Bill Savings in a Clean Energy Future

Clean Power Means Lower Bills for States

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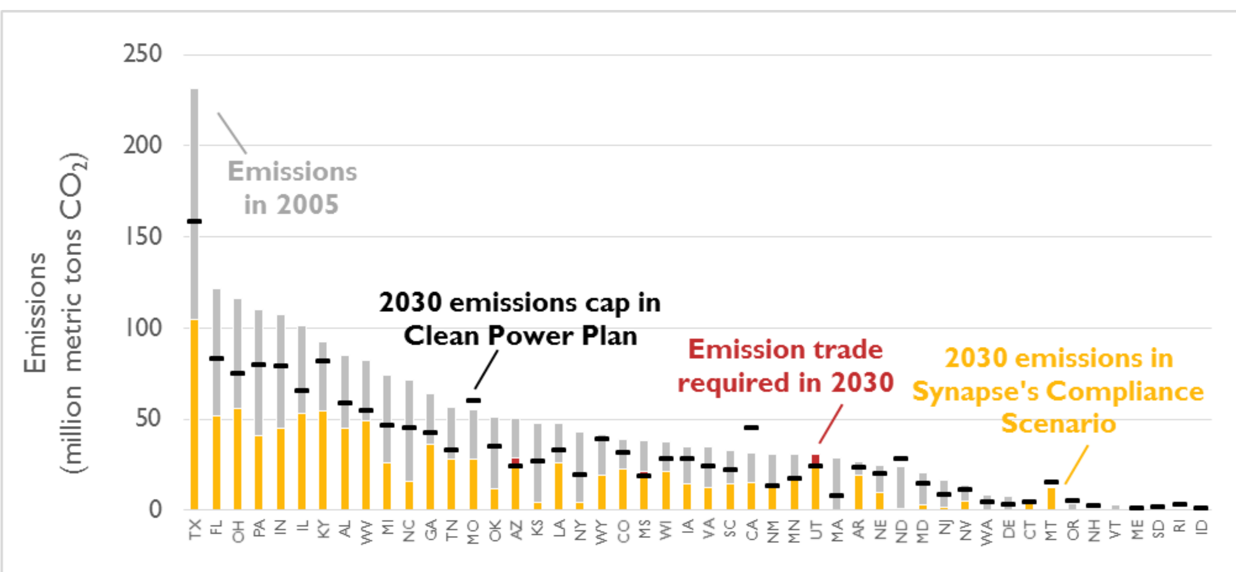
EXECUTIVE SUMMARY

On June 2, 2014, the U.S. Environmental Protection Agency (EPA) released its proposed Clean Power Plan under Section 111(d) of the Clean Air Act. The Clean Power Plan aims to reduce emissions of carbon dioxide (CO_2) from existing fossil fuel-fired power plants by approximately 30 percent below 2005 levels by 2030. Synapse Energy Economics, Inc. (Synapse) analyzed the impacts of the proposed Clean Power Plan on electricity consumers in every state modeled by modeling what would happen if each state invested heavily in energy efficiency and renewable energy. Analysis showed that reducing electricity sector emissions through the addition of energy efficiency and renewable energy actually lowers electricity costs over the long term compared to continuing with existing practices and policies. Moreover, in Synapse's modeling, the scenario that produced those lower electricity costs achieved a much greater emissions reduction on average than that called for by the proposed Clean Power Plan.

In a Synapse Clean Power Plan compliance scenario with strong energy efficiency and renewable energy investments (the "Clean Energy Future" scenario), consumer bills are expected to fall while states meet or exceed their emissions targets. For the two-thirds of residential consumers who participate in ratepayer-funded energy efficiency programs under this scenario, 2030 bills are expected to be $35 per month lower than in a business-as-usual ("Reference") scenario and, on average, $14 per month cheaper than residential bills were in 2012.

As reported in Figure ES-1, in 2030, the vast majority of states have far lower CO_2 emissions than their target levels under the proposed Clean Power Plan. On average, states achieve a 58 percent reduction in CO_2 emissions in Synapse's Clean Energy Future scenario.

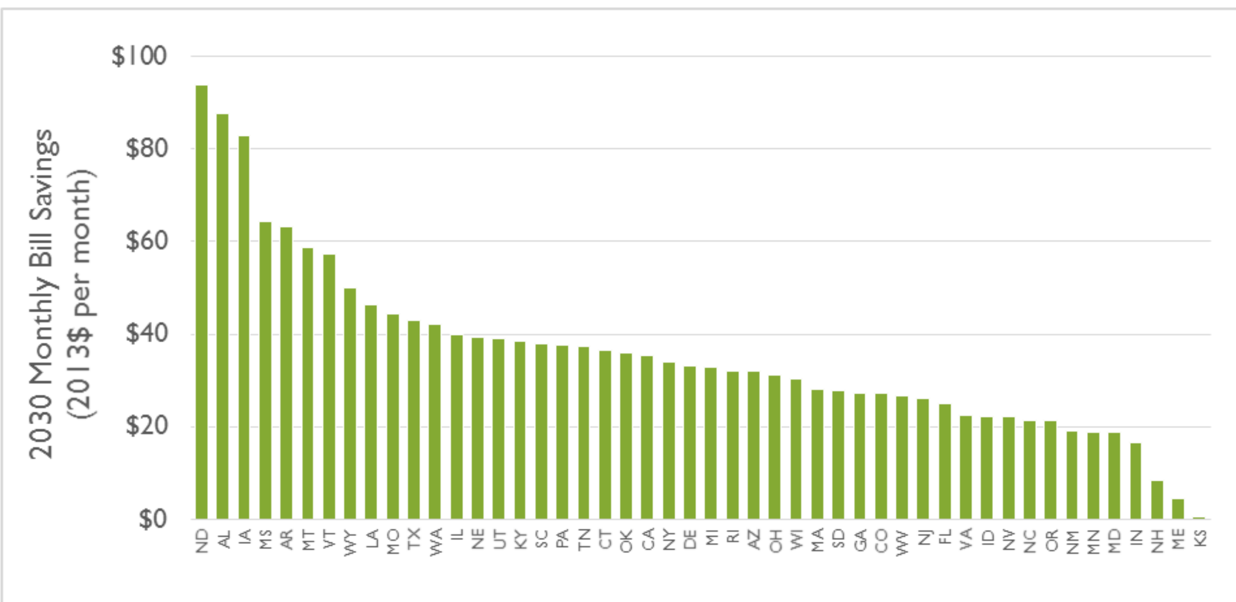
Figure ES-1. CO_2 emissions (Clean Power Plan target and Clean Energy Future result) in 2030 compared to 2005



In Synapse's Clean Energy Future scenario, most electric-sector investments are in renewables and efficiency, and all states achieve Clean Power Plan compliance. Monthly bill savings for participants in energy efficiency programs range from $0.50 in Kansas up to $94 in North Dakota, as reported in Figure ES-2. Even after accounting for households' share of the cost of energy efficiency, this Clean Power Plan strategy saves consumers money on their electric bills in 2030. The Clean Energy Future energy efficiency investments are aggressive, but realistic: they are based on levels already achieved in several states.

Electricity customers in the Clean Energy Future scenario save the most in states that are "first movers", meaning their states invest in new renewable energy sources early on. Their electricity costs decline even after incorporating the integration costs for wind and solar to account for variability and capacity factors. First mover states are able to export clean power in later years to those states that continue to depend heavily on existing fossil fuel plants, which must eventually be retired. Those states that exceed Clean Power Plan compliance are also able to sell compliance credits to states that miss their targets, although these credits are expected to cost very little. In the interim period, all but 15 states will be in compliance and add to an abundance of supply that will drive down compliance credit prices.

Figure ES-2. 2030 residential monthly bill savings for energy efficiency participants in the Clean Energy Future



Additional description of this analysis can be found in the brief accompanying this report, *Clean Power Means Lower Bills for Consumers*, available at http://synapse-energy.com/clean-power-plan-means-lower-bills-brief.

1. INTRODUCTION

On June 2, 2014, the U.S. Environmental Protection Agency (EPA) released its proposed Clean Power Plan under Section 111(d) of the Clean Air Act. The Clean Power Plan aims to reduce emissions of carbon dioxide (CO_2) from existing fossil fuel-fired power plants by approximately 30 percent below 2005 levels by 2030.[1] Achieving this level of emissions reductions may require significant changes to the nation's electric system, but these changes need not come at an increased cost to consumers. EPA is expected to release the final rule in late summer 2015.

Synapse conducted an analysis of the impacts of intensive investment in renewables and efficiency on electric-sector emissions and costs, presented in our accompanying policy brief, *Clean Power Means Lower Bills for Consumers*. In this background report to the brief, we document the data, assumptions, and results related to modeling the emissions reductions of two scenarios of the future U.S. electric system: a "Clean Energy Future" approach to Clean Power Plan compliance that emphasizes cost-effective energy efficiency and renewable energy investments, and a business-as-usual "Reference" scenario.

In this analysis we modeled the intent of the Clean Power Plan (rather than the details of the proposed rule which are still under review and likely to change). The Clean Power Plan calls for affordable CO_2 emission reductions in the electric sector. We designed our inputs to achieve a "no-regrets" cost scenario with lower emissions. The amount of emission reduction was an output of our modeling.

Our Clean Energy Future scenario represents a substantial shift towards renewable generation as the costs of these technologies continue to decline and incentives are put in place to encourage adoption. Aggressive energy efficiency policies reduce total demand by 22 percent as compared to the Reference scenario in 2030, even after accounting for the impacts that an expansion of electric vehicles would have on the electric sector.[2]

The Reference scenario is a "no new policy" scenario in which existing state renewable portfolio standards are met but not expanded. New load is met largely by new gas-fired generating capacity, and the existing fleets of coal-fired and nuclear plants are retrofit to continue operating.

