the quality of its data and projections for these sources through regular internal and external reviews. While EIA's internal processes and engagement with stakeholders are both continuing, this paper shares some early findings of EIA's current review of our wind and solar data and projections, focusing in part on some of the issues that have been publicly raised by EIA's critics.

EIA's findings with respect to wind and solar information are grouped under three headings: data, capacity and generation projections, and technology costs. A more detailed review of past EIA capacity and generation projections, and actual and projected technology costs for both wind and solar, is provided in the Appendix.

EIA wind and solar data

Some critics suggest that EIA does not account for distributed PV systems (also known as "roof-top" or "end-use" PV systems) in its statistics and projections, thus missing as much as one-third of the current solar generation in the United States, along with associated future growth potential from this market

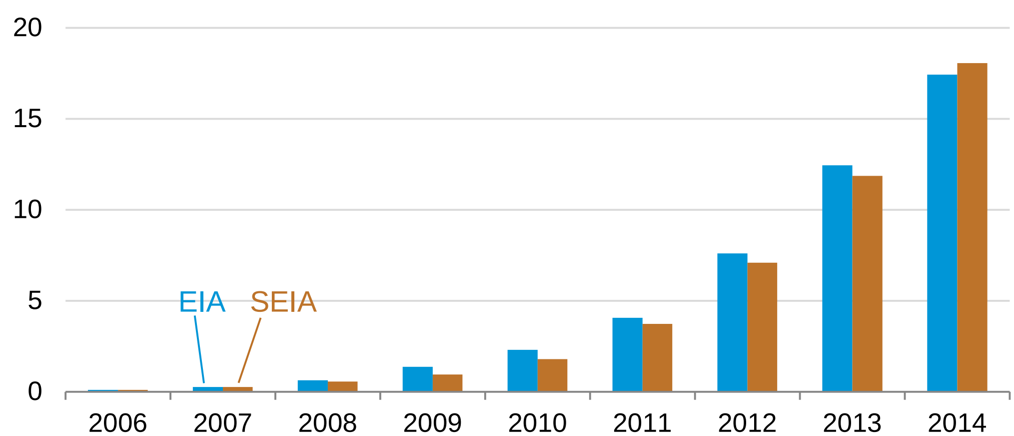
[1] Scientific American, "*U.S. Solar is Producing 50 Percent More Electricity than We Thought*" (accessed 9/24/2015), http://blogs.scientificamerican.com/plugged-in/u-s-solar-is-producing-50-percent-more-electricity-than-we-thought/.
[2] American Energy Economy, "*Competitiveness of Renewable Energy and Energy Efficiency in U.S. Markets*", (June, 2015).
[3] Cleantechnica, "EIA 2040 Forecast Understates Renewables, Policy, Contingencies" (accessed 9/25/2015), http://cleantechnica.com/2015/04/20/eia-2040-forecast-understates-renewables-policy-contingencies/
[4] American Energy Economy, "*Competitiveness of Renewable Energy and Energy Efficiency in U.S. Markets*", (June, 2015).

segment.[5] In fact, EIA has long produced current estimates and projections for both distributed and utility-scale PV installations and generation, and has recently enhanced its data on small-scale distributed PV.

- EIA renewable generation data, including distributed solar PV estimates, are virtually identical to data cited by EIA's critics. A recent article claiming that EIA data understated total 2014 PV generation by 50%[6] states that solar energy systems in the United States generated 30.4 billion kilowatthours of electricity in the 12 months ending in March 2015. Although EIA's *Annual Energy Outlook 2015*, which presents annual data and projections, does not provide an estimate of generation from April 2014 through March 2015, a rough approach to generate such an estimate is possible. This method uses a weighted average of the 2014 estimate of 28.9 billion kilowatthours and the 2015 estimate of 36.0 billion kilowatthours, with 75% of the weight on the former and 25% of the weight on the latter.[7] The resulting estimate of 30.7 billion kilowatthours is very close to (and actually slightly *higher* than) the 30.4 billion kilowatthour number for U.S. solar production cited in the article critiquing EIA. Furthermore, EIA's published estimates of total solar PV installations from both utility and distributed generators (shown in Figure 1), closely match those of the Solar Energy Industries Association (SEIA), the source cited in the above generation estimate above, and one of the leading solar industry trade associations.

Figure 1. Cumulative additions of solar PV capacity, 2006-14

gigawatts (GW_{DC})



Sources: EIA, Annual Energy Outlook (2009–2015 editions); SEIA, Solar Market Insight Report 2014 Q4. Note: A DC-to-AC ratio of 1.25 was assumed for utility-scale PV capacity to reflect inverter sizing and losses.

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[5] Greentechmedia, "*Why EIA's Energy Outlook Misses the Real Value of Renewable Energy*" (accessed 10/20/2015), http://www.greentechmedia.com/articles/read/why-the-eias-energy-outlook-misses-the-real-value-of-green-energy

[6] Scientific American, "*U.S. Solar is Producing 50 Percent More Electricity than We Thought*" (accessed 9/24/2015), http://blogs.scientificamerican.com/plugged-in/u-s-solar-is-producing-50-percent-more-electricity-than-we-thought/.

[7] EIA, *Annual Energy Outlook 2015*, Table 16, available at http://www.eia.gov/forecasts/aeo/tables_ref.cfm

- EIA recognizes that a more integrated presentation of generation data for utility-scale solar and small-scale (less than 1 megawatt) distributed PV would be beneficial. Since late 2014, EIA has been working to develop monthly state-level estimates of distributed small-scale PV generation, matching the periodicity and geographic breakdown used in presenting utility-scale generation data on EIA's website. Starting with the publication of the November 2015 *Electric Power Monthly* (EPM) EIA is reporting these estimates together with utility-scale generation data in the EPM and including them in electricity-related tables and browsers associated with that publication.

EIA projections for wind and solar electricity capacity and generation

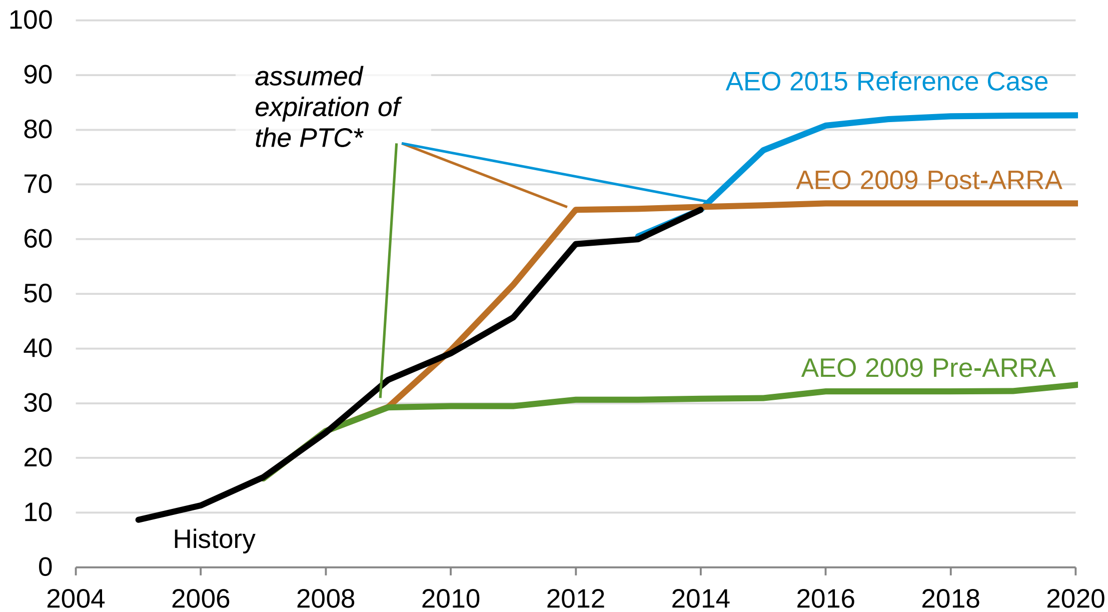
A number of critics have suggested that EIA "consistently" under-projects wind and solar capacity and generation, or even is "always underestimating –and never overestimating –future deployment of renewables."[8] EIA's projections for wind and solar markets have been largely dependent on how well policies in EIA projections match with policies as actually implemented, and the projections have both under- and over-estimated market growth for renewables.

- EIA's Reference case projections explicitly assume current laws and regulations in place at the time the projections are developed, consistent with EIA's mandate to provide a neutral baseline for policy analysis. These projections have consistently shown the importance of state and federal policies in driving growth in renewable generation and capacity. EIA's Reference cases are intended to be used in conjunction with relevant policy cases to draw informed conclusions about the prospects for renewable energy under a number of potential future market scenarios.
- When policies are assumed that support renewables, EIA's projections show significantly higher penetration rates for both wind and solar than when such policies are not considered. For example, one recent critique of EIA forecasts cited the AEO2009 Reference case projection that wind generating capacity would grow to 44 gigawatts (GW) in 2030, noting that capacity had actually grown to 66 GW by the end of 2014.[9] However, the AEO2009 Reference case, first issued in December 2008, was updated only a few months later in April 2009 to reflect the passage in February 2009 of the American Recovery and Reinvestment Act (ARRA), which extended and expanded incentives for both wind and solar. The updated projection for wind capacity in 2014 was 65.9 GW, nearly identical to the actual outcome nearly six years later, as shown in Figure 2.

[8] American Energy Economy, "*Competitiveness of Renewable Energy and Energy Efficiency in U.S. Markets*", (June, 2015).
[9] Politico, "*Why are the government's energy forecasts so bad?*" (accessed 10/23/2015), http://www.politico.com/agenda/story/2015/06/why-are-the-federal-governments-energy-forecasts-so-bad-000111

Figure 2. Wind capacity projections to 2020 for all sectors in AEO 2009 and AEO 2015 Reference cases

gigawatts (GW)



Sources: EIA, Form EIA-860, AEO 2009 [Pre- and Post-American Recovery and Reinvestment Act (ARRA)], and AEO 2015.
*Note: In 2013 the American Taxpayer Relief Act changed the Production Tax Credit (PTC) expiration from a placed-in-service deadline to a construction-start-date deadline for all qualifying technologies.