The Clean Energy Future scenario meets or exceeds EPA targets in all states and obtains higher levels of total national emission reductions—58 percent below 2005 levels by 2030—compared to the 30 percent reduction achieved by EPA's proposed Clean Power Plan. As demonstrated in Synapse's recent report on

[1] Previous Synapse reports on the implications of the Clean Power Plan and best practices for planning for Consumer advocates include Stanton, E. A., et al. 2014. *Final Report: Implications of EPA's Proposed Clean Power Plan,* available at http://synapse-energy.com/sites/default/files/Final%20Report%20-%20Implications%20of%20EPAs%20Proposed%20Clean%20Power%20Plan%2014-026.pdf and Wilson, R. et al. 2015. *Best Practices in Planning for Clean Power Plan Compliance,* available at http://synapse-energy.com/sites/default/files/NASUCA-Best-Practices-Report-15-025.pdf.

[2] By 2030, electric vehicles make up 1.9 percent of total electric load in the Clean Energy Future.

air emission displacement, high levels of energy efficiency and renewables take the place of fossil fuel generation; the result is the avoidance of substantial emissions.[3] Even with substantial emission reductions, we found that with participation in energy efficiency programs, the average household can save $35 per month on its electric bills in the Clean Energy Future in 2030 as compared to the high-emissions Reference scenario.

This report discusses the methodology used to calculate emissions and household bills under each scenario, along with the state-by-state results of Clean Power Plan compliance and household bill impacts in the Clean Energy Future scenario.

2. METHODOLOGY OVERVIEW

Synapse developed its Clean Energy Future and Reference scenarios using the ReEDS, CAVT, EE Savings Tool, CP3T, and RePRT models together with publicly available data.

Using this combination of models, we analyzed compliance with EPA's proposed Clean Power Plan and bill impacts in two scenarios, a compliance scenario featuring extensive investment in energy efficiency and renewable energy ("Clean Energy Future"), and a business-as–usual ("Reference") scenario with no new policies to meet EPA targets. See Appendix A for more information on the methodology used in this analysis. For more detailed information on the development of these scenarios, see Synapse's July 2015 *Clean Energy Future Technical Review*.[4]

In this analysis we compared Clean Energy Future to Reference case bill savings in 2030 (the final year of requirements under the proposed Clean Power Plan), and 2030 emissions and bill savings to their near-current levels. Data availability lags behind the current day with 2012 being the most recent year of data available for the particular data used by EPA. Some other electric-sector data (such as emissions, plant-level generation, and energy efficiency savings) are available for 2013 or 2014, but 2012 is the most recent year in which *all* required data are available. Furthermore, this is the same year that EPA uses in its proposed Clean Power Plan baseline, making it a helpful reference point for our comparisons.

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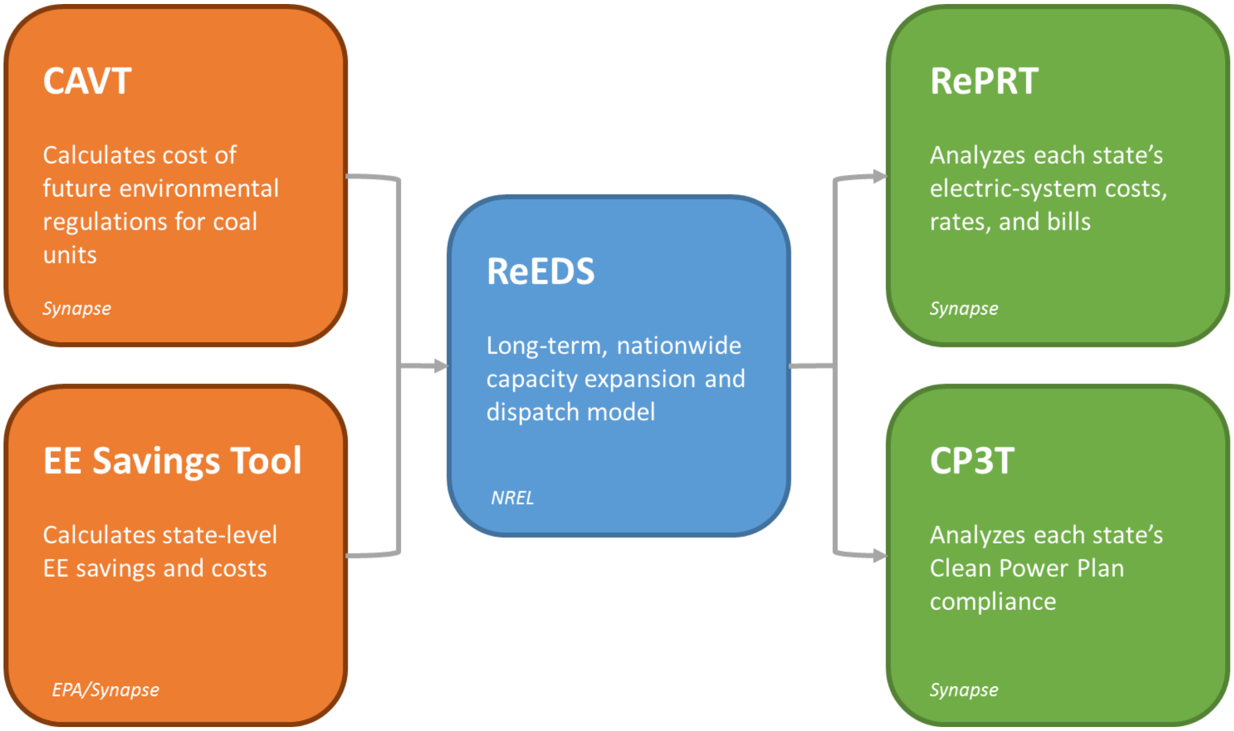
[3] Biewald, B. et al. 2015. *Air Emissions Displacement by Energy Efficiency and Renewable Energy.* Available at http://www.synapse-energy.com/sites/default/files/Air-Emissions-Displacement-by-Energy-Efficiency-and-Renewable-Energy_0.pdf.

[4] Fields, S, et al. 2015. *Clean Energy Future Technical Review*. Available at http://www.synapse-energy.com/sites/default/files/Clean-Energy-2040-Technical-Review.pdf.

Figure 1 depicts the interrelations of the models used in this analysis.

Figure 1. Schematic of models used in Clean Energy Future analysis

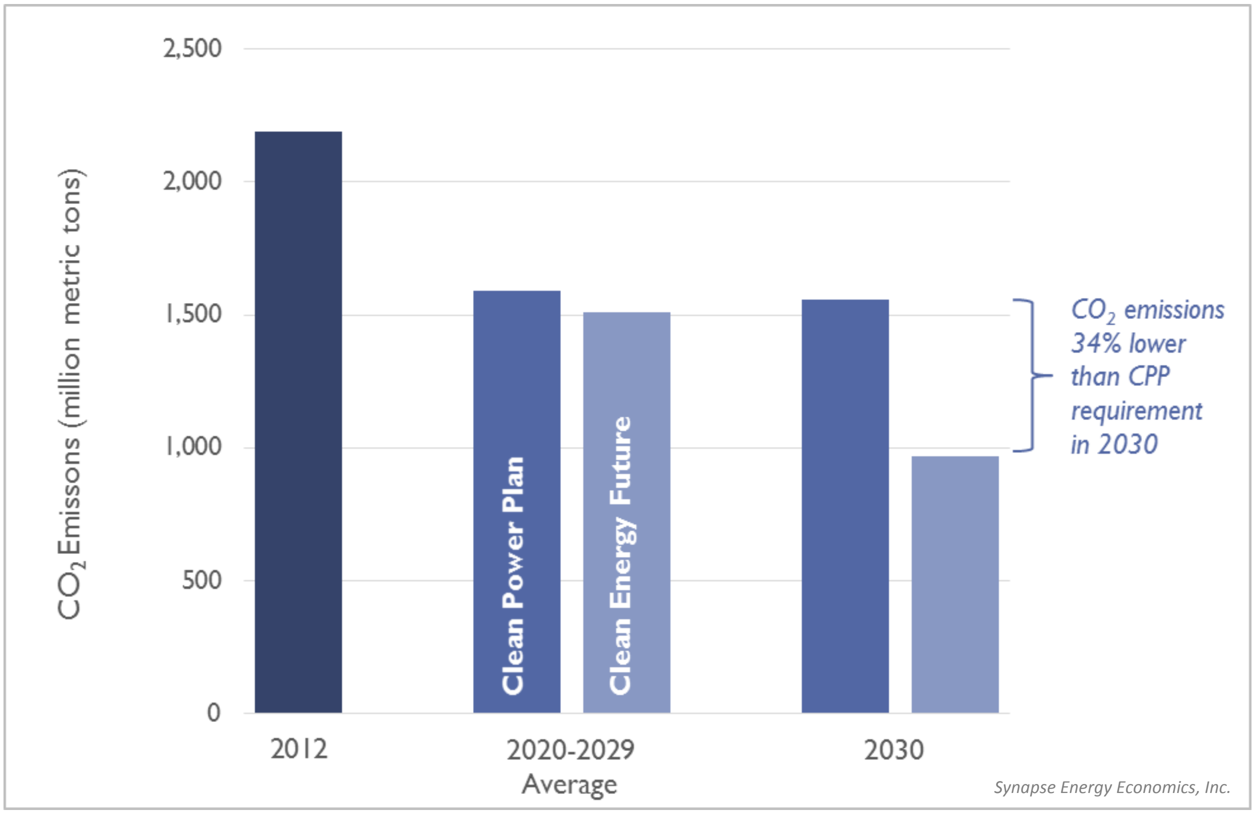


3. Emissions Results

In 2030 in the Clean Energy Future, all states comply with EPA's mass-based targets for the proposed Clean Power Plan.[5] Figure 2 illustrates the U.S. total electric-sector CO_2 emissions in 2012, and compares emissions in the Clean Energy Future to EPA's targets in the proposed rule for two time periods: an annual average for the 2020-2029 period and 2030.