- When policies are assumed that restrict existing generation that competes with new renewables, EIA's projections show significantly higher penetration rates for both wind and solar than when such policies are not considered. This effect is shown by comparing renewable capacity additions in EIA's AEO2015 Reference case with its subsequent analysis of the Clean Power Plan (CPP)[10, 11] as proposed by the U.S. Environmental Protection Agency (EPA) in June 2014. With the proposed CPP in place, wind capacity reaches 192 GW by 2030 and 205 GW by 2040, well above the projected levels of 87 GW and 110 GW for the same years in the Reference case. Solar PV capacity also grows much more rapidly with the CPP in place, reaching 74 GW in 2030 and 135 GW in 2040, compared to 37 GW and 59 GW for the same years in the Reference case.
- EIA's AEO and CPP analyses reflect the view that with very slow growth in U.S. electricity demand, electricity from new wind and solar plants will largely be competing in the near term to displace generation from existing coal- and natural gas-fired power plants. In the Reference cases of recent AEO editions, new coal-fired generation plants are not economically competitive with renewables and other generation sources, as reflected by the near absence of new coal capacity additions over the 2015-40 period, even without an assumed extension of tax credits for renewables or promulgation of the CPP rules for new and existing sources. However, under the then-current laws reflected in those Reference cases, displacing incumbent coal generation is much less economically

[10] U.S. Energy Information Administration, "Analysis of the Impacts of the Clean Power Plan", May, 2015
[11] This report considers EPA's proposed Clean Power Plan rule issued in June 2014. The AEO2016 will include EIA's final Clean Power Plan rule issued in August 2015.

viable than under the recently analyzed CPP proposal, which essentially forces existing coal-fired units to reduce their generation.

- EPA's promulgation of the final CPP rules in August 2015 and the long-term extension of both the wind PTC and the solar PTC passage enacted in December 2015 as part of the Consolidated Appropriations Act, 2016 are two major policy developments affecting wind and solar projections that will be included in the AEO 2016 Reference case, which will also include updates to technology costs. As already noted above, such policies are a key driver of EIA's wind and solar projections.
- Although some studies by renewable advocates have criticized past EIA projections, many leading renewable energy stakeholders have openly stated that policy support for renewables is critical to their future continued growth, as implied by EIA's Reference case projections. For example, the President of the Solar Energy Industries Association (SEIA) and the Senior Vice President for Government and Public Affairs at the American Wind Energy Association (AWEA), have recently stated that extension of tax credits is essential to their respective industries. According to the SEIA President:

> "I think people don't understand the importance of the ITC. What the BNEF [Bloomberg New Energy Finance] says is that the person sitting to your left or right, one of those two people is not going to be working in solar in 2017 or 18 if the ITC expires. So this is a big deal, and there's a lot we can be doing as an industry to make sure we extend it."[12]

In commenting on a question regarding the need for an extension of the production tax credit for wind in light of an analysis from the National Renewable Energy Laboratory (NREL) showing that wind power can expand throughout the 2022-30 CPP compliance period even if the tax credit is not renewed, the AWEA Senior VP responded that "the short answer is yes, the PTC is essential." He also said:

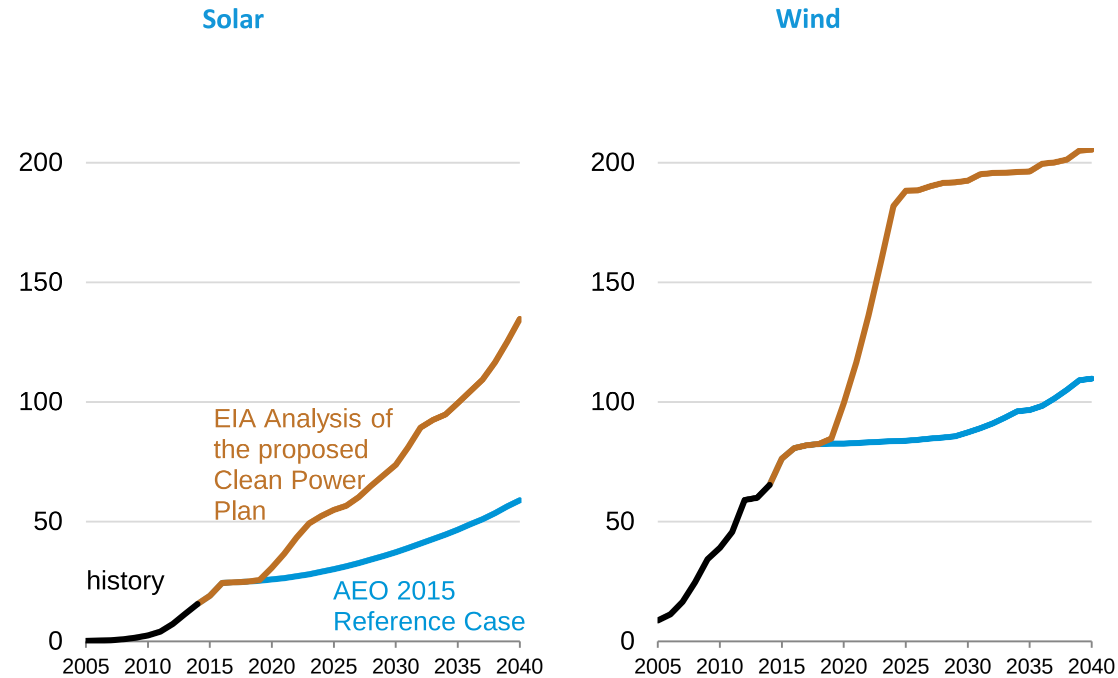
> *"It's true that wind is increasingly cost-competitive, but recent experience and studies such as NREL's recent one show that development would fall significantly without the PTC."*[13]

In some respects, these stakeholders appear to be less optimistic than EIA about the future of renewables' absent extension of tax policy support. As noted above and shown in Figure 3, EIA's modeling of the proposed CPP also shows significant growth in both wind and solar generating capacity as a result of restrictions on existing fossil generation, even without the extension of federal tax incentives for renewables beyond their then-scheduled expiration dates.

[12] PVTECH, "*SPI 2015: US Solar Industry Must Unite to Save ITC, Warns SEIA's Resch*" (accessed 10/23/15), http://www.pv-tech.org/news/spi_2015_us_solar_industry_must_unite_to_save_itc_warns_seias_resch .
[13] E&E Publishing, "*A Mighty Optimistic Wind Estimate Fuels EPA Rule"* (accessed 10/23/15), http://www.eenews.net/energywire/2015/08/07/stories/1060023138.

Figure 3. Capacity projections for solar and wind in the AEO 2015 Reference case and in EIA's May 2015 analysis of the proposed Clean Power Plan, 2005-40

gigawatts (GW)



Source: EIA, Form EIA-860, Annual Energy Outlook 2015, and Analysis of the Impacts of the Clean Power Plan, May 2015

EIA continually reviews its past projections and modeling assumptions and is committed to continual improvement and enhancement of its energy models. For wind, previous EIA projections and realized outcomes are reasonably aligned, when considering projections that were made using policy assumptions consistent with realized policy.

- For solar, however, some significant gaps between projected and realized outcomes are apparent, even when policy assumptions used in making the projections align with realized policies. EIA projections for distributed solar PV have tended to perform better than those for utility-scale solar, but EIA is examining ways to enhance its modeling capabilities in both areas. Topics being evaluated include:
    - Representing the granular interactions between potential solar resources, markets, and policies, in the context of a national-level model with large, multi-state regions
    - Accounting for differences in implementation of investment tax credits for solar in distributed and utility-scale applications
    - Considering behavioral factors influencing both utility and non-utility investments that go beyond the dispatch economics
- EIA recognizes that the interests of policy makers, stakeholders, and the public are well served through access to a wide variety of outlooks and projections and is strongly committed to open and transparent discourse regarding its own projections and their relationship to other analyses. EIA seeks to advance the dialogue surrounding energy projections through its standard practice of

providing full disclosure of its assumptions regarding policy, technology, and methodologies. In the interest of furthering a constructive dialogue that sheds more light on critical issues surrounding the future of electricity generation from wind and solar resources, EIA believes that policy-makers, the media, and the public would be well-served through disclosure and explanation of key assumptions and methodologies for all such outlooks and analyses, including:

- Assumptions regarding future policies towards renewables and other generation sources, including existing generation
- The going-forward costs of operating existing nonrenewable capacity of various types and how those costs vary regionally
- The growth rate of electricity demand, and the regional variation in demand

Wind and solar costs

Other critics have stated that EIA "doesn't keep up with industry data on the rapidly falling costs of these technologies."[14] However, EIA re-examines a variety of sources for wind and solar costs every year to ensure that its cost assumptions are as closely aligned with this fast-changing market as possible.

- Capital cost estimates for wind and solar electric generating technologies vary significantly from source to source, because of the difficulty of obtaining reliable data, but also because different data collection approaches measure different aspects of cost. EIA updates its wind and solar costs annually using a wide variety of sources. EIA's costs are typically within ranges suggested by these sources, and they have tracked trends seen in leading cost analyses. We are now reviewing technology costs to be used in AEO2016, a process that includes workshop discussions involving stakeholders.
- EIA, like many other industry trend watchers, did not anticipate the sharp decline in solar PV costs seen over the past several years, but has kept the baseline cost assumptions up-to-date as the costs have declined. EIA has run the National Energy Modeling System (NEMS) using a variety of lower-cost assumptions for the future costs of wind and solar. While lower costs have the expected directional effect on renewables' future share in the generation mix, policies towards new renewables and existing fossil generation remain the dominant driver of projected outcomes.
- The cost of wind and solar capacity certainly matters, but projections of the future generation mix are not always very sensitive to advantages that renewables have when compared to certain other technologies in levelized cost values that are often widely cited. For example, even without consideration of the recently extended tax credits for renewables and the final CPP rules, new coal plants were generally not cost-competitive with either new renewables or with new natural gas capacity in EIA's Reference case, and therefore were not projected to be built. However, with relatively low fuel and operating costs, existing coal plants were often very cost-competitive.
- With very limited growth in electricity demand, significant amounts of new renewables would compete primarily with existing fossil capacity rather than with newly-added fossil capacity. To a certain degree, the slow growth in demand is testament to the effectiveness of energy efficiency, another competing resource and frequent policy objective

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[14] Greentechmedia, "*Why the EIA's Energy Outlook Misses the Real Value of Renewable Energy*" (accessed 10/23/15), http://www.greentechmedia.com/articles/read/why-the-eias-energy-outlook-misses-the-real-value-of-green-energy .

Appendix

Detailed review of EIA projections and cost estimates for wind and solar

EIA has found that the information used to support recent critiques is often selective and misleading, and that the broad conclusions drawn from that information are therefore exaggerated, fail to account for key aspects of the projections, or are factually incorrect. Careful examination of the record indicates the following:

- Given the importance of policy assumptions in driving modeled outcomes for renewable technologies, the comparison of projected and realized outcomes is appropriately considered over periods when projections are made using policy assumptions that line up with realized policies. For this reason, this review focuses on projections that incorporate significant policy changes responsible, at least in part, for much of the recent growth in wind capacity (that is, the American Recovery and Reinvestment Act of 2009) and in solar capacity (the Emergency Economic Stabilization Act).
- Over the past six *Annual Energy Outlook* (AEO) Reference cases, projections for wind electric generating capacity have been well-centered with respect to actual market outcomes. When compared to history, the projections have overestimated capacity about as much as they have under estimated capacity; with differences generally less than 5% in either direction.
- Although solar projections have been generally under more than over when compared to actual, they have not been consistently under.
- Evolving policies at both the state and federal levels are likely to account for much of the differences between projections and realized outcomes; where projected policies match realized policies for wind and distributed solar, projections have been very much in line with actual market developments.
- Although EIA does not currently publish aggregated estimates for distributed solar photovoltaic (PV) installations, EIA for many years has estimated this market segment and has included it in its projections dating back more than 15 years. Rather than ignoring this market sector in its projections, as some have suggested,[15] EIA Reference case projections over the past five years show distributed solar PV accounting for most of the growth in the solar market. In addition, EIA began publishing more-detailed estimates for distributed solar PV in November of 2015.