[5] EPA. 2014. *Rate to Mass Technical Support Document.* Available at http://www2.epa.gov/sites/production/files/2014-11/rate_to_mass_translation.xlsx.

Figure 2. Emissions in 2012, 2020-2029, and 2030 for Clean Power Plan targets and the Clean Energy Future

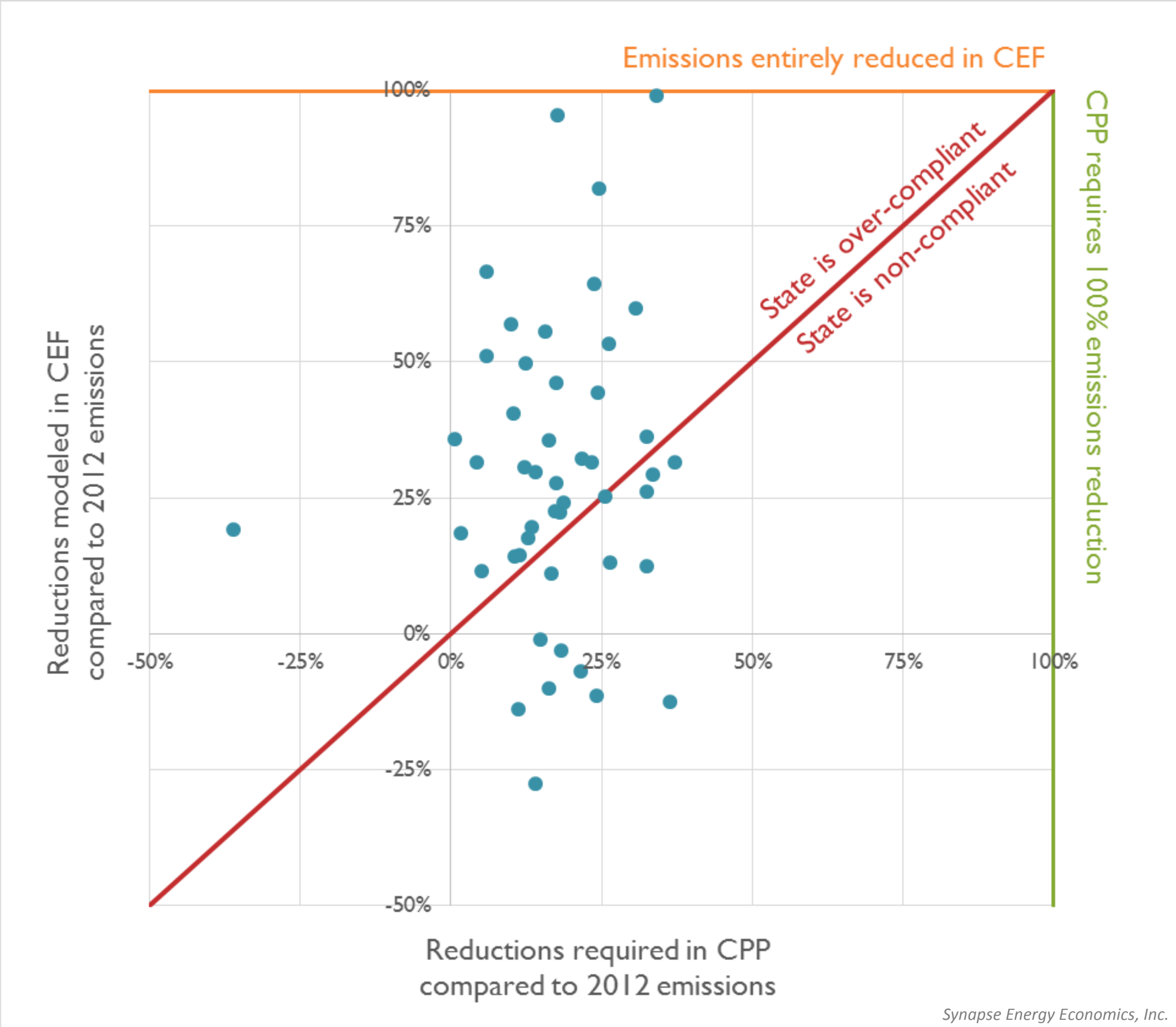


While emission targets in the proposed Clean Power Plan are calculated on a state-by-state basis, the aggregate national emissions are 34 percent lower than the 2030 target in the Synapse scenario. Figure 3 and Figure 4 compare states' Clean Energy Future emissions and proposed Clean Power Plan targets in the 2020-2029 and 2030 periods, respectively. We assumed that states with emissions greater than their target purchase CO_2 compliance certificates at low cost from states that over-comply. These figures show Clean Energy Future emissions using the proposed Clean Power Plan formula but prior to any trade in certificates with other states.

As shown in Figure 3, on average in the 2020-2029 period, 15 states have emissions greater than their targets prior to trading in CO_2 compliance certificates with other states. Thirty-two states over-comply with the proposed Clean Power Plan during this period, resulting in 13 available compliance credits for every unmet emission reduction obligation.[6] The supply of compliance credits greatly exceeds demand, and, for this reason, the price associated with compliance credits would be very low. During this period Delaware, Oregon, and Washington are shown near the top, orange edge of the chart, indicating that these states have reduced their emissions compared to 2012 by over 75 percent. See Appendix B for a discussion of compliance with the proposed Clean Power Plan in the 2020-2029 interim period.

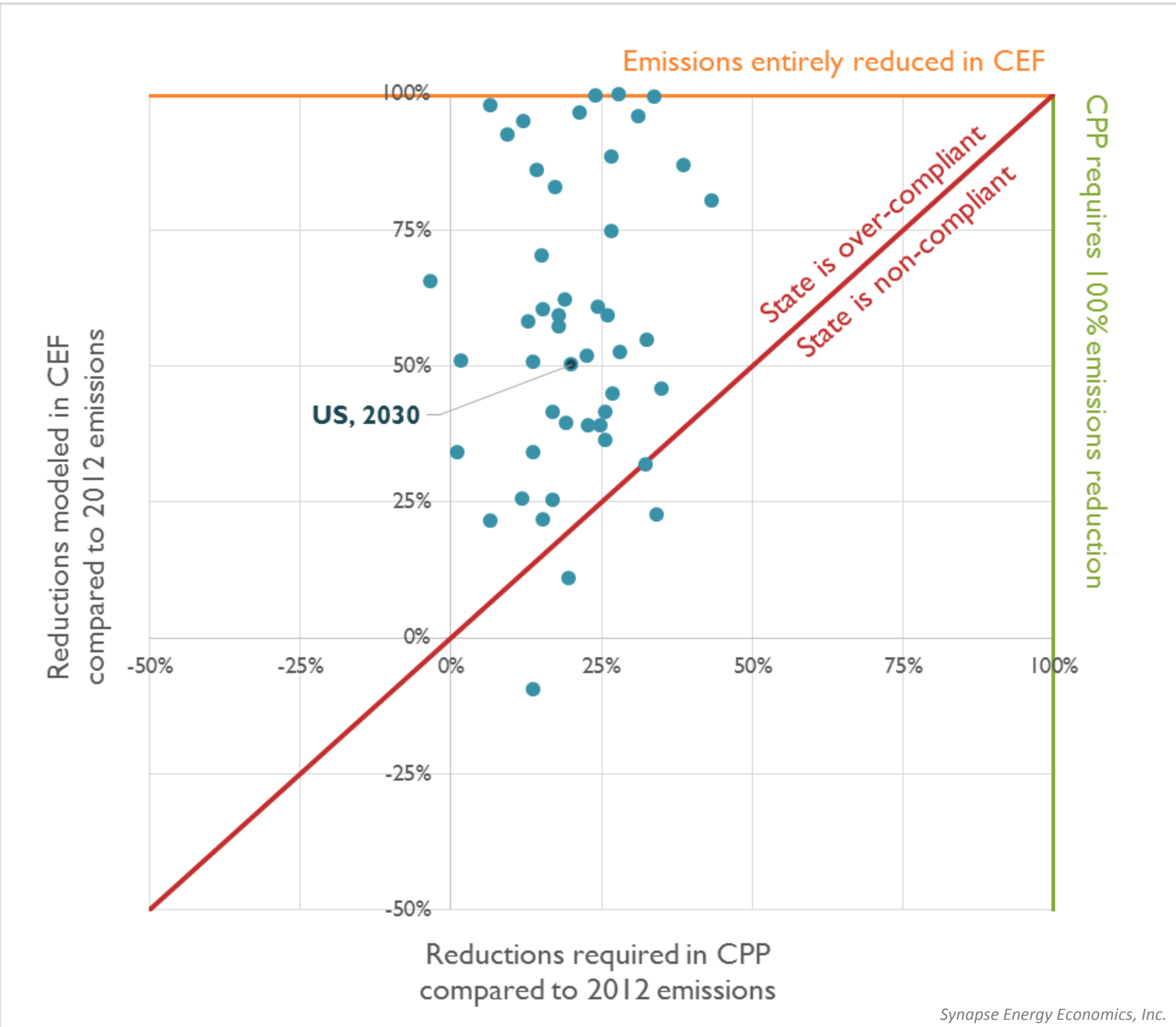
[6] Note that Vermont is the only state in the Lower 48 that is not obligated to meet a compliance target in the Clean Power Plan.

Figure 3. Average 2020-2029 emissions as a percent of 2012 emissions for each state's Clean Power Plan compliance target compared to Clean Energy Future emissions



As shown in Figure 4, in 2030 in the Clean Energy Future, national electric-sector emissions are 50 percent lower than they were in 2012. In this year, four states (Arizona, Minnesota, Mississippi, and Utah) emit CO_2 in excess of their targets. As with the 2020-2029 period, the available certificates from over-complying states far exceed the number required: there are 375 available compliance credits for every unmet emission reduction obligation. In this year, 15 states' reductions from 2012 levels exceed 75 percent.