Careful examination of the evidence presented here, as well as the full archive of AEO projections publicly available on the EIA website, show that EIA market projections for wind and solar electric generating capacity provide a reasonable basis for understanding the impacts of laws, policies, and market conditions on the growth of renewable energy markets. By extension, EIA's projections offer a sound foundation for analyzing the impact of policy proposals that may affect these markets in the future.

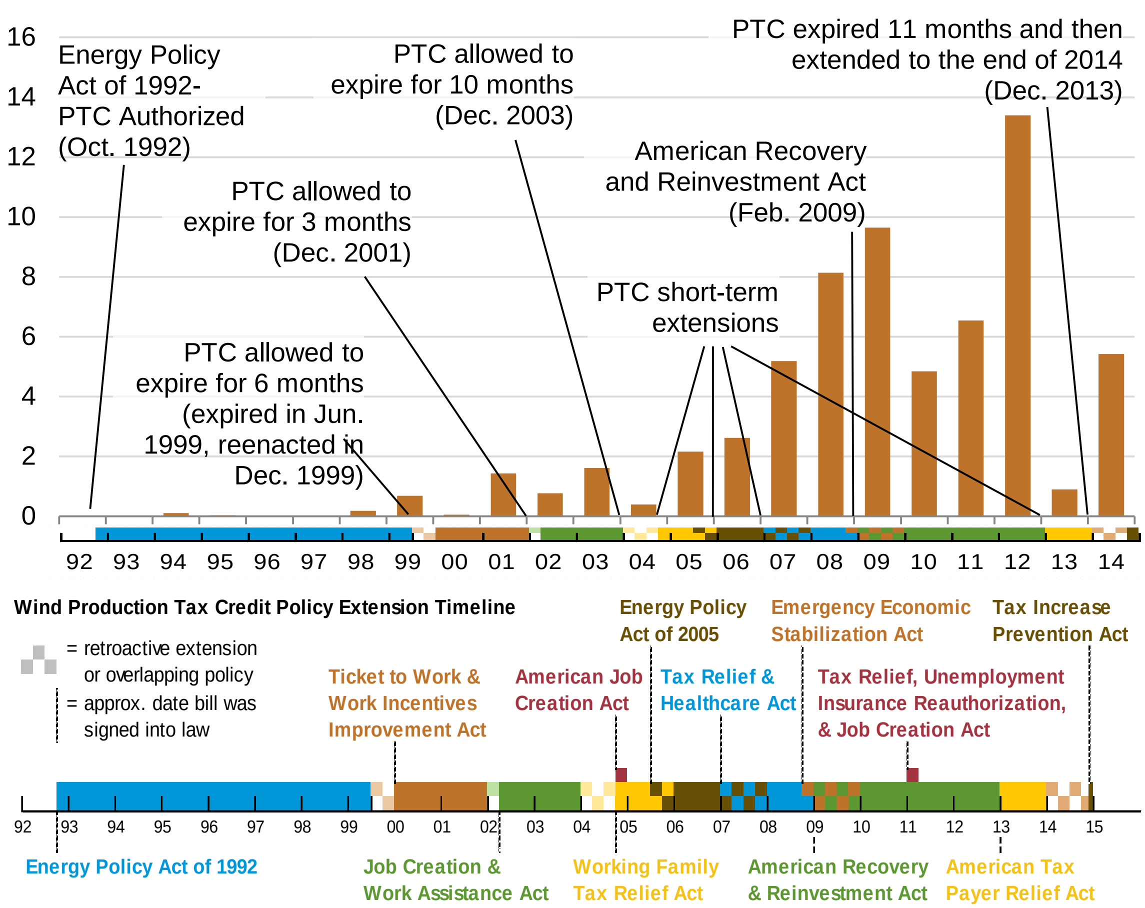
[15] Greentechmedia, "*Why EIA's Energy Outlook Misses the Real Value of Renewable Energy*" (accessed 9/28/2015), http://www.greentechmedia.com/articles/read/why-the-eias-energy-outlook-misses-the-real-value-of-green-energy

Wind

The wind industry has changed dramatically within the past decade, with significant volatility of both policies and market factors such as technology costs, electricity demand, and fuel prices for natural gas and other competing electric generating technologies. The critical uncertainty affecting EIA projections has been the expiration and extension cycle experienced with the federal Production Tax Credit (PTC). Factors such as wind electric generating technology costs, the impact of electricity demand growth, natural gas prices, and other factors, have been both above and below realized historical values, but these factors have had less impact on the accuracy of wind projections.

The renewable electricity PTC, currently a 2.3-cent-per-kilowatthour (kWh) tax credit for the first 10 years of production for electricity generation from certain renewable resources, has been a valuable asset for the wind industry. It was first enacted in 1992 and first allowed to expire in 1999. Since 1999, the PTC has been extended eight times and, in several cases, allowed to expire before being retroactively extended, as shown in Figure A-1. This expiration and extension cycle of the PTC has led to a boom-and-bust type of response from the wind industry, as there is a rush to build out wind capacity before the expiration of the credit, followed by a relative lull in new wind capacity installations in the following year.

Figure A-1. Annual wind capacity additions, 1992-2014



Source: EIA, Form EIA-860, Annual Electric Generators Report

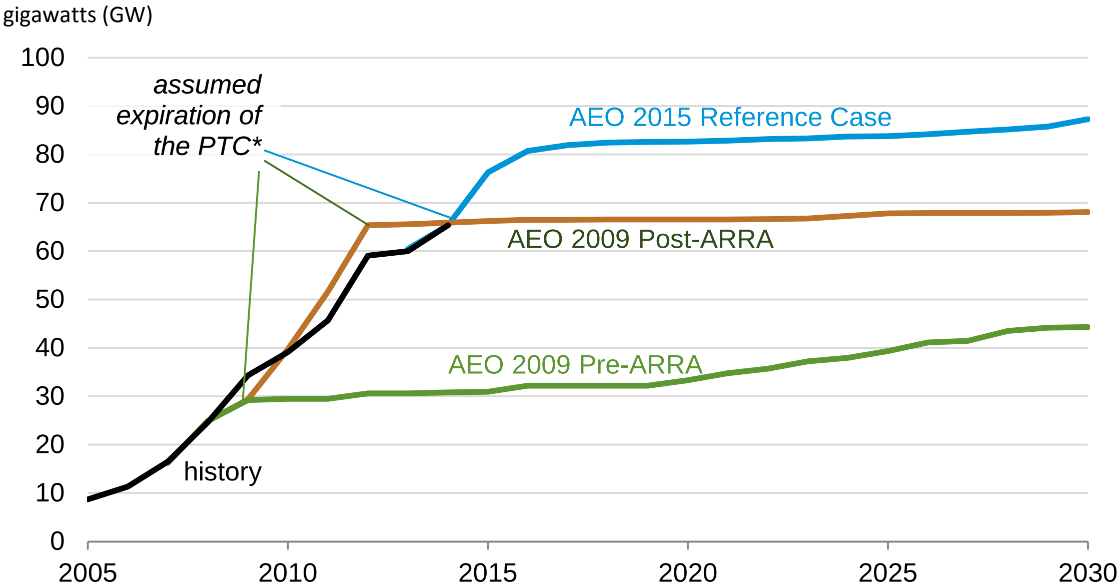
On December 18th 2015, both the PTC for wind and Investment Tax Credit (ITC) for solar were extended as a part of the Consolidated Appropriations Act, 2016. The extension maintains the current credits through the end of 2016; the 2.3-cent-per-kilowatthour wind PTC will remain in place for projects that have commenced construction by December 31, 2016. Incremental reductions in the value of PTC credits for wind energy will begin for projects commencing construction in the following year, dropping to 80% of full value in 2017 (to about 1.8 cents per kilowatthour), 60% in 2018 (to about 1.4 cents per kilowatthour), 40% in 2019 (to about 1 cent per kilowatthour), and then complete expiration in 2020. The current 30 percent ITC for residential and commercial solar, previously scheduled to expire at the end of 2016 for projects not yet in service, will remain for projects commencing construction through 2019, but in following years will begin to taper off: the credit will fall to 26% in 2020 and 22% in 2021. The ITC goes away for residential projects commencing construction in 2022 while the credit drops to 10% in 2022 for commercially-owned projects[16]. These provisions will be included in the AEO2016 reference case.

Because the AEO represents current laws and policies, past editions of the AEO use a PTC expiration date based on the then-current law (for example, AEO 2003 showed the PTC expiring at the end of 2003 for wind). AEO 2009 is particularly illustrative of the importance of this policy for the wind projections. The AEO 2009 Reference case, initially published in December of 2008, is based on laws in effect as of late 2008. This Reference case was updated and re-released in April of 2009 to reflect the provisions of the American Recovery and Reinvestment Act (ARRA) that were enacted in February 2009.

ARRA contained a number of provisions potentially affecting wind energy markets, including establishment of a loan guarantee program for renewable energy projects, extension of the PTC through 2012, and the ability to convert the PTC into either a 30% Investment Tax Credit (ITC) or an equivalent investment grant. Although the original AEO 2009 Reference case substantially underestimated wind capacity growth over the next five years, as shown in Figure A-2, the updated AEO including the ARRA provisions actually overestimated the wind capacity additions for several years, but eventually matched capacity in 2014 to within 2%.

[16] Solar installations that are owned by private individuals (that is, directly by a home owner) are governed by a different section of the U.S. tax code than for-profit installations. Credits for these owners will expire completely on January 1, 2022. Residential installations that rely on a “third party ownership”, where a commercial entity owns the system and sells the power directly to the host home owner, are eligible for the business (for profit) tax credit, and thus will remain eligible for a 10% tax credit in 2022 and beyond.

Figure A-2. Wind capacity projections in AEO 2009 and AEO 2015 Reference cases, all sectors, 2005-2030

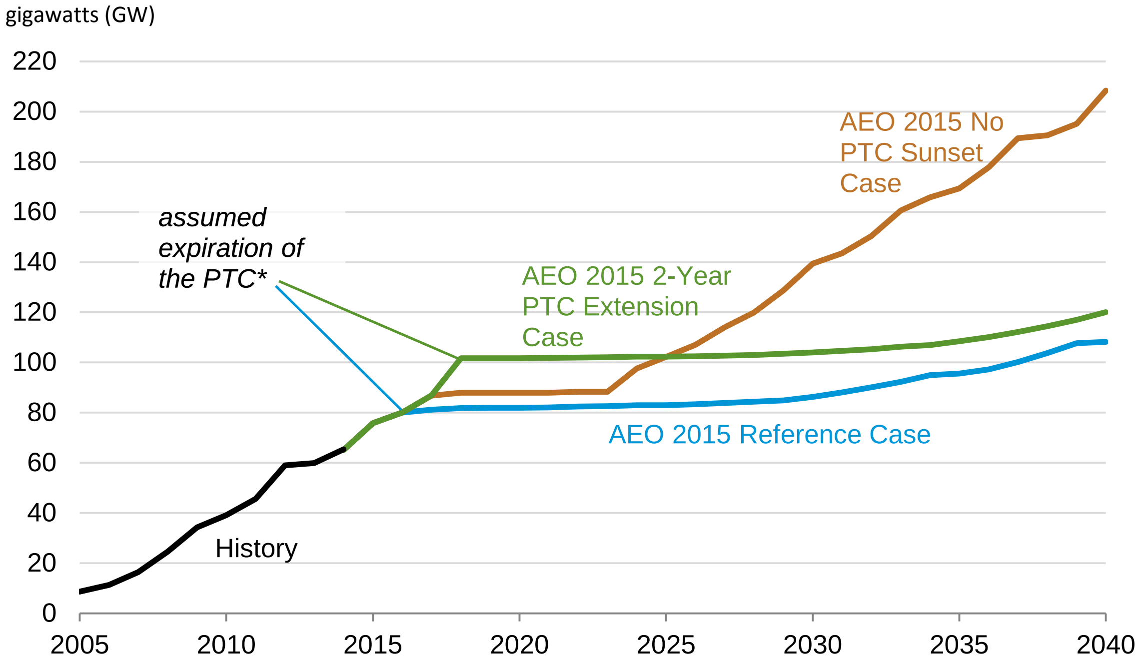


Sources: EIA, Form EIA-860, AEO 2009 [Pre- and Post-American Recovery and Reinvestment Act (ARRA)], and AEO 2015.
*Note: In 2013 the American Tax Payer Relief Act changed the Production Tax Credit (PTC) expiration from a placed-in-service deadline to a construction start date deadline for all qualifying technologies.

Subsequent AEO editions have projected levels of wind capacity both higher and lower than realized capacity additions, but the projected levels have tended to align well with actual capacity additions, at least through 2012, when the near-term uncertainty regarding extension of the PTC returned as a persistent feature of this market.

Because of the uncertainty concerning the extension of the PTC, EIA has published a No Sunset case in the majority of recent AEO publications. The No Sunset case assumes that the PTC and other expiring tax provisions will be extended for the duration of the projection period. While providing a reasonable long-term view of the potential impact of a PTC extension, this side case is not able to capture the impacts of the short-term expiration/extension cycle. In general, the AEO projects that there may be some need for wind capacity in the near term, with additional demand further in the future as load grows, states require additional renewable generation, and natural gas prices increase creating more favorable market conditions for new capacity from wind and other resources. With a near-term expiration looming, EIA projects that the market will try to satisfy some of this longer-term demand for wind capacity sooner rather than later to take advantage of the pending expiration of the PTC. With an indefinite continuation of the PTC, the market will tend to wait until demand materializes before making new capital investments in wind capacity.

Figure A-3. Wind capacity projections in AEO 2015 Reference case and various side cases, all sectors, 2005-2040



Sources: EIA, Form EIA-860 *Annual Electric Generator Report* and Annual Energy Outlook 2009, 2015, and additional runs.
*Note: In 2013 the American Taxpayer Relief Act changed the PTC expiration from a placed-in-service deadline to a construction-start-date deadline for all qualifying technologies.

Figure A-3 illustrates the behavioral differences occurring in the AEO 2015 Reference case (blue line) and two previously unpublished cases showing variations on a PTC extension. When there is a two-year extension of the PTC (expiring in 2017) (green line), the market builds 15 GW more capacity through 2017 than in the Reference case, but it only grows by an additional 5 GW from 2017 through 2030. With the indefinite continuation of the PTC, the near-term build-out is much lower, with only 5 GW more capacity than in the Reference case through 2017, but with extensive additional growth beyond 2022, ending up at 140 GW by 2030 and more than 200 GW by 2040.

EIA's cost estimates for wind capacity have been both above and below external assessments of historical costs. This review of EIA's renewables projections focuses on capital costs, because those costs represent the major cost component for wind, and they have the most reliable assessments of realized historical value. Although the levelized cost of energy (LCOE) accounts for the performance of wind plants (as measured by capacity factor) as well as costs associated with project finance, taxes, and depreciation, the LCOE is a largely theoretical construct. While some entities compare prices from Power Purchase Agreements (PPA) against historical LCOE estimates to assess the accuracy of the LCOE estimates, the LCOE estimates developed by EIA are not intended as an estimate of PPA pricing. The LCOE estimates do not necessarily align with common pricing practices that include the impact of local, state, and federal incentives, that use a wide variety of financial mechanisms, and that use value-of-output in determining price.

Starting with AEO 2011, EIA's overnight capital costs[17] for all electric power sector technologies have been based on periodic reports[18, 19] commissioned by EIA to assess electric power sector capital costs using a consistent approach for each generating technology, including those technologies with much more publicly available data and those technologies with little recent market activity and/or little or no publicly available cost data. To ensure a complete accounting for investment costs, EIA estimates include costs such as owner's costs, engineering planning and construction costs, and insurance costs. The wind industry has developed many projects over the past 10 years, and there are good efforts to collect and report on cost data from this industry.[20] However, these other data collection efforts may rely on costs from a variety of sources that do not consistently report these additional costs.[21]

Figure A-4 includes a comparison of EIA's annually reported assumption for initial-year overnight costs with other published capital costs for that year. Before commissioning its periodic study of electric power sector capital costs and before the availability of reliable assessments of observed market data, EIA primarily used anecdotal sources and engineering costing to estimate wind capital costs. During this time, EIA consistently underestimated capital cost values compared to data later developed by Lawrence Berkeley National Laboratory (LBNL) and others. Subsequent EIA estimates have been somewhat higher than reported data. However, it should be noted that EIA's cost estimates have been for a hypothetical plant at the same location used for costing other generator technologies. When taking account of actual plant locations, EIA costs are significantly below the value shown in Figure A-4. EIA is currently reviewing electric-power sector technology costs for AEO2016, including costs for wind. The current review process involves consideration of a recently updated contractor study as well meetings and discussions with stakeholders and a variety of other experts.

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[17] Overnight capital costs represent the cost of building a facility exclusive of interest accrued on money borrowed during the construction period; that is, the cost as if the facility were constructed in a single day, or "overnight".

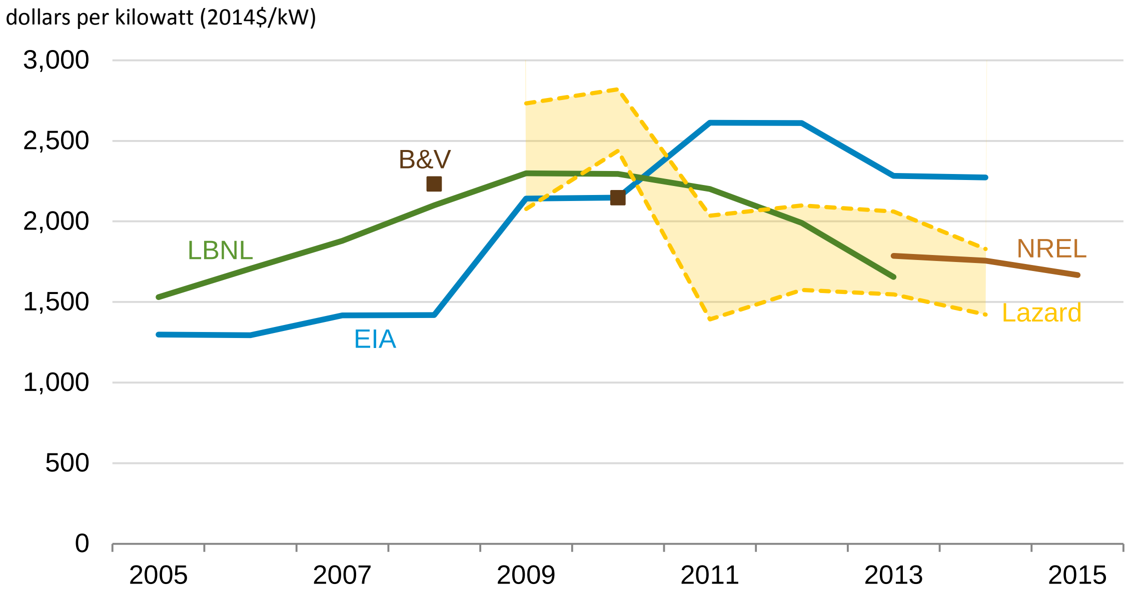
[18] U.S. Energy Information Administration, Updated Capital Cost Estimates for Electricity Generation Plants (November 2010), Appendix A, Technology Documentation Report.

[19] U.S. Energy Information Administration, Updated Capital Cost Estimates For Utility-Scale Electricity Generating Plants (April 2013), Appendix B, Technology Documentation Report.

[20] U.S. Department of Energy, "2014 Wind Technologies Market Report" (August 2015), and previous annual editions.

[21] For example, LBNL (see page 49 in the reference above) cautions "In general, reported project costs reflect turbine purchase and installation, balance of plant, and any substation and/or interconnection expenses. Data sources are diverse, however, and are not all of equal credibility, so emphasis should be placed on overall trends in the data rather than on individual project-level estimates."

Figure A-4. Annual estimated capital costs for wind technologies from various agencies, 2005-2015



Source: EIA, *Annual Energy Outlook* (2003-2015); LBNL, Wind Technologies Market Report (2013-2014); Black & Veatch (B&V), Cost and Performance Data for Power Generation Technologies; NREL, Annual Technology Baseline 2014; Lazard, Levelized Cost of Energy (versions 3 through 8).

As indicated in Figure A-4, the capital cost of wind generating capacity has also changed over time, and it may be expected to change in the future as a result of learning-by-doing effects,[22] as well as from other market forces. EIA accounts for this type of cost change in its projections through a learning curve approach, as well as through the use of factors that account for cost reductions. Cost reductions can result from government-funded R&D and broader economic factors, such as the relative scarcity or abundance of critical construction commodities such as finished metals.