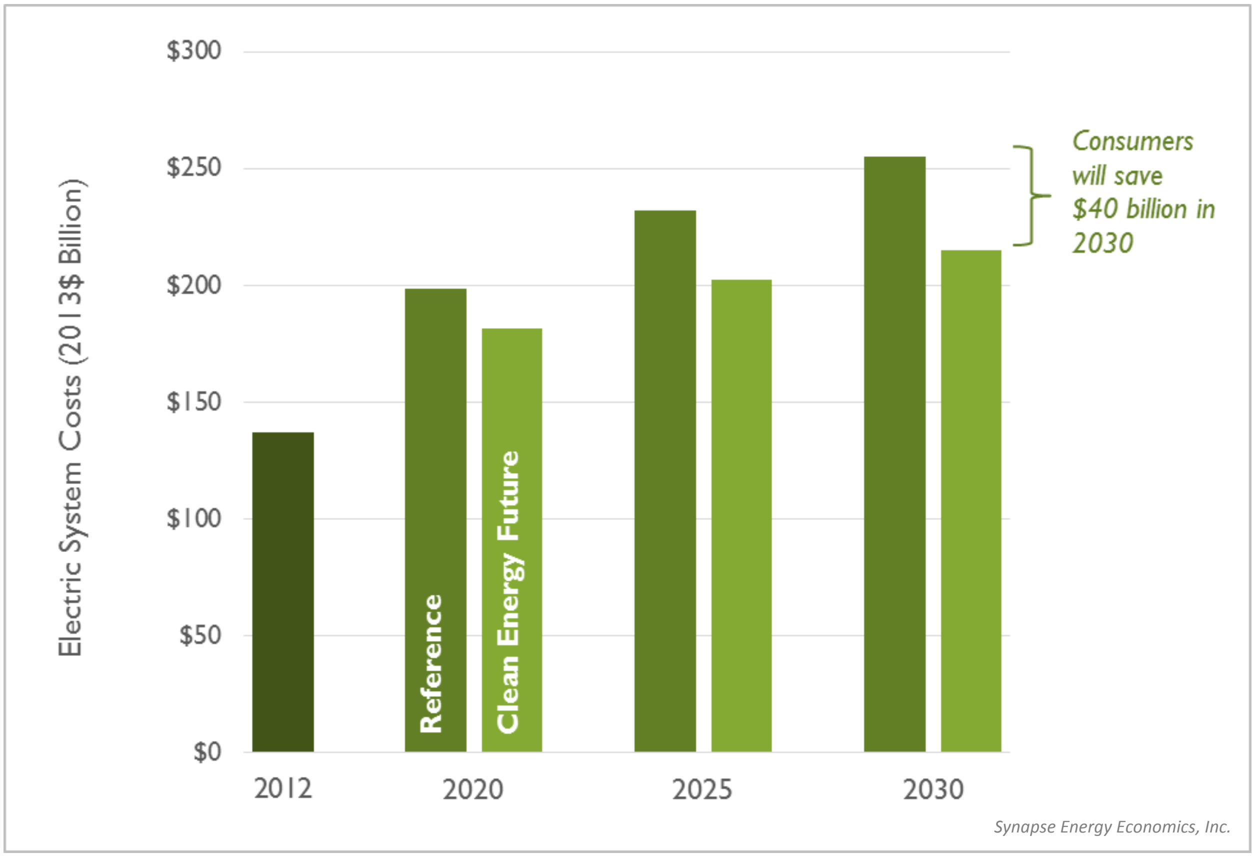
Figure 4. 2030 emissions as a percent of 2012 emissions for each state's Clean Power Plan compliance target compared to Clean Energy Future emissions



4. Cost and Bill Results

Even in a scenario in which states meet or exceed their EPA targets and CO_2 emissions are dramatically lower than the levels required in the proposed Clean Power Plan, costs to consumers need not rise. In 2030, investments in high levels of energy efficiency and renewables result in $40 billion of savings in total U.S. electric-system costs (see Figure 5).

Figure 5. Estimated electric system costs in 2020, 2025, and 2030 in the Reference and Clean Energy Future scenarios

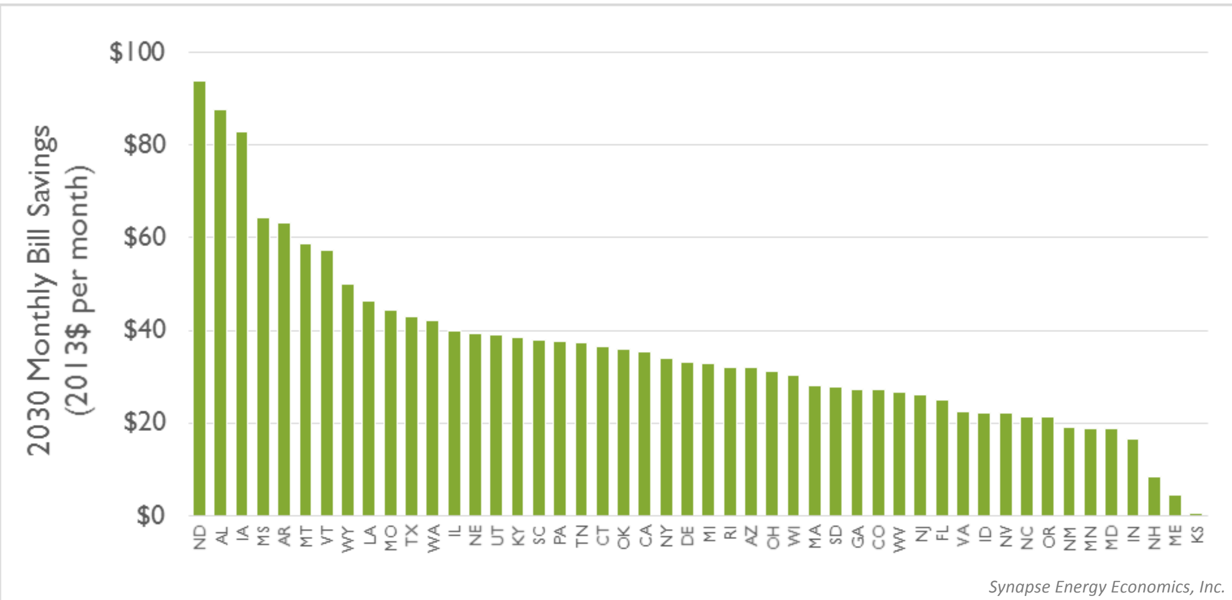


Over time, costs are expected to decrease as a result of the falling costs of renewables, steady costs of energy efficiency, and increasing costs of conventional generation. These increasing costs are caused by higher prices for fuel and the high cost of environmental controls unrelated to the Clean Power Plan. See Appendix C for additional information on our modeling of the integration costs of renewables, Appendix D for a discussion of the future costs of all generating resources, Appendix E for a discussion on energy efficiency cost approaches, and Appendix F for state-level detail on bill impacts and renewable addition assumptions.

These cost savings are passed on to electricity consumers. In the business-as-usual, or Reference scenario, we estimated that on average across the United States, residential bills would be $126 per month in 2030. In the Clean Energy Future, however, consumers who take advantage of energy efficiency measures would save $35 per month, paying only $91. While two-thirds of households choose to participate energy efficiency programs in the Clean Energy Future, even those that do not will see only marginal impacts on their electric bills: we estimated non-participants in the Clean Energy Future will pay $130 per month for electricity, just $4 more than in the Reference scenario. Participant bill savings are even more significant when compared to 2012 bills: we estimated that on average, 2030 bills for participants will be $14 per month cheaper than in 2012.

Figure 6 reports the range of monthly bill savings for residential consumers in 2030 in the Clean Energy Future. In eight states, more than 90 percent of households participate. Compared to the Reference scenario, households that participate save on bills, with monthly savings ranging from $0.50 in Kansas up to $94 dollars in North Dakota. Note that even non-participants' bills fall in 16 states, with the average non-participant household in the Clean Energy Future seeing bills that are just $4 higher than in the business-as-usual future.

Figure 6. 2030 residential monthly bill savings for energy efficiency participants in the Clean Energy Future



In this analysis, we did not make any assumptions about which households do and do not participate in energy efficiency programs. Instead we assumed program participants avoid 30 percent of their electric consumption based on current-day Massachusetts program data. The number of program participants was an output given total state efficiency savings and assumed household savings.

States that see large bill savings typically build renewable generation capacity early on and become net exporters of electricity. These first movers save money compared to states that continue operating fossil fuel generation well into the future and become electricity importers once these plants retire.

As described in Appendix A, inputs into our bills calculation included the variable costs of fuel and operations, levelized capital costs of new investments in generation and transmission, energy efficiency and solar rooftop program costs, the costs of purchasing power from other states (or the revenues from selling power), the costs (or revenues) of CO_2 compliance trading, the sunk costs of previous investments (whether still in use or not), the cost of environmental retrofits, and the cost of distributing electricity to customers). We assumed participants in energy efficiency programs save 30 percent on electricity consumption compared to typical usage based on current-day savings to ratepayers in Massachusetts who participate in energy efficiency at high levels.

APPENDIX A: METHODOLOGY

In order to analyze the Clean Power Plan compliance and bill impacts of the Clean Energy Future and Reference scenarios, we utilized five different, inter-related models (see Figure 1 above for a schematic). This appendix details the analysis performed in each model, and how the inputs and outputs from each model interact.