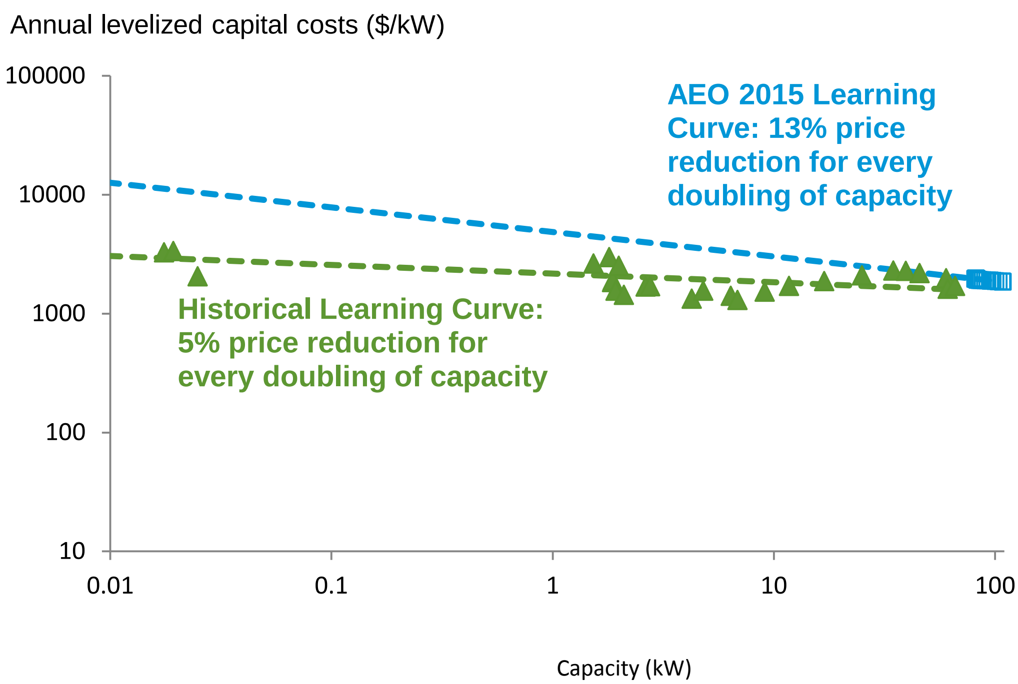
The data reported by LBNL (see above) are transactional and presumably account for the impact of all of these factors (that is, learning effects, time-dependent cost reduction, and commodities pricing). When the LBNL data are compared to EIA projected cost data after incorporating all of these factors, EIA has projected a substantially better cost-reduction potential for wind than is apparent in the historical data. As shown in Figure A-5, although the first gigawatt or so of wind built in the United States indicated a traditional, downward-sloping learning curve, the bulk of the installations in the United States, representing more than six doublings of capacity, have been associated with an upward trajectory in installed costs, only recently turning downward, but not yet reduced to levels seen when installed capacity was less than 2 GW. Reasons for this upward cost trajectory include improvements in technology that allow better productivity from the turbines for additional capital cost,[23] a general increase in prices for construction materials and labor, possible arbitrage against competing projects

[22] Learning-by-doing effects are seen across a wide variety of technologies and industries, and they are generally realized as the result of the ability of technology developers to identify process efficiencies and technology improvements as more experience with a given process or technology is gained.
[23] While resulting in a higher capital cost, the trade-off of performance for up-front cost may ultimately reduce the overall cost of energy production.

(i.e., via bidding strategies for power purchase agreements) and the need to build in more difficult and/or more expensive locations as the best locations to install wind generating facilities have already been taken. However, the AEO has always projected a downward-sloping learning curve, with a gross cost reduction.[24]

It is worth noting that while the commodity price impacts implied by historical cost data are explicitly accounted for in the EIA costs shown, EIA accounts for performance improvement (as measured by capacity factor) and supply curve effects through separate mechanisms not shown in the cost learning analysis in Figure A-5. Also, as previously noted, wind projections made prior to the AEO 2009 ARRA supplement (and projections from subequent AEOs that extend beyond the changing PTC expiration date) have tended to underestimate total wind capacity installations. Because much of the cost reduction projection is dependent on market growth, realized cost estimates for a given year will likely not align well with observed cost reductions where capacity additions do not also align, even when the gross cost-reduction potential for every doubling of capacity is the same as or more optimistic than the observed historical cost reduction rate.

Figure A-5. Historical and projected wind capital costs

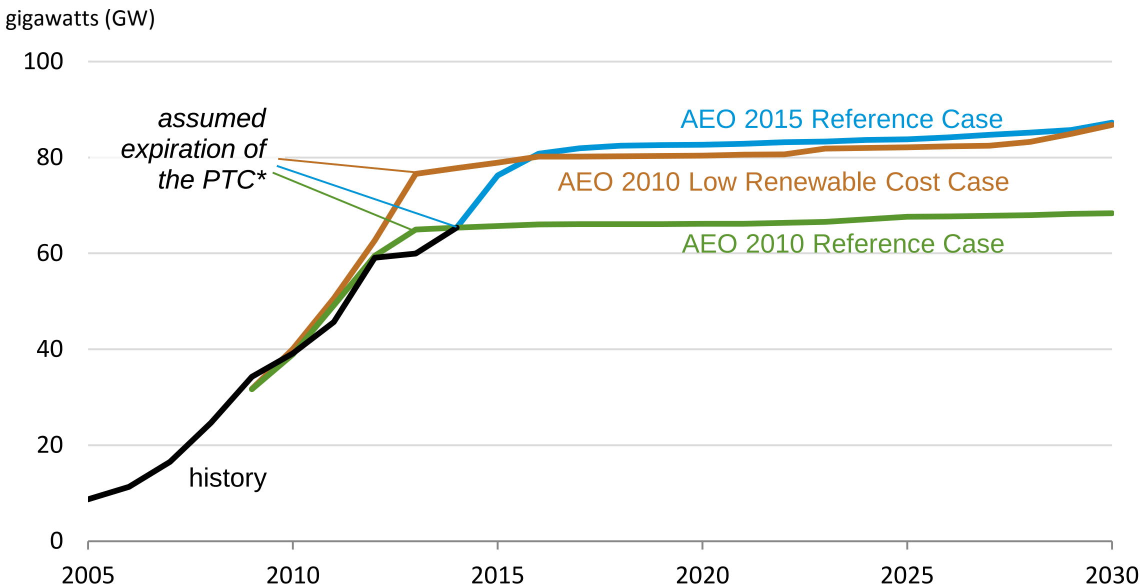


Source: EIA, Form EIA-860 and Annual Energy Outlook 2015

[24] EIA does project that as the best resources are utilized, additional investment may be required to mitigate transmission constraints or to overcome local adverse development conditions. While some of these costs are likely included in the LBNL data, the broad transmission investments needed to support wind development have not typically been allocated on a project-by-project basis. Instead, they have been funded by other mechanisms such as the Texas CREZ process or the various projects undertaken in Minnesota to expand transmission into windy areas. EIA has removed these supply curve costs from the learning curve shown to help ensure comparability with the available project cost data.

Because there is uncertainty about current cost and about cost reduction potential, EIA also frequently publishes low renewable technology cost side cases that explore the build-out of capacity assuming a lower initial cost and accelerated cost reduction. For example, AEO 2010 included a Low Renewable Technology Cost case, which assumed that the levelized cost of energy for wind and other renewable generating technologies started 10% below the Reference case cost assumptions in 2010 and declined to 25% below the projected Reference case costs by 2035. Because of the relatively long-term (through 2012) extension of the PTC as a result of ARRA, AEO 2010 is relatively well-aligned from a policy perspective. As shown in Figure A-6, while the Reference case was more or less in line with realized history, the Low Renewable Technology case overestimated wind capacity additions by almost 20% in 2014. However, subsequent extensions and modifications of the PTC (in 2012 and again in 2014) have resulted in a closer alignment for post-2015 projections between the AEO2015 Reference case and the AEO2010 Low Renewable Technology Cost case.

Figure A-6. Wind capacity projections in AEO 2015 and AEO 2010 Reference cases and AEO2010 low Renewable Cost case, all sectors, 2005-2040



Sources: EIA, Form EIA-860 *Annual Electric Generator Report* and *Annual Energy Outlook* 2010 and 2015.

Other factors such as electricity demand growth, state-level policies, and natural gas prices also impact the outlook for wind generating capacity, making forecasts uncertain. Despite these uncertainties, EIA continues to provide useful annual projections for wind generating capacity. In addition, EIA reviews and updates the assumptions as needed for wind generating technologies in each edition of the AEO, including capital cost, performance (as measured by capacity factor), learning parameters, and resource constraints. EIA also represents key uncertainties in this market through the publication of side cases that examine sensitivity to cost assumptions, federal tax policy, and other market factors. In contrast, the solar industry is smaller, younger and more dynamic than the wind industry, making forecasts for this technology, discussed next, much more challenging.

Solar

Although wind generating capacity growth has seen more than a decade of solid, if periodically disrupted, expansion, growth in solar capacity has been more concentrated in the past five years (roughly starting in 2009). EIA has not been as successful at projecting solar PV installations as compared to wind installations. Although data on PV installations, especially smaller installations in residential and commercial buildings, have been more challenging for EIA to collect, EIA has for many years produced relatively accurate current-capacity estimates for these installations in its projections. EIA's assessment of this market has not significantly contributed to the challenges of projecting solar energy markets. This section will review issues related to the collection and reporting of data from solar installations, identify where solar projections have been relatively accurate and inaccurate, and discuss the challenges that have contributed to differences between projected and realized PV installations.

Technologies that convert solar energy to electricity come in a wide variety of designs and are used in distinct segments of the electric power market. A number of solar technologies produce electricity by using concentrated sunlight to create steam to drive a conventional steam turbine. Photovoltaics (PV) convert sunlight directly to electric power through solid-state electronic materials. There are a number of PV materials currently on the market, each with differing cost and efficiency characteristics. Furthermore, PV is used in applications ranging from personal electronics (not covered in this report or generally by EIA reporting), to rooftop installations on residential or commercial buildings, to ground-mounted utility-scale plants ranging from 1 to more than 100 megawatts in size.

This report focuses on PV technologies of all types connected to the grid, and the discussion distinguishes between the end-use sector and the utility-scale sector. The end-use sector generally refers to projects on residential and commercial buildings, typically owned by the electricity consumer or by a third-party power provider and typically sized at less than 1 MW; the utility-scale sector is typically ground-mounted installations of 1 MW or larger and owned by a utility or independent power provider, that sells electricity to the bulk transmission grid. Although there have been a few concentrated solar thermal power installations in the United States, most of the recent market growth has been in the PV market.