ReEDS

The Renewable Energy Development System (ReEDS) model is designed by the National Renewable Energy Laboratory (NREL) for long-term analysis of the development of the electric power sector.[7] ReEDS is a long-term capacity expansion and dispatch model of the electric power system in the lower 48 states. It has a high level of renewable resource detail with many wind and solar resource regions, each with availability by resource class and unique grid connection costs. Model outputs include generation, capacity, transmission expansion, capital and operating costs, and emissions of CO_2, sulfur dioxide (SO_2), nitrogen oxides (NO_X), and mercury. The model operates through 2050 in two-year steps, with each two-year period divided into 17 time slices representing morning, afternoon, evening, and night in each of the four seasons, plus an additional summer peak time slice. ReEDS includes data on the existing fossil fuel facilities in each of the model's 134 Power Control Areas (PCAs).[8]

Synapse uses a version of ReEDS that we have adapted in house to provide detailed costs by resource type and to include updated emission and heat rate assumptions for fossil fuel-based resources. Key input assumptions to ReEDS for the Clean Energy Future and Reference scenarios are reported in Table 1.[9]

[7] Short et al. 2010. Regional Energy Deployment System (ReEDS). Available at: http://www.nrel.gov/docs/fy12osti/46534.pdf.

[8] These 134 PCAs are contiguous with the lower 48 states. States are made up of between one and 11 PCAs.

[9] Note that preliminary model runs resulted in residential consumer electric bill savings for every state in the lower 48 except for one: North Dakota. Upon further investigation of the causes of this anomaly, we found that coal plants were remaining in operation later in North Dakota than in nearby states, delaying North Dakota's adoption of renewables in the Clean Energy Future. By the time North Dakota's coal plants retire, other states' efficiency savings make abundant clean energy resources available for export; as a result, North Dakota purchases imported energy rather than building its own low-cost renewables. To mitigate this anomaly, we adjusted our inputs to assume that North Dakota, like its neighbors, is an early adopter of wind technology, and in this way avoids the cost of importing energy towards the end of the compliance period. See Fields, S, et al. 2015. *Clean Energy Future Technical Review*. Available at http://www.synapse-energy.com/sites/default/files/Clean-Energy-2040-Technical-Review.pdf.

Table 1. Key input assumptions in Reference and Clean Energy Future scenarios

Assumption	Reference	Clean Energy Future
Demand-Side Resources		
Energy Efficiency	AEO 2014 Reference Case	Ramping from near-term state-specific targets to 2% annual savings beginning in 2020
Demand Response	10% potential by 2040	15% potential by 2040
Distributed PV	EF Reference: 80% below Sunshot 50 costs and capacity additions	Adjusted Sunshot 75 scenario: 75% cost reduction with capacity additions redistributed across the scenario
Electric Vehicles	No electric vehicles integrated as electric-grid storage	25% of light vehicles by 2040 (45% of this load available for grid management)
Supply-Side Resources		
Coal Retirements	Only those announced by June 2015	All retired by 2040 or at 35 years old if built after 2005
Nuclear Lifetime	60 years	60 years
Renewable Target	Existing state RPS	70% National RPS

CAVT

Costs of retrofitting aging coal plants to meet federal environmental regulations other than the proposed Clean Power Plan are modeled using Synapse's Coal Asset Valuation Tool (CAVT).[10] We use the mid-case for environmental retrofit assumptions from our 2015 report on forecasting coal unit competiveness to provide input on the forward-going costs of complying with EPA regulations other than the Clean Power Plan.[11]

EE Savings Tool

As part of its work with EPA, Synapse helped to develop an energy efficiency (EE) savings tool, attached as an appendix to the proposed Clean Power Plan technical support documents.[12] This model allows users to specify an energy efficiency ramp rate, savings level target, measure life distribution, and first-year cost of saved energy for each state. EE Savings Tool outputs—cumulative savings from energy

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[10] CAVT is freely available at http://synapse-energy.com/tools/coal-asset-valuation-tool-cavt.

[11] Knight, P. and J. Daniel. 2015. *Forecasting Coal Unit Competitiveness: Coal Retirement Assessment Using Synapse's Coal Asset Valuation Tool (CAVT).* Available at: http://synapse-energy.com/sites/default/files/Forecasting-Coal-Unit-Competitiveness-14-021.pdf.

[12] EPA. 2015. *Data File: GHG Abatement – Scenario 1 (XLS).* Available at http://www2.epa.gov/sites/production/files/2014-06/20140602tsd-ghg-abatement-measures-scenario1.xlsx.

efficiency and costs of achieving such savings—were used as inputs in the ReEDS and RePRT models in this analysis.

CP3T

ReEDS outputs on generation, costs, emissions, and other state-specific variables for each scenario are analyzed in Synapse's CP3T model.[13] CP3T, or the Clean Power Plan Planning Tool, is an Excel-based spreadsheet tool for performing first-pass planning of statewide compliance with EPA's proposed Clean Power Plan. It is based on the unit-specific data assembled by EPA to create its "building blocks" for target-setting and compliance. CP3T users can:

- Adjust fossil unit capacity factors, renewable energy and energy efficiency projections, unit retirements, and 111(b) unit additions for each state,
- Compare differences in generation, capacity, emissions, emission rates, and costs across created scenarios and EPA's base case,
- Substitute the default assumptions in CP3T for user-selected inputs, including data from ReEDS runs, and
- Compare emissions in both the Clean Energy Future and Reference scenarios against Clean Power Plan requirements.

In this analysis, we use CP3T to determine whether states are compliant with the Clean Power Plan during the 2020-2029 and 2030 periods.

RePRT

State-level electric-system costs, rates, and bills are calculated in the Synapse-developed ReEDS Postliminary Reporting Tool (RePRT). RePRT translates ReEDS outputs into annualized total cost to the system by technology and PCA. For fixed operations and maintenance (O&M) charges and fuel costs, RePRT simply pulls outputs straight from ReEDS. For capital costs for new technologies, however, the tool calculates and adds interest during construction to the capital cost outputs from ReEDS, and then amortizes those costs over a technology-specific investment life.

We used RePRT to estimate the state-by-state bill impacts of both the Clean Energy Future and Reference scenarios. To do this, we relied on the following components, modeled in ReEDS at the PCA level:

- **Environmental retrofit costs:** Estimated in the CAVT model, these include the costs to comply with environmental regulations addressing SO_2, NO_X, mercury, and particulate emissions, as well as cooling water, effluent, and coal ash control standards.

[13] CP3T is freely available at www.cp3t.com.

- **Non-transmission system costs:** Derived from ReEDS and reported by PCA, these are the system costs associated with capital expenditures, fuel, and O&M for all resource types except transmission and energy efficiency.

- **Transmission costs:** Derived from ReEDS and reported by PCA, we reallocated these costs across all the PCAs in a single North American Electric Reliability Corporation (NERC) region in proportion to annual sales data to approximate the distribution these transmission costs across ratepayers.

- **Import / export costs and revenues:** Each PCA's net export or net import of electricity is estimated based on its generation and electric demand. These net imports (or exports) are multiplied by regional energy and capacity prices to estimate the cost of (or revenue from) supplying this additional electricity need.

Next, PCA-specific costs are aggregated by state and combined with the following cost components:

- **Energy efficiency program costs:** Program administrator costs, also known as utility costs, are calculated at the state level for the Clean Energy Future scenario. (The Reference scenario assumes no additional efficiency measures beyond those already implemented today.)

- **Clean Power Plan compliance certificate costs and revenues:** Depending on the year, some states require trading in order to comply with the proposed Clean Power Plan's mass-based (that is, tons of CO_2-emissions-based) targets; they emit more CO_2 than the EPA-specified cap allows.[14] As a result, some states pay to purchase compliance credits, while other states receive revenue for their sale of these credits. In the Clean Energy Future, in any given year, there are far more states over-complying with the Clean Power Plan than there are states that require trading to comply. As a result, the price of compliance credits would be very low. In this analysis, we assumed a $1 per ton certificate price. Costs and revenues associated with Clean Power Plan compliance credits were not calculated in the Reference scenario.

State-specific costs were then divided by the kWh sales in a given year and scenario to derive the cost of supply. Costs of supply in a given year are added to a fixed, per consumer bill component to estimate each state's residential electric rate.[15] Electric rates were then multiplied by forecasted monthly residential usage in each year to estimate monthly bills. For non-participants in energy efficiency

[14] For a detailed discussion of Clean Power Plan compliance trading see Synapse's forthcoming modeling analysis of multi-state compliance with the proposed Clean Power Plan: Knight, P., et al. (Forthcoming in 2015) *Multi-State Compliance with the Clean Power Plan in CP3T.* http://www.synapse-energy.com/project/clean-power-plan-reports-and-outreach-national-association-state-utility-consumer-advocates.

[15] The fixed per consumer component is typically made up of historical capital costs that have already been rate-based. It is certainly possible that this component will decrease in the future as plant in ratebase is depreciated, or if, as older plants retire, ratepayers are no longer obligated to pay some portion of investments that are no longer used and useful. We do not, however, assume a reduction in this bill component in this analysis. The fixed per consumer component is calculated by subtracting the cost of supply rate calculated for 2012 from the statewide residential electric rate reported in the EIA Form 861 for 2012. Actual electric rates can vary widely by utility, even within a single state.

programs, electric usage was based on average statewide usage in 2012.[16] Participants in energy efficiency programs see their usage reduced by 30 percent and their electric bills fall by about one-third compared to non-participants.[17]

[16] Calculated using EIA Form 861 2012, available at http://www.eia.gov/electricity/data/eia861/index.html.

[17] Savings level based on usage reduction achieved by Massachusetts energy efficiency programs in 2013 through 2015. See Massachusetts Program Administrators, "2013-2015 Massachusetts Joint Statewide Three-Year Electric and Gas Energy Efficiency Plan." November 2, 2012, see e.g., D.P.U. 12-107, Cape Light Compact, Exhibit 1.

APPENDIX B: 2020-2029 INTERIM PERIOD

Some of the most common requests EPA received regarding its Clean Power Plan proposal had to do with the interim goals set for states and the compliance trajectory, or glide path, required for meeting those interim goals. In its proposal, EPA set an interim goal that each state must meet. The interim goal is based on the simple average of the adjusted yearly emission rate target calculated for each year (2020 to 2029) in each state, accounting for each of the four building blocks.[18] In this calculation, Building Blocks 1 and 2 are assumed to be fully implemented by 2020, while Building Blocks 3 and 4 ramp up over the compliance period. EPA adopted interim goals in order to ensure continuous progress toward achieving the final 2030 state goals.

However, some commenters suggested that the proposed plan's calculation of the interim goals could be too challenging, especially for those states whose compliance comes largely from Building Block 2. In these states, a significant portion of the emission reductions needed to achieve both the interim and final goals are assumed to occur by 2020. While the proposal allows substantial flexibility for states to substitute other measures for EPA's building block assumptions, many commenters expressed concern that if a majority of the needed reductions had to occur by the first year of the compliance period, then the state's options for compliance were actually very limited. These same commenters challenged EPA's conclusion that significant redispatch from coal to natural gas could occur by 2020 and raised concerns about stranded costs if coal plants are forced to shut down before the end of their useful lives due to this near-term redispatch to gas.

Several commenters, such as the Edison Electric Institute, writing on behalf of U.S. investor-owned utilities, recommended that EPA eliminate the interim goal altogether and allow states to determine their own glide path for compliance with the 2030 targets. Others suggested that EPA should revise its application of Building Block 2 to ramp up the shift from coal to natural gas more slowly. Still other commenters, such as the Natural Resource Defense Council, suggested that the interim goals were too lenient and should be strengthened.

In its October 27, 2014 Notice of Data Availability (NODA), EPA sought comment on alternatives for the interim compliance period. Acknowledging the concerns raised by commenters about the significant reductions that would be needed by 2020, EPA has suggested that it may allow states to take credit for pre-compliance period CO_2 emission reductions and/or phase in Building Block 2 similarly to Building Blocks 3 and 4. It is not clear from the NODA how EPA would phase in Building Block 2. Nevertheless, this approach may alleviate the concerns about steep emission reductions being required by 2020, while providing credit for early action would help incentivize states to implement measures early.

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[18] Building Block 1 involves reducing coal emission rates; Building Block 2 involves redispatch to natural gas-based sources; Building Block 3 relates to renewable and nuclear energy generation; and Building Block 4 relates to energy efficiency improvements.

The Clean Power Plan is unusual in its proposed timeline (15 years) and flexibility for states to comply; however, the Regional Haze Rule also offers an extended compliance timeline and flexibility. Under the Regional Haze Rule, states must reduce emissions of particulate matter and SO_2 that degrade visibility in pristine areas like national parks and wilderness areas. The rule, released in 1999, requires states to achieve "natural conditions" for visibility in these areas by 2064. It lays out specific control requirements for certain sources that must be met in the near term, and then requires states to hit regular milestones demonstrating reasonable progress toward meeting the goal of the rule over the compliance period. Certain states in the West were given the option of complying on a regional basis. The program allows states to reduce SO_2 emissions in whatever way they like, but establishes a mandatory cap-and-trade program that kicks in should the region fail to achieve the milestones.

In this analysis, we assumed states are able to treat the 10-year 2020-2029 period as a single compliance period, and may trade compliance credits over the entire interim period.

APPENDIX C: INTEGRATION OF WIND AND SOLAR COSTS

The amount of electricity generated from moment to moment by wind and solar resources is uncertain. In order to reliably manage variable resources, several measures may be necessary on top of the conventional operating and planning reserves that system operators have historically used to maintain the reliability of the electric power system. ReEDS endogenously calculates several integration-related parameters, including:

- Capacity value: As wind and solar penetration increases, their contribution to peak capacity must decline based on region-specific parameters. As capacity value declines, ReEDS will have to build more, or other, resources to meet regional planning reserve requirements.

- Forecast error reserves: In addition to contingency and regulation reserves, ReEDS calculates incremental reserve requirements to ensure the grid can sufficiently ramp resources up or down with unexpected fluctuations in wind and solar output. ReEDS must maintain sufficient reserves at all times, and will build new conventional (or storage) capacity to serve these reserves.

- Curtailment: In some situations, more renewable energy is produced than can be consumed—either as a result of low demand or inflexible "must run" conventional generators. This represents a real cost to the system, which could otherwise use this curtailed energy.

The costs of these integration measures are typically a small fraction of the energy saved. A recent Argonne National Lab study found integration costs of $1.7 per megawatt-hour (MWh) to $3.8 per MWh for a 17 percent solar scenario, in order to account for the reserves and forecast error requirements that ReEDS calculates internally.[19] ReEDS does not account for the increased costs of wear and tear on conventional generators as a result of having to turn off and on more frequently. These costs are estimated to be below $1 per MWh of wind or solar generation, as compared to fuel and operating costs of about $30 per MWh for conventional fossil fuel-fired generators.[20]

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[19] Mills, A., A. Botterud, J. Wu, Z. Zhou, B-M. Hodge, and M. Heaney. 2013. *Integration of Solar PV in Utility System Operations*. Argonne National Laboratory. Available at: http://emp.lbl.gov/sites/all/files/lbnl-6525e.pdf.

[20] Lew, D. and G. Brinkman. 2013. Western Wind and Solar Integration Study – Phase 2. National Renewable Energy Laboratory. Available at: http://www.nrel.gov/docs/fy13osti/58798.pdf.

APPENDIX D: FUTURE COST OF GENERATING RESOURCES

Our Clean Energy Future analysis found that a key strategy for keeping future bills lower for consumers is the amount of energy efficiency and renewables modeled. The more energy efficiency and renewable generation, the lower the electric system costs. This finding resulted from two main changes to electric generation costs expected over the next 15 years:

- **Increasing cost of fossil fuel generation:** First, the cost of producing electricity from fossil fuels is expected to increase with projections of rising fuel costs and costs of incremental environmental retrofits needed for compliance with upcoming EPA regulations not related to the Clean Power Plan.
- **Decreasing cost of renewable generation:** Second, renewable generation is projected to see significant cost decreases over this same period.
- **Steady costs of energy efficiency:** Third, the cost of energy efficiency is assumed to remain relatively constant over this period.

Increasing cost of fossil fuel generation

The rising cost of fossil fuel generation is driven by an expected increase in fuel costs and the added expense of technologies needed to keep coal and other fossil units in compliance with federal environmental regulations. In our analysis, we relied on fuel prices from Energy Information Administration's (EIA's) Annual Energy Outlook (AEO) 2014 Reference Case.[21] Costs of future environmental regulations were calculated using Synapse's CAVT model and were based on the mid-case for environmental retrofit assumptions described in Synapse's 2015 report *Forecasting Coal Unit Competitiveness: Coal Retirement Assessment Using Synapse's Coal Asset Valuation Tool (CAVT)*.[22]

On average nationwide, coal prices rise 22 percent from $2.45 per million Btu (MMBtu) in 2012 to $2.98 MMBtu in 2030. Natural gas prices rise 65 percent from $3.56 per MMBtu in 2012 to $5.87 per MMBtu in 2030. Figure 7 depicts how these prices are forecasted to change between 2012 and 2030.

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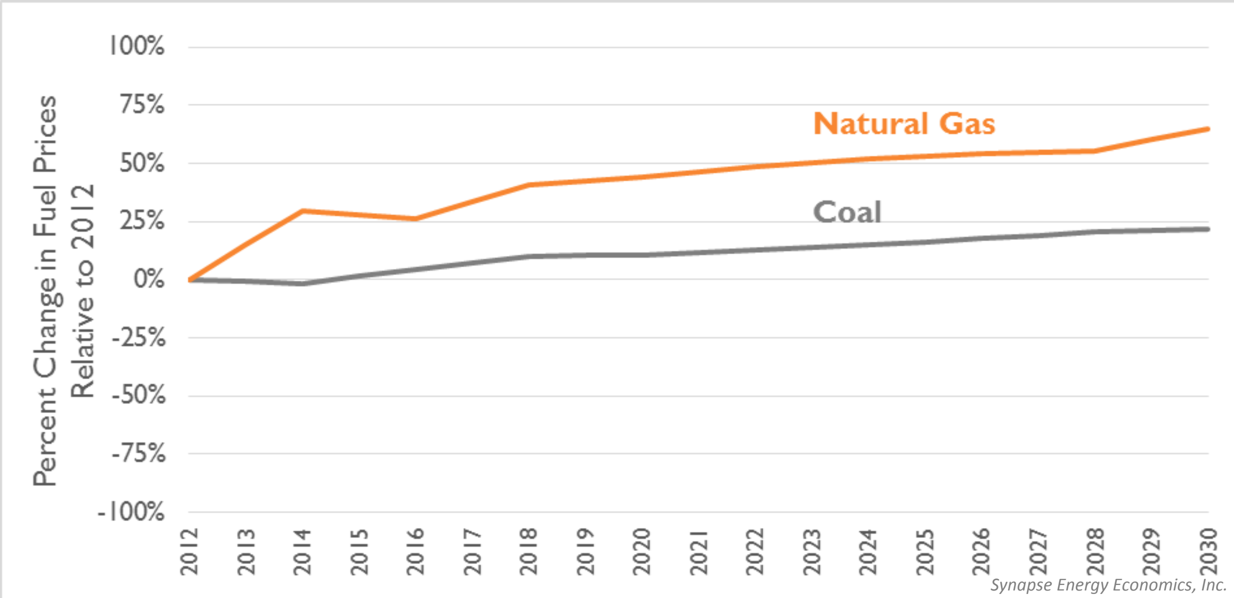
[21] EIA. 2014. Available at http://www.eia.gov/forecasts/archive/aeo14/.

[22] Knight, P. and J. Daniel. 2015. *Forecasting Coal Unit Competitiveness: Coal Retirement Assessment Using Synapse's Coal Asset Valuation Tool (CAVT).* Available at: http://synapse-energy.com/sites/default/files/Forecasting-Coal-Unit-Competitiveness-14-021.pdf.