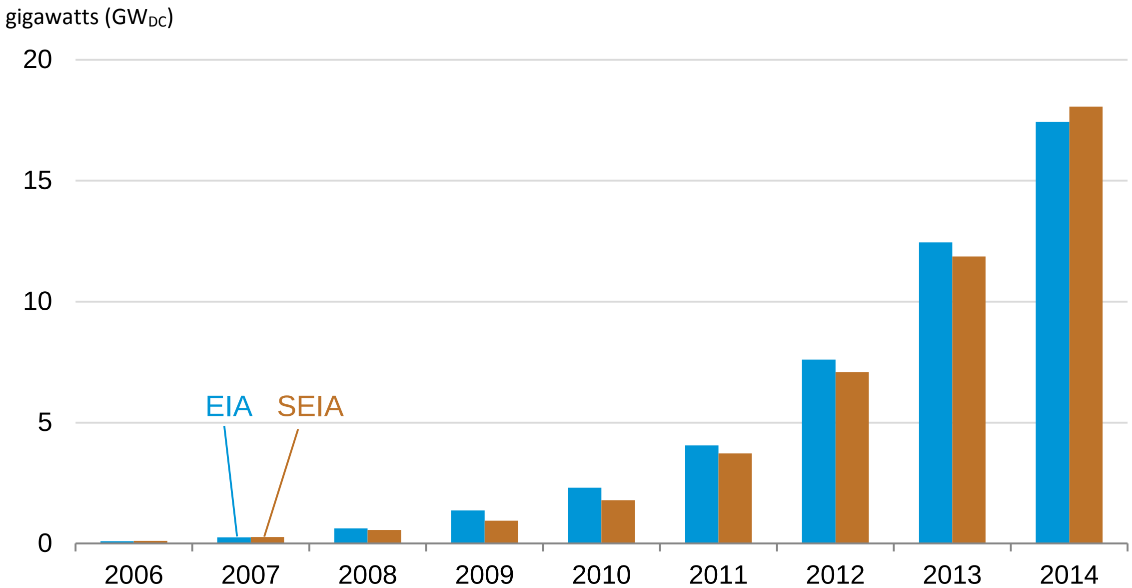
PV modules[25] are typically rated and sold based on their tested peak power output under standard test conditions based on the fundamental direct current (DC) output characteristics of the photovoltaic technology. Because the U.S. electric power grid is operated as an alternating current (AC) grid, the DC output from a PV installation must be converted to AC before the electricity can be used in a grid-tied application (either for sale on wholesale electricity markets or for direct use in an AC household system). Prior to a few years ago, there were few grid-tied PV systems, and industry sources (including EIA's survey of PV manufacturers) tended to report statistics based on the DC rating of systems. Currently, there is a mix of reporting grid-tied system characteristics in DC and AC terms, which can cause

[25] The fundamental building block of a PV installation is the photovoltaic cell. An aggregation of cells, pre-wired and packaged for modular installation, is generally called a "panel" or "module". This report uses both terms interchangeably.

confusion when evaluating both total installed capacity and system cost. While EIA's AEO will generally report utility-scale PV statistics on an AC basis, much end-use reporting is still done on a DC basis.[26] This report uses both conventions as necessary to accommodate available projection and historical data (although a given comparison will always be AC to AC or DC to DC; never AC to DC).

Figure A-7 shows historical cumulative capacity additions for both end-use and utility-scale PV from EIA's various Annual Energy Outlooks and from the Solar Electricity Industry Association (SEIA), with both estimates shown in DC watts. EIA and SEIA estimates for total grid-tied PV were within 4% of each other for 2014, although for most years before 2014, EIA shows somewhat higher PV capacity.

Figure A-7. Cumulative additions of solar PV capacity, 2006-2014



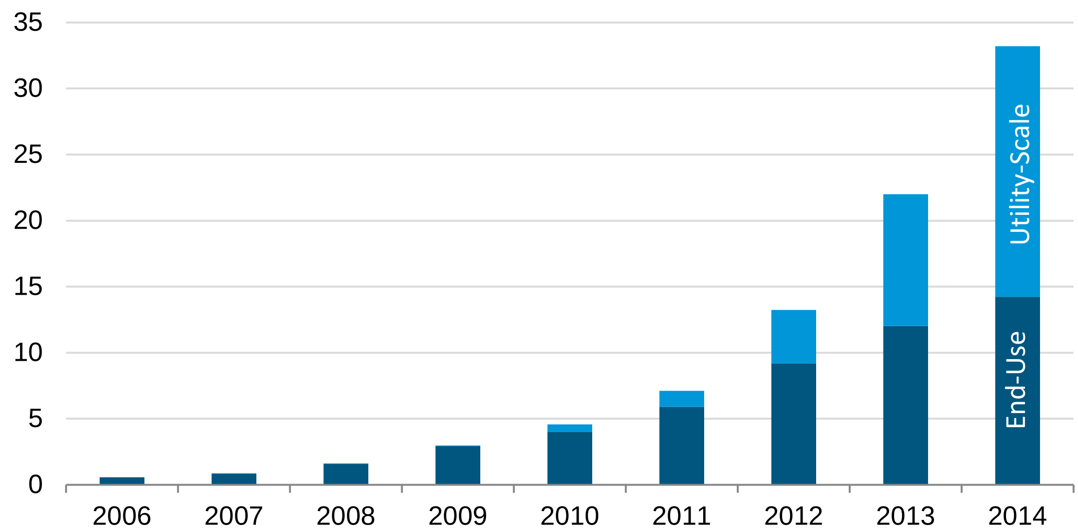
Sources: EIA, *Annual Energy Outlook* (2009–2015 editions); SEIA, Solar Market Insight Report 2014 Q4.
Note: A DC-to-AC ratio of 1.25 was assumed for utility-scale PV capacity.

EIA also regularly publishes current estimates and projections of generation from both end-use and utility-scale PV installations as part of the AEO. These estimates are shown in Figure A-8. Annual estimates of PV generation are not available from SEIA or other reliable market analysts for purposes of comparison.

[26] In order to optimize the cost structure of a project, typical practice for utility-scale PV systems is to size the inverter (which converts the DC power to AC power) somewhat smaller than the rated DC capacity of the panels. Specific AC-to-DC ratios vary across projects; for purposes of AEO projections, EIA assumed AC ratings are 80% of the DC panel rating. For more information, see LBNL's analysis by Mark Bolinger and Samantha Weaver "Utility-Scale Solar 2013: An Empirical Analysis of Project Cost, Performance, and Pricing Trends in the United States" (September 2014).

Figure A-8. EIA estimates for PV solar generation, 2006–2014

billion kilowatthours (BkWh)



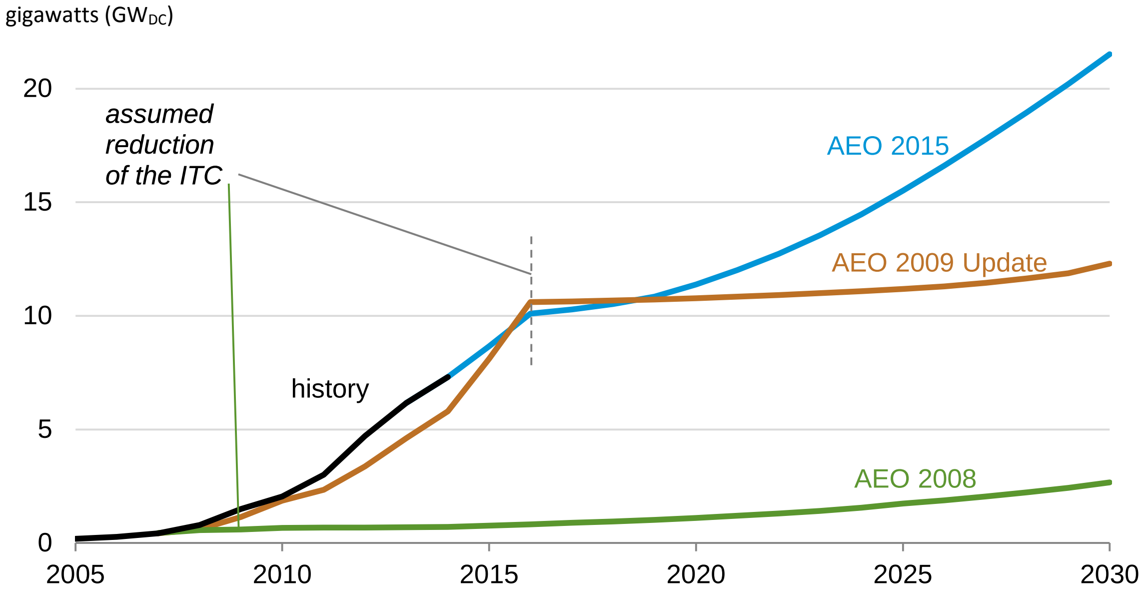
Sources: EIA, Annual Energy Outlook (2009–2015 editions).

Note: An DC-to-AC ratio of 1.25 was assumed for utility-scale PV capacity.

Solar installations in the United States have been substantially supported by both federal and state-level policies. Much like the PTC for wind, the federal Investment Tax Credit (ITC) has played an important role in the growth of solar PV for the United States. The ITC reduces federal income taxes for PV and other solar generators with a tax credit worth 30% of qualified investment expenditures. The ITC has been around in various forms since the late 1970s. Originally the ITC was only available to businesses and not to private individuals. In 2007 the Energy Independence Security Act (EISA) increased the tax credit to 30% and opened it up to the residential sector, but with a limit on how much money homeowners could claim. However, the ITC became more significant to the industry in 2008 when the Emergency Economic Stabilization Act (EESA) was passed, which removed those caps and included an eight-year extension of the 30% ITC for both individuals and corporate project owners. As mentioned previously, per the Consolidated Appropriations Act, 2016, the ITC will decrease annually beginning in 2020, settling at 10% in 2022 for corporate owners and will expire for individual homeowners at the end of 2021.

Changes in tax policy for solar had a significant impact on EIA's solar market projections, as well as on the market itself. EIA's projections for end-use solar installations through 2016 increased by 10 GW between AEO 2008 and AEO 2009, as shown in Figure A-9, following the enactment of EESA and then again in the updated AEO 2009 Reference case, to reflect the enactment of ARRA. Although these projections still underestimated the capacity additions for end-use solar, the capacity additions were within 20% of the estimated capacity. By way of comparison, the AEO 2007 solar capacity projection through 2014 was 90% below the actual capacity installed by that time.