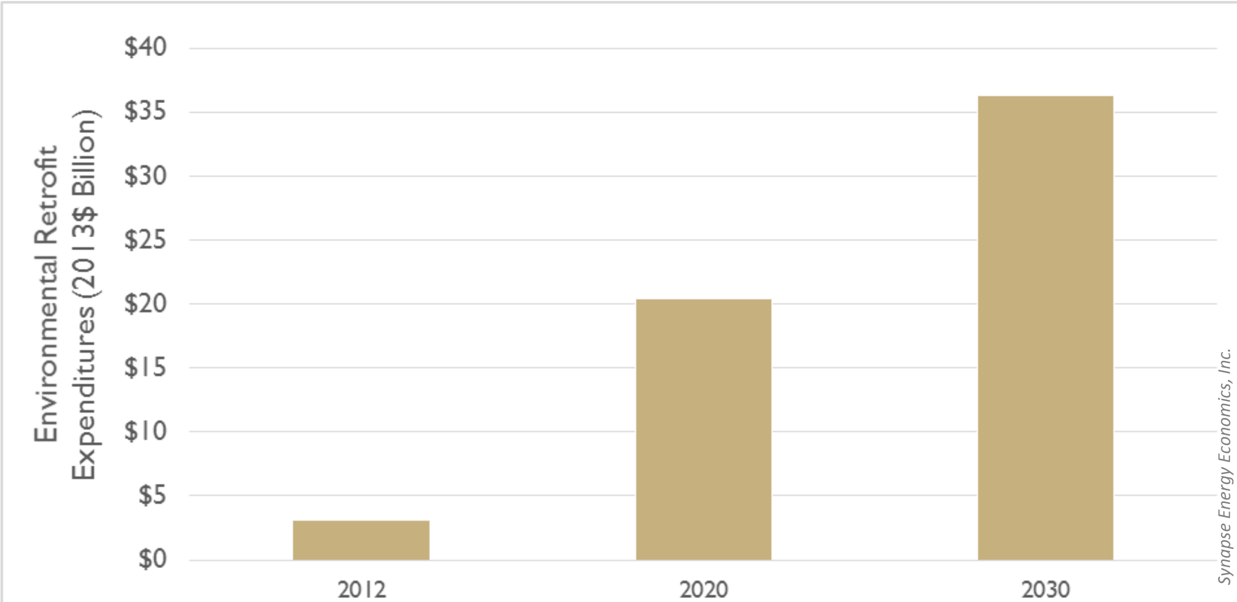
Figure 7. Percent change in fuel prices for natural gas and coal between 2012 and 2030



Note: In addition to fuel prices, model results for fossil fuels also rely on ReEDS assumptions for variable O&M costs and fixed O&M costs.

Over the next several years, new EPA regulations that are unrelated to the Clean Power Plan are expected to result in a higher cost of coal generation. This is due to capital and operating expenses from technologies that reduce emissions and provide other safeguards to the environment. In addition to fuel and O&M costs—which are modeled in ReEDS—we also added in the forward-going costs of installing environmental retrofits at coal plants. We did this using cost estimates from Synapse's open-source Coal Asset Valuation Tool (CAVT) model, which uses publicly available unit-specific data on existing environmental controls and environmental control cost curves from Sargent and Lundy, among other sources. We estimated that if all coal units that have not currently announced retirement dates were to remain in operation, environmental retrofits will add an additional $33 billion per year to the cost of coal generation by 2030 (see Figure 8).

Figure 8. Annual electric-sector expenditures associated with future compliance with environmental regulations other than the Clean Power Plan



Note: Costs shown in 2012 are limited to costs associated with O&M environmental retrofits and do not include capital costs, which are considered to be "sunk". Forward-going costs in 2020 and 2030 include levelized capital costs along with O&M costs, as all can be avoided.

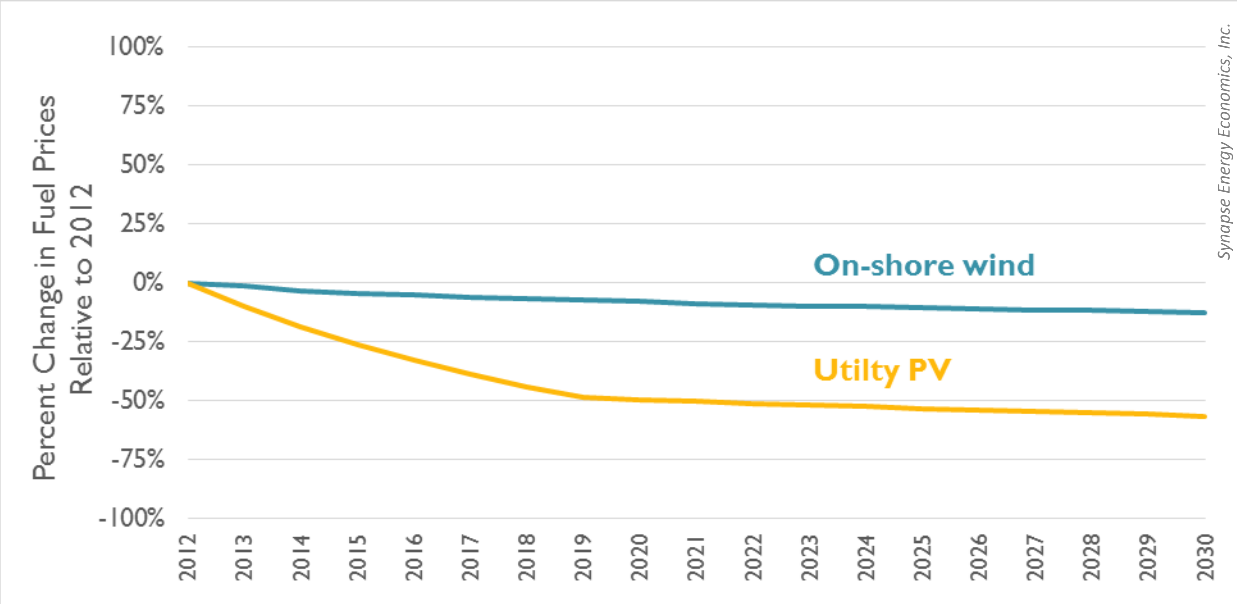
Decreasing costs of renewable generation

The falling cost of renewable generation is largely driven by competition among developers. Significant reductions are expected in costs related to marketing and customer acquisition, permitting and inspection, and installation. The costs of these renewable technologies themselves are also expected to drop: for example, future wind turbine installations will likely consist of taller, larger, and more efficient turbines, resulting in better capacity factors—or more electricity produced by each turbine.

As the costs of producing electricity from fossil fuels rise, the cost of producing electricity from renewables is expected to fall. Cost estimates and forecasts for renewables in ReEDS are based on research by the National Renewable Energy Laboratory, supplemented where necessary by Synapse research. On average nationwide, on-shore wind prices drop 12 percent from $45.49 per MWh in 2012 to $39.82 per MWh in 2030.[23] Utility-scale solar prices drop 57 percent from $162.47 per MWh in 2012 to $71.58 per MWh in 2030. Figure 9 depicts how these prices are forecasted to change between 2012 and 2030.

[23] Reported prices refer to class VII wind resources; the production cost of wind varies depending on the wind resource available.

Figure 9. Percent change in production costs for wind and utility solar relative to 2012 and 2030



Note: Figure 9 is not directly comparable with Figure 7; while Figure 7 displays only the change in cost associated with fuel prices (i.e., non-capital, non-O&M), Figure 9 displays the total change in production cost associated with wind and utility-scale solar.

Steady low costs of energy efficiency

Today, energy efficiency is typically the lowest-cost resource throughout the country. For 2030, we assumed a program administrator cost of energy efficiency of about $19 per MWh (on a levelized—or "planning"—basis) based on a Synapse literature review of the cost of electric generation avoided by efficiency measures.[24] Appendix E provides a detailed description of our energy efficiency cost estimates. While established efficiency programs may experience cost increases in future years as the most easy-to-reach efficiency gains are achieved, it is also expected that energy efficiency costs will decrease as technology evolves and program administrators become more experienced and sophisticated at providing efficiency as a resource.

Efficiency and renewables lower electric-sector costs

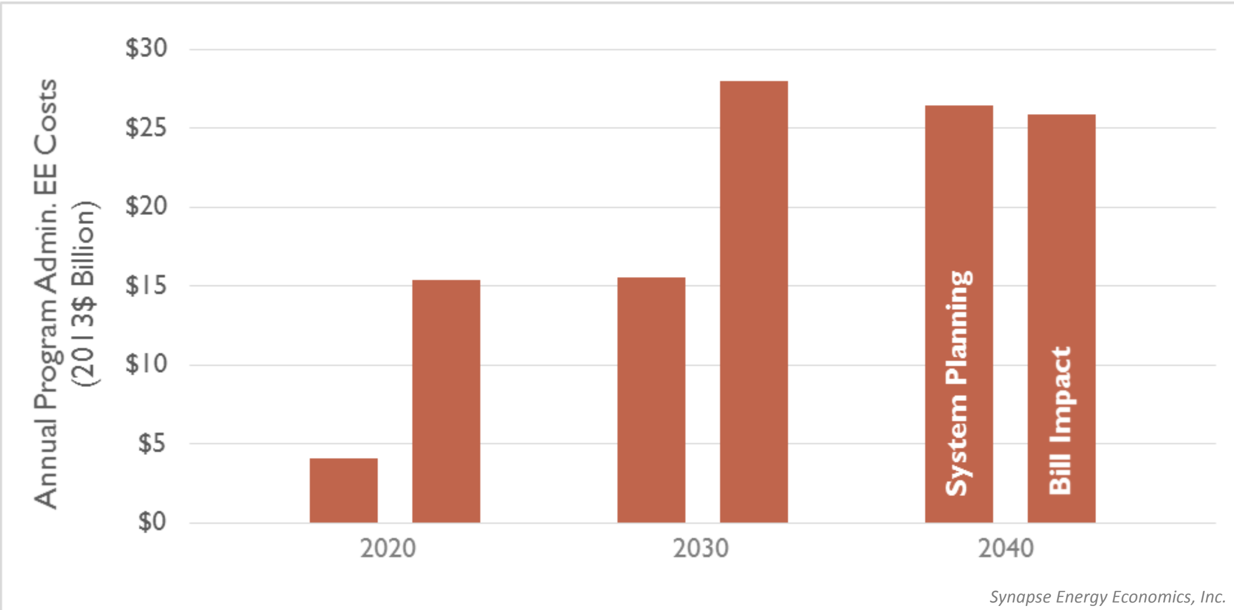
The cost of producing electricity falls as energy efficiency and renewables supply a larger share of generation. These lower-cost resources gradually displace resources such as coal and natural gas combined-cycle generators that require greater expenditures to produce the same level of electricity.