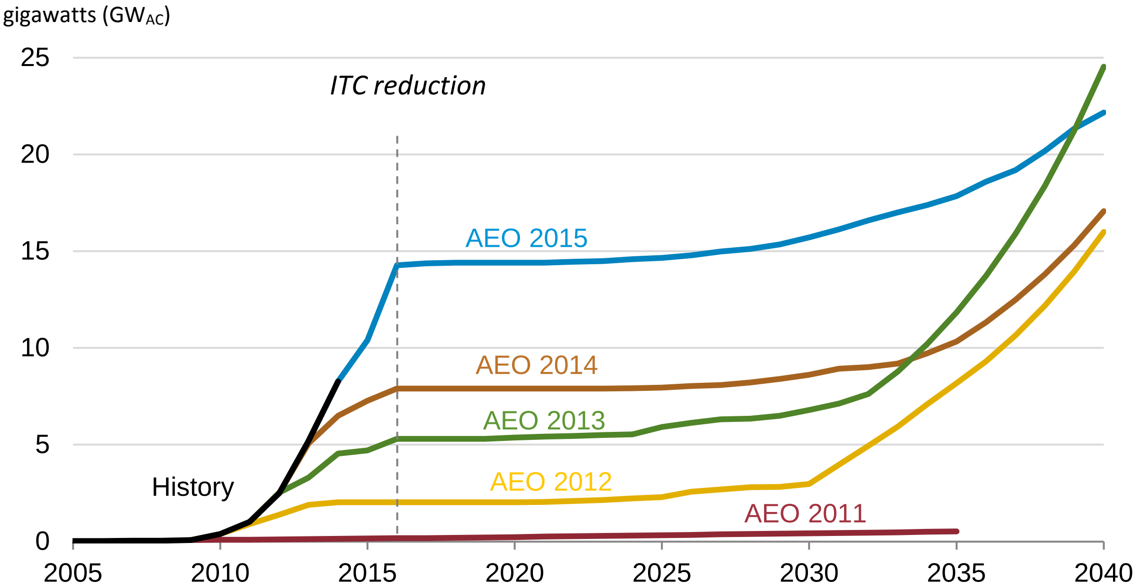
Figure A-9. End-use solar PV capacity projections in AEO 2015, 2009, and 2008 Reference cases, 2005-2030



Sources: EIA, *Annual Energy Outlook* 2008, 2009, 2015.

These early post-EESA projections, however, largely missed the rapid build-out of utility scale-solar PV projects, as seen in Figure A-10. Currently more than half of the solar PV capacity is in the utility sector. More recent AEOs have captured some of this build-out, but projections have generally not been as accurate for the utility sector as they have been for end-use sector PV and for the wind markets.

Figure A-10. Utility-Scale solar PV capacity projections in AEO 2011 to 2015 Reference cases, 2005-2040



Sources: EIA, *Annual Energy Outlook* 2011–2015 editions.

Policies at the local, state, and even international level have made it challenging for EIA to project PV markets in general, but these policies have especially hampered utility-scale projections. Some utility-scale PV development has been the result of programs and support originating at the local level, either from individual utilities or local government. More significant have been policies at the state level, creating more complex and nuanced treatment of solar resources than can be accounted for in EIA's regional projection framework.

The importance of state-specific programs is highlighted by Figure A-11. While also affected by available solar resources, the states with the most utility-scale installations (California, Nevada, Arizona, New Mexico, New Jersey, and North Carolina) all have strong state-level policies specifically targeting solar resources. For example, North Carolina has one of the largest state-level solar ITC programs.

Figure A-11. Utility-scale solar project location

Sources: EIA, Form EIA-860, *Annual Electric Generation Report*

EIA does model the overall state-level targets for Renewable Portfolio Standards (RPS); however the regional structure of the projection cannot effectively capture many state-specific RPS implementation details or other state-level policy mechanisms, such as North Carolina's ITC, nor does it represent technology-specific portions of the RPS, including distributed generation or solar set-asides. Many of these solar-specific policy mechanisms were established or substantially modified within the past five years, and they have limited representation in AEO projections, which represent 22 electricity market regions for utility-scale capacity expansion decisions.

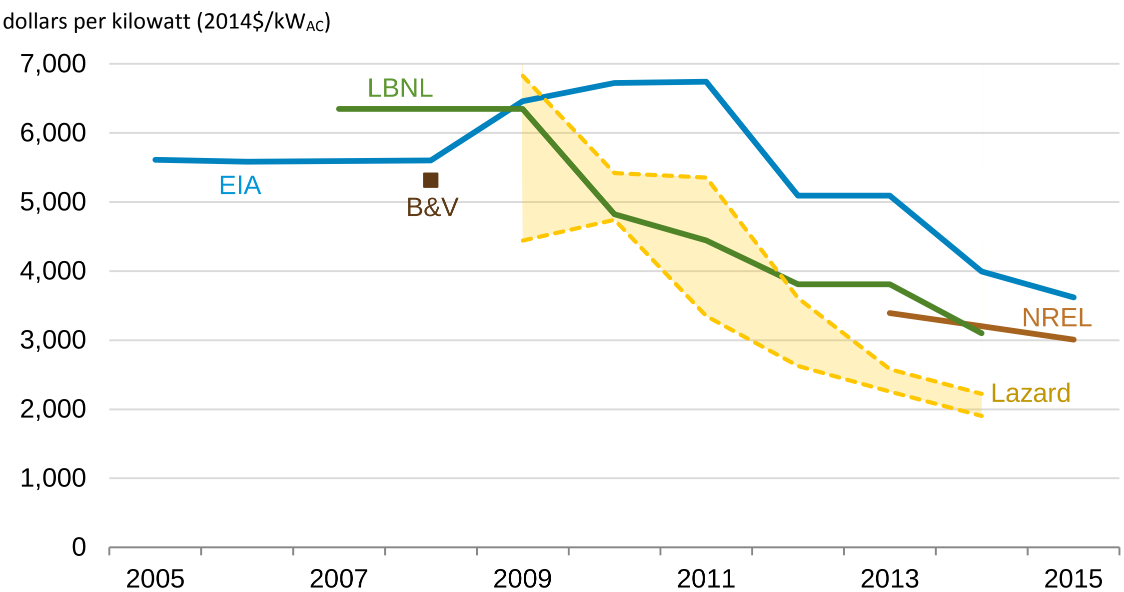
Over the past 10 years, government policies in Europe (Germany and Spain, most notably) created very large new markets for PV technology, where one key factor enabling significant technology cost reductions was through learning effects. These policies, in combination with the fast (and not unrelated) expansion of PV manufacturing capacity in China over the past five years, have contributed to the approximately 75% decline in global prices for PV modules since 2007.[27] EIA does not directly represent these international policy and market impacts in its domestic energy model. Events outside the United States that may affect PV capital cost dynamics in real time must instead be taken into account in EIA's ongoing assumption development processes.

[27] NREL, *Photovoltaic System Pricing Trends* (accessed 10/23/2015), http://www.nrel.gov/docs/fy14osti/62558.pdf .

These factors have generally affected EIA's ability to project utility-scale markets more than end-use markets. The price of the modules to both markets is essentially the same.[28] However, balance of system costs and other non-module installation costs are generally higher for end-use (smaller residential and commercial) systems than they are for utility-scale systems. Because the decline in non-module costs has been much slower than the decline in module costs, the decline in aggregate costs for end-use systems has not been as large as the decline in aggregate costs for utility systems.

While EIA was not able to project the international policy developments that, in large part, precipitated the dramatic decline in costs for solar PV installations, EIA has closely tracked these declines in its assumptions for PV installed costs, as shown in Figure A-12. As with wind generating capacity costs, EIA cost estimates for solar PV that pre-date the availability of observed market data tend to underestimate these costs. Since 2010, EIA cost assumptions have dropped roughly in step with observed market costs, although on average they are 14% higher than costs reported by LBNL.

Figure A-12. Annual estimated capital costs for utility-scale solar PV technologies from various agencies, 2005-2015



Sources: EIA, *Annual Energy Outlook* (2003-2015); LBNL, *Tracking the Sun 2014*; LBNL, *Utility-Scale Solar* (2013-2014); Black & Veatch (B&V), *Cost and Performance Data for Power Generation Technologies*; NREL, *Annual Technology Baseline 2014*; Lazard, *Levelized Cost of Energy* (version 3-8)

The same cautions discussed with respect to the scope of wind generating capacity cost estimates produced by EIA and observable in the project data also apply to solar: EIA is estimating a specific and relatively complete project scope that is not necessarily or consistently captured in the available project data used for the LBNL estimate or in other published cost estimates for these technologies. However, the observed solar project database is generally much smaller than the wind project database used by

[28] Utility project developers may obtain more of a discount for large volume purchases than local installers of rooftop systems, but large, corporate installers will presumably get similar volume discounts. Either way, the dramatic price declines had a roughly proportionate impact on module prices in both sectors.

LBNL (although in some years, wind may have fewer projects than solar, there has been much more wind installed over the past 10 years than solar). Additionally, the technologies represented in the solar project database are much more diverse (with different fundamental system configurations and even fundamentally different cell technologies). Therefore, the uncertainty range on the solar PV statistics is much greater than the range for wind generating capacity.

Factors such as natural gas prices, demand for new sources of generation, and the impact of nonrenewable electricity policies also have a significant impact on solar PV projections. Other factors affecting solar PV projections may include the representation of intra-regional variation in resource quality, load shape (of particular importance for a resource with a highly predictable and highly constrained output profile), and localized variation in time-of-day value of the resource.

EIA is dedicated to continually enhancing its modelling efforts to more accurately reflect real-world changes in the solar industry. Activities EIA is currently undertaking to improve model results include annually re-evaluating project costs, analyzing policy side cases, examining different technology options, and re-examining the solar value proposition with respect to retail tariff structures.

Furthering EIA's efforts to more accurately capture trends within the solar industry, EIA has been working with industry organizations, such as SEIA, to develop a monthly report of electric generation from solar PV, which EIA released in November of 2015.

EIA projection side cases and key assumptions affecting the outlook for wind and solar

Most of the projections discussed above and in recent critiques of EIA's work are based on the AEO Reference case, which is the most visible of the cases presented in each AEO. EIA's AEO Reference case is neither intended as a *most likely* outcome or as an average or median value of the published side cases. Instead, the Reference case represents EIA's best estimate of energy market evolution given the implementation of current laws and policies at the state and federal level as of the time a particular projection is being prepared. By having a Reference case that incorporates current laws and regulations, EIA can isolate the impacts of proposed new laws and policies compared to implementation of current law. The side cases then provide a platform for measuring the difference between the current policies (Reference) scenario and alternatives based on uncertainty in current market conditions, future market evolution, or significant changes to policy.

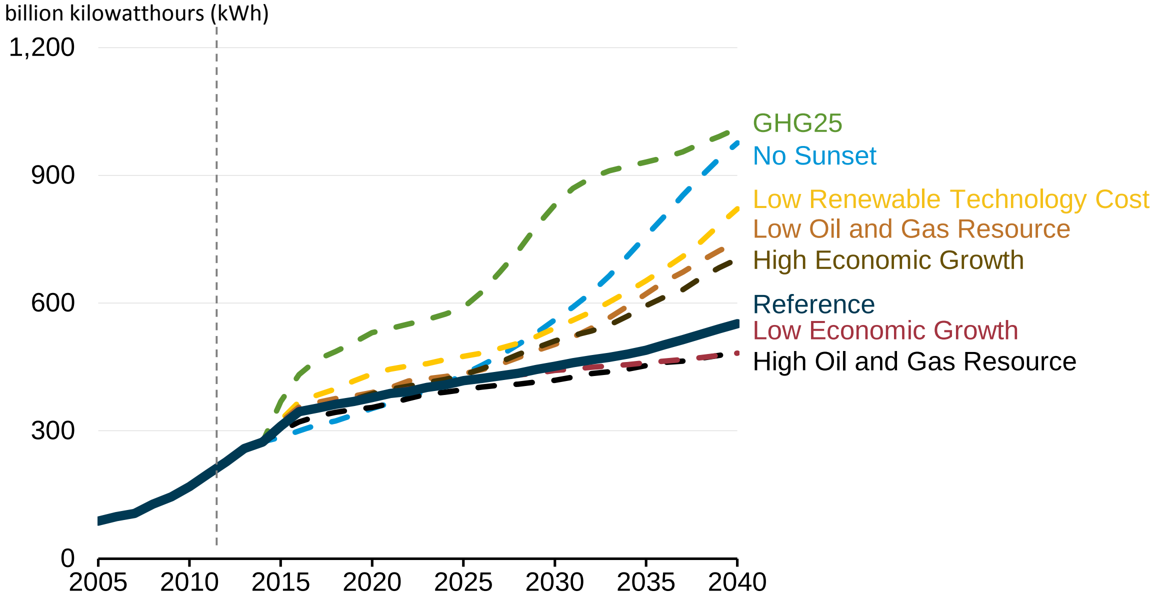
The side cases help EIA explore a number of different uncertainties. As shown in Table A-1, in previously published AEO reports EIA used these common side cases to examine uncertainties that may affect the demand for renewable energy, the cost of renewable technologies, the price of natural gas (a key fuel that competes with renewable energy to serve electricity generation markets), and key policies that might affect renewable energy deployment.

Table A.1. Description of Reference and Side Cases for a Typical AEO Report

Reference	Assumes no changes in policy or law; laws with an expiration date are assumed to expire as scheduled.
Low Economic Growth	Real GDP grows at an average annual rate lower than the Reference case. Other energy policy/market assumptions are the same as in the Reference case.
High Economic Growth	Real GDP grows at an average annual rate higher than the Reference case. Other energy policy/market assumptions are the same as in the Reference case.
Low Oil and Gas Resource	Estimated ultimate recovery (EUR) per shale gas, tight gas, and tight oil well is lower than in the Reference case.
High Oil and Gas Resource	Estimated ultimate recovery (EUR) per shale gas, tight gas, and tight oil well is higher than in the Reference case. Also, tight oil resources are added and well spacing is closer than in the Reference Case.
Low Renewable Technology Cost	Capital costs for new non-hydropower renewable generating technologies are reduced in each year relative to corresponding costs in the Reference case.
No Sunset	Assumes extension of all existing tax credits and policies that contain sunset provisions, except those requiring additional funding (e.g., loan guarantee programs) or extensive regulatory analysis. Ethanol and biodiesel subsidies are extended.
GHG25	Applies a price for CO2 emissions throughout the economy, starting at $25/metric ton and rising through the projection period.

Side cases allow EIA to explore a number of different uncertainties in projections and should not be viewed as confidence intervals with symmetric impacts on any given market segment (that is, the side cases are not designed as simple model sensitivities, or risk variance cases). As shown in Figure A-13, AEO 2014 Reference case renewable projections tend to fall on the lower end of range of projections from the renewable-related side cases in that publication. While projected growth generally exceeds the targets established by state RPS policies, these policies do effectively create a lower bound for renewables growth. However, there is not a parallel bound on the upside, and as renewables become increasingly cost competitive, these results become increasingly sensitive in the upward direction. In all cases, long-term growth is generally projected to be higher than near-term growth, as near-term demand for new generating capacity of any type (renewable or conventional) is constrained by the substantial build-out over the past 5-10 years of natural gas, wind, and solar capacity, and the slow (sometimes negative) electric demand growth seen over that same timeframe.

Figure A-13. U.S. non-hydropower renewable electricity generation in eight cases (2005-2040)



Source: EIA, Annual Energy Outlook 2014, EIA Conference 2014, *The Outlook for Renewable Electricity*

Over the past several decades, growth in renewable electricity markets has been closely tied to both state and federal policies that directly target renewable energy technologies. While in a constant state of flux, starting in 2009, federal policies, especially toward wind generating capacity, were relatively constant and stable over a four-year period, and as a result, the projections presented in the AEO reports during this period are well-aligned with actual policy outcomes.

Going forward, EIA recognizes that EPA has recently released final regulations pertaining to carbon emissions from both new and existing fossil fuel plants (the Clean Power Plan, under Sections 111(b) and 111(d) of the Clean Air Act, respectively).[29] In May 2015, EIA released its Analysis of the Impacts of the Clean Power Plan that evaluated the potential impacts of EPA's June 2014 proposed rule for existing fossil generators under section 111(d). The analysis shows that the proposed Clean Power Plan rule would result in a substantial increase in both wind and solar capacity, as shown in Figure 3. Because the AEO always reflects current laws and policies, the AEO2016 Reference case will reflect EIA's final Clean Power Plan rules issued in August 2015, as well as the new provisions to the PTC and the ITC, as described in the Consolidated Appropriations Act, 2016.

On December 18th 2015, both the PTC for wind and Investment Tax Credit (ITC) for solar were extended as a part of the Consolidated Appropriations Act, 2016. The extension maintains the current credits through the end of 2016; the 2.3-cent-per-kilowatthour wind PTC will remain in place for projects that have commenced construction by December 31, 2016. Incremental reductions in the value of PTC

[29] In June 2014, EPA issued its proposed Clean Power Plan to regulate CO2 emissions from existing power plants under section 111(d) of the Clean Air Act.[2] The Clean Power Plan proposes to limit carbon emissions from existing fossil fuel-fired electric generating units, including steam generating, integrated gasification combined-cycle, or stationary combustion turbines (in either simple-cycle or combined-cycle configuration) operating or under construction by January 8, 2014.

credits for wind energy will begin for projects commencing construction in the following year, dropping to 80% of full value in 2017 (to about 1.8 cents per kilowatthour), 60% in 2018 (to about 1.4 cents per kilowatthour), 40% in 2019 (to about 1 cent per kilowatthour), and then complete expiration in 2020. The current 30 percent ITC for residential and commercial solar, previously scheduled to expire at the end of 2016 for projects not yet in service, will remain for projects commencing construction through 2019, but in following years will begin to taper off: the credit will fall to 26% in 2020, 22% in 2021. The ITC goes away for residential projects commencing construction in 2022 while the credit drops to 10% in 2022 for commercially-owned projects[30]. These provisions will be included in the AEO2016 reference case.

Other future policies remain uncertain. Few states have established new RPS policies in the past few years; however, there have been numerous changes to RPS policies, including policies that expand the scope of the policy and those that have restrained the potential impact of these policies. Some potential future policy developments and trends are better understood, but remain too uncertain to effectively model and project the impact.

Summary

Recent criticisms of EIA projections for wind and solar markets have included exaggerated, misleading, or simply false conclusions regarding the accuracy and usefulness of EIA's results. Although EIA projections are not always accurate, and are better in some areas than others, careful review shows EIA projections to be reliable indicators of overall energy market conditions and the importance of federal and state policies for utility-scale wind and end-use solar markets. Utility-scale solar projections have not been as reliable as projections for residential/commercial solar and wind systems, because this market has been more subject to the direct effects of state policy and the indirect effects of international developments, as well as experiencing unanticipated rapid declines in PV unit costs.

EIA's AEO Reference case projections provide a critical jumping-off point for analyses that assess the implications of potential new policies that go beyond current laws and regulations. But it is vital to consider the EIA Reference case in its proper context, incorporating existing laws and policies rather than as a singular *most likely* case. The Reference case, which assumes the expiration of existing tax credits for renewable energy as specified in current law, also provides useful insight into the implications of an expiration of tax credits for future growth in wind and solar capacity. In both respects, EIA projections are more relevant and useful than any simple extrapolation of past trends, which are heavily influenced by policies that might not be in place for the projection period, and which cannot account for complex dynamics in the U.S. energy markets such as fuel prices, emissions regulations, and changing demand conditions.

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[30] Solar installations that are owned by private individuals (that is, directly by a home owner) are governed by a different section of the U.S. tax code than for-profit installations. Credits for these owners will expire completely on January 1, 2022. Residential installations that rely on a "third party ownership", where a commercial entity owns the system and sells the power directly to the host home owner, are eligible for the business (for profit) tax credit, and thus will remain eligible for a 10% tax credit in 2022 and beyond.

State-level policies also play an important role in determining the outlook for new renewable capacity and generation. More than half of the states have RPS policies, and the rate of new RPS policy adoption has slowed considerably from the rate 5 or 10 years ago. Several existing policies will reach their final target in the next couple years, and nearly all RPS policies reach their maximum target in or before 2025. Whether or not states have met their terminal target, many states are already exceeding their interim goals. The rules for net metering limits, compensation, and grid charges are still being worked out. These rules have been a topic of debate and regulatory action in several state legislatures, public utilities commissions, and utilities over the past year.

In addition, despite the fact that renewables are increasingly competitive with traditional electricity generation technologies over time, growth potential is limited by several factors, including:

- Slow electricity demand growth
- Relative cost of new renewable installations that would displace existing generation from traditional generation fuels
- Low natural gas prices
- Electricity grid interconnection/integration concerns

Even with these challenges, a careful review of EIA projections shows that EIA's approaches have had a good track record of representing growth for wind and distributed PV markets. In particular, EIA's projections have accurately reflected the impact of key federal tax incentives on these markets. While gaps between projected and realized outcomes have sometimes occurred, these gaps have largely resulted from a divergence between policy assumptions used in developing the projections and the policies ultimately adopted by Congress and the states. In the case of utility-scale PV, the gaps have resulted from an inability to model both very narrow state-level geography and the impact of global events. EIA's projections are reasonably accurate when policy assumptions closely represent realized policies, but may "miss" when policy assumptions do not line up with realized policies. This kind of accuracy suggests that EIA's modeling methodology and renewables projections are well-suited for their intended purpose: to provide a baseline projection with which to measure the impact of policy proposals that may have a significant impact on energy markets.

While EIA stands by the overall methodology used to develop its wind and solar projections, it is committed to continuing efforts to improve areas of weakness identified above. EIA will also continue to assess renewable electricity technologies, markets, and policies to keep abreast of the latest developments and to improve analytic capabilities in this fast-growing and fast-changing environment. Just as policy and market developments over the past 10 years have made EIA projections from 10 years ago largely obsolete, policy and market developments happening now, such as implementation of EPA's Clean Power Plan and the extension of tax credits for wind and solar technologies, will result in dramatic changes to the renewables market trajectories over the next 10 years. Still unknown and unknowable are the policy and market innovations of the future. While EIA strives to anticipate market evolution and keep up-to-date with changing policies, EIA is not able to accurately represent policies and market conditions that have yet to develop. Nevertheless, EIA's record for projecting renewable energy markets over the past 5 to 10 years has provided useful insight to evaluate policy options for U.S. energy markets.