[24] For a more detailed explanation see Stanton, E. A., S. Jackson, B. Biewald, and M. Whited. Nov. 2014. *Final Report: Implications of EPA's Proposed "Clean Power Plan."* Synapse Energy Economics for the National Association of State Utility Consumer Advocates.

Appendix E: Estimating Energy Efficiency in Bill Impacts

The future costs to program administrators of energy efficiency measures were estimated in two different ways for two distinct styles of economic analysis: system planning and bill impact assessment. The distribution of these costs over time differs depending on the type of analysis (see Figure 10).

Figure 10. Comparison of program administrator costs under system planning and bill impact approaches



System planning

In the system planning approach to modeling energy efficiency program costs, first-year costs are spread over the entire lifetime of savings in order to facilitate comparisons between investments in supply- and demand-side resources. (First-year costs are the actual measure cost in the year it is implemented. Efficiency measures are implemented in one year but provide savings for many years to come. Supply-side measures are typically modeled with their costs spread across the lifetime of the technology using terms similar to the actual financing arrangements for these capital expenses.) We levelized first-year program administrator costs at a 3 percent discount rate equivalent to $19 per MWh in 2030.

This approach is standard in integrated resource planning and other long-range electric-sector modeling, and was the approach taken in Synapse's 2015 report *Clean Energy Future Technical Review* and the first brief in this series, *Lower Electric Costs in a Low-Emission Future*.[25] When we refer to savings to states of $40 billion in 2030 in the Clean Energy Future, it is in terms of a system planning approach to energy efficiency cost estimation.

[25] See http://www.synapse-energy.com/project/consumer-costs-low-emissions-futures.

Bill impact analysis

Bill impact analysis, however, must be conducted differently. While efficiency program costs are levelized for system planning and comparison to supply-side resources, financing of efficiency investments is uncommon—a reality that undoubtedly has some effect on utilities' investment choices.

To estimate the effect of program administrators' energy efficiency investments on consumers' bills we instead assumed that all energy efficiency costs are paid for in their first year of savings and not spread over each measure's savings lifetime. By 2030 for bill impact estimates, we assumed a total first-year cost of energy efficiency of about $770 per MWh based on a Synapse literature review of the cost of electric generation avoided by efficiency measures.[26] Program administrator, or utility, costs were assumed to be 50 percent of total costs, resulting in a cost to the system in the first year of $385 per MWh.[27]

These two approaches yield approximately equal results by 2040, as depicted in Figure 10, above.

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[26] For a more detailed explanation see Stanton, E. A., S. Jackson, B. Biewald, and M. Whited. Nov. 2014. *Final Report: Implications of EPA's Proposed "Clean Power Plan."* Synapse Energy Economics for the National Association of State Utility Consumer Advocates.

[27] As a comparison to traditional supply-side resources, note that when levelized at a 3 percent discount rate this first-year program administrator cost is equivalent to $19 per MWh in 2030.

Appendix F: State-Level Modeling Results

Table 2. Residential monthly bills

	2012	2030			2030 Delta
		Reference	*Clean Energy Future*		*Reference less*
			EE participant	EE non-participant	*CEF EE participant*
AL	$137	$184	$96	$138	$88
AR	$106	$141	$78	$111	$63
AZ	$122	$146	$114	$163	$32
CA	$89	$103	$68	$97	$35
CO	$82	$100	$72	$103	$27
CT	$99	$106	$70	$99	$36
DE	$127	$148	$115	$165	$33
FL	$125	$149	$124	$177	$25
GA	$125	$138	$110	$158	$27
IA	$96	$124	$41	$59	$83
ID	$89	$96	$73	$105	$22
IL	$80	$92	$52	$75	$40
IN	$107	$102	$85	$121	$17
KS	$108	$97	$97	$138	$0
KY	$108	$147	$109	$155	$39
LA	$107	$139	$93	$132	$46
MA	$88	$107	$79	$113	$28
MD	$112	$132	$113	$162	$19
ME	$40	$32	$28	$40	$4
MI	$97	$113	$80	$114	$33
MN	$91	$103	$85	$121	$19
MO	$109	$136	$92	$131	$44
MS	$124	$173	$108	$155	$64
MT	$86	$101	$43	$61	$59
NC	$119	$143	$122	$174	$21
ND	$100	$160	$66	$94	$94
NE	$102	$132	$92	$132	$39
NH	$99	$56	$47	$67	$8
NJ	$100	$116	$90	$129	$26
NM	$76	$96	$77	$110	$19
NV	$112	$117	$94	$135	$22
NY	$98	$114	$80	$114	$34
OH	$87	$106	$75	$107	$31
OK	$109	$145	$109	$155	$36
OR	$95	$101	$79	$114	$21
PA	$88	$124	$86	$123	$38
RI	$87	$122	$90	$129	$32
SC	$134	$151	$113	$162	$38
SD	$100	$100	$72	$103	$28
TN	$125	$144	$107	$152	$37
TX	$130	$159	$116	$165	$43
UT	$80	$112	$73	$104	$39
VA	$126	$150	$128	$183	$22
VT	$98	$137	$80	$114	$57
WA	$90	$113	$70	$101	$42
WI	$94	$114	$84	$120	$30
WV	$108	$120	$93	$133	$27
WY	$87	$111	$61	$87	$50
US Avg	**$105**	**$126**	**$91**	**$130**	**$35**

Note: All bills reported in 2013 dollars per month

Table 3. Renewable capacity additions in the Clean Energy Future scenario

	Solar			Wind		Other				Energy Efficiency
	Distributed PV	*Utility PV*	*Concentrating Solar*	*On-Shore*	*Off-Shore*	*Geothermal*	*Hydro*	*Storage*	*Demand Response*	*Incremental % achieved*
AL	0.5	1.2		1.1			3.9		2.0	2%
AR	0.2	1.2		3.8			2.4		1.1	2%
AZ	7.9	2.2	0.3	1.9			2.4		1.8	2%
CA	30.8	3.4	1.3	6.2		7.2	14.1		6.0	2%
CO	4.5	0.1	0.0	2.8		0.0	1.2		0.3	2%
CT	2.1	0.9		0.2	0.6		0.2		0.6	2%
DE	0.6	1.6		0.0			0.0		0.2	2%
FL	9.8	17.3	0.9				0.1		5.6	2%
GA	2.2	5.8		0.3			4.2		3.3	2%
IA	0.9	0.0		16.6			0.7		0.9	2%
ID	0.1			1.1		0.0	2.7			2%
IL	1.7	0.5		18.3			0.9	0.1	3.2	2%
IN	0.7	0.0		11.1			0.1	0.2	2.1	2%
KS	0.9	1.2		3.5			0.1		1.1	2%
KY	0.3	1.4		2.4			2.7		1.8	2%
LA	1.4	1.2		1.5			1.0		1.9	2%
MA	1.8	0.1		0.6	0.6		1.9		0.3	2%
MD	1.4	11.1		0.8			0.6		1.6	2%
ME	0.5			1.0			0.6			2%
MI	1.3	0.0		5.6			2.1		2.3	2%
MN	1.2	0.3		3.7		0.0	0.3	0.2	1.3	2%
MO	1.9	0.1		7.1			2.7		2.0	2%
MS	0.2	2.1		0.5			0.2		1.1	2%
MT	0.4			5.9			2.8		0.0	2%
NC	2.3	15.0		0.9	0.2		2.0		3.1	2%
ND	0.1	0.0		13.8		0.0	0.5	4.3	0.2	2%
NE	0.5			2.4			0.3		0.7	2%
NH	0.2	0.0		1.0			0.5			2%
NJ	2.6	5.1			0.6		0.4		1.9	2%
NM	1.2	0.2	0.2	1.5			0.1		0.5	2%
NV	3.5	0.4	0.2	0.2		0.8	0.8			2%
NY	6.2	0.1		5.3	0.4		6.1		2.5	2%
OH	0.9	1.5		14.6			0.3		3.1	2%
OK	1.1			5.2			1.4	0.2	1.5	2%
OR	0.6	0.0		3.7		0.1	6.7			2%
PA	3.2	2.9		8.4			3.8	3.0	2.8	2%
RI	0.7	0.8		0.0			0.0		0.1	2%
SC	0.7	0.1					4.1		1.8	2%
SD	0.3			1.8			1.6		0.2	2%
TN	1.0	0.0		1.8			4.2		2.2	2%
TX	14.1	9.5	0.1	41.1			0.9	0.5	9.5	2%
UT	0.8	0.0		0.6		1.4	0.3			2%
VA	1.6	2.4		1.0			4.1		2.6	2%
VT	0.2	0.0		1.1			0.3			2%
WA	2.0	0.0		7.6			21.9			2%
WI	1.3	0.0		2.8			0.5		1.4	2%
WV	0.2			2.6			0.4		0.6	2%
WY	0.2			4.8			0.3		0.1	2%
US Total	**119.0**	**89.8**	**3.0**	**217.8**	**2.4**	**9.7**	**109.3**	**8.7**	**75.0**	**-**

Note: Additions represent total incremental capacity in 2030 to 2015 capacity, in GW. In this table, "Hydro" includes both conventional hydro and pumped hydro and "Storage" includes storage both from batteries and compressed air.