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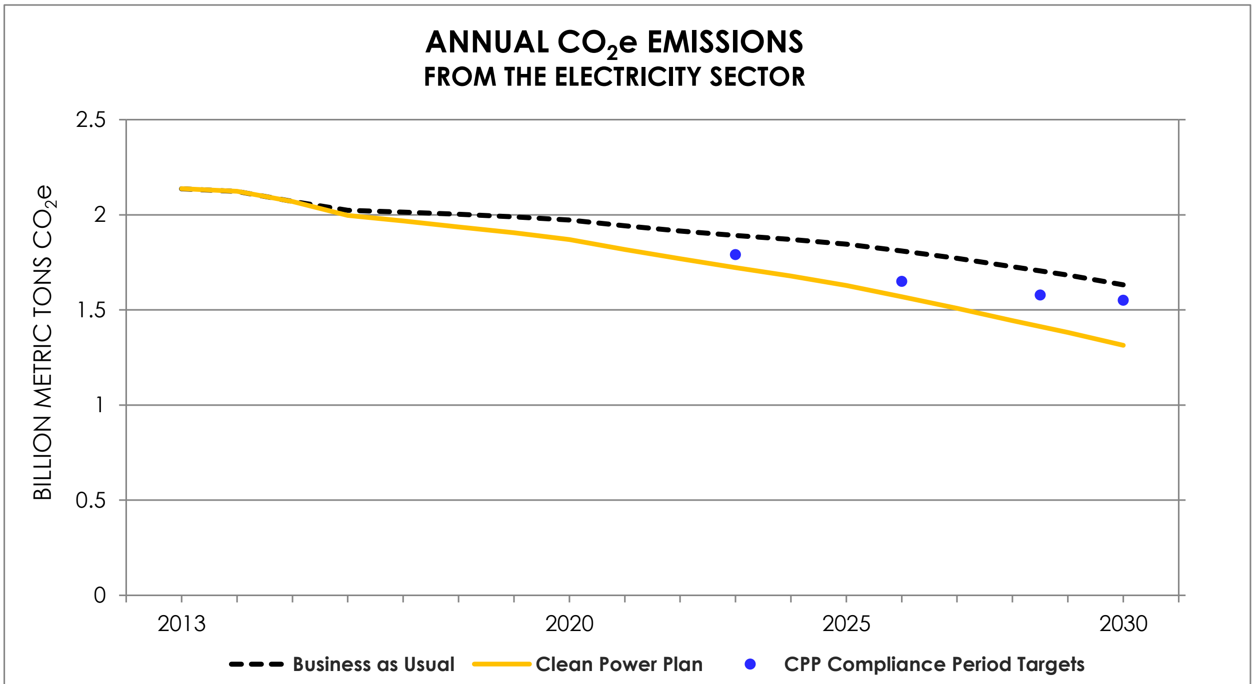
ENERGY POLICY SOLUTIONS

THE CLEAN POWER PLAN IS WITHIN REACH

Last August, the U.S. Environmental Protection Agency (EPA) released the final Clean Power Plan (CPP), which sets public health standards for fossil-fuel fired electric generating units. The CPP requires 32 percent less CO_2 emissions from the power sector by 2030. But which policies can achieve these standards most cost-effectively?

Energy Innovation analyzed thousands of possible policy combinations to understand the most cost-effective way to achieve the CPP, using the *Energy Policy Simulator*.[1] The *Energy Policy Simulator* is a quantitative tool that models combined effects of about 50 policies, showing impacts on 12 pollutants, changes in the U.S. electricity generation sector, and overall economic cash flows—all in real-time.

Energy Innovation identified a cost-effective package of six policies that the U.S. could use to meet the CPP at a national average scale.[2] This scenario actually exceeds the emissions goals in later years, as policies designed to meet earlier targets continue to reap benefits in later years.



It may come as a surprise to some, but this package of policies could meet all these emissions goals and **save America nearly 40 billion dollars** between 2016 and 2030.[3,4]

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[1] To use the simulator, visit https://energypolicy.solutions. This analysis is based on v1.0.2.
[2] The Clean Power Plan scenario meets each of the compliance period average annual targets included in the final CPP issued by the EPA.

The following sections describe which policies are included in this cost-effective Clean Power Plan scenario ("CPP scenario").

CLEANING THE EXISTING FLEET

Improving the efficiency of existing power plants is a cost-effective way to achieve emissions reductions. The CPP scenario includes a six percent improvement in the efficiency (heat rate) of coal power plants by 2030, in line with the EPA's Building Block 1.[5]

In addition to addressing the existing coal fleet's heat rates, the CPP scenario retires an additional 3 gigawatts (GW) of coal-fired power plants each year beyond business-as-usual. This acceleration reduces total U.S. coal power plant capacity to 241 GW in 2030, down from 330 GW in 2013.[6]

Energy Innovation also investigated the potential for increasing the utilization of existing natural gas plants, in line with EPA's Building Block 2. However, modeling suggests increased natural gas acts as a substitute for renewable energy, which can achieve deeper carbon reductions at lower cost. Therefore, this policy is not included in the selected CPP scenario.

REDUCING DEMAND

Reducing energy waste through energy efficiency is another important step to cost-effectively meeting the CPP targets. The CPP scenario thus includes increased building codes and appliance standards, as well as improved industrial equipment efficiency standards.

In the buildings sector, the CPP scenario achieves a 50 percent improvement in the efficiency of newly sold lighting in 2030 relative to the business as usual scenario. This is reasonable, based on the U.S. Department of Energy's (DOE) projection of 74 percent market share for LEDs in 2030.[7]

The CPP scenario also achieves a three percent improvement in energy intensity of America's industry by 2030 (0.2 percent improvement per year) via industrial energy efficiency standards.

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[3] The Energy Policy Simulator operates on an annual average and national average basis. It does not have a geographic representation of the power generation fleet, so it does not represent each state's target individually. It does include grid flexibility limits and a distribution of technology costs as a proxy for geographical differences. This analysis could be thought of as representing the benefits of a national trading system and implementing other policies in many states nationwide. Data for 2014 coal capacity taken from EIA's Electric Power Annual, Table 4.3, https://www.eia.gov/electricity/annual/html/epa_04_03.html

[4] Using inflation-adjusted 2012 dollars and a three percent discount rate, savings represent the cumulative capital expenditures and operational savings resulting from the policies used here to meet the Clean Power Plan.

[5] See http://www2.epa.gov/cleanpowerplan/fact-sheet-overview-clean-power-plan

[6] EPA's business-as-usual coal capacity in 2030 includes the effects of the Mercury and Air Toxics Standard, while the Energy Policy Simulator (based on information from the latest Annual Energy Outlook from the Energy Information Administration) does not. See http://www3.epa.gov/airquality/cpp/cpp-final-rule-ria.pdf Table 3-12.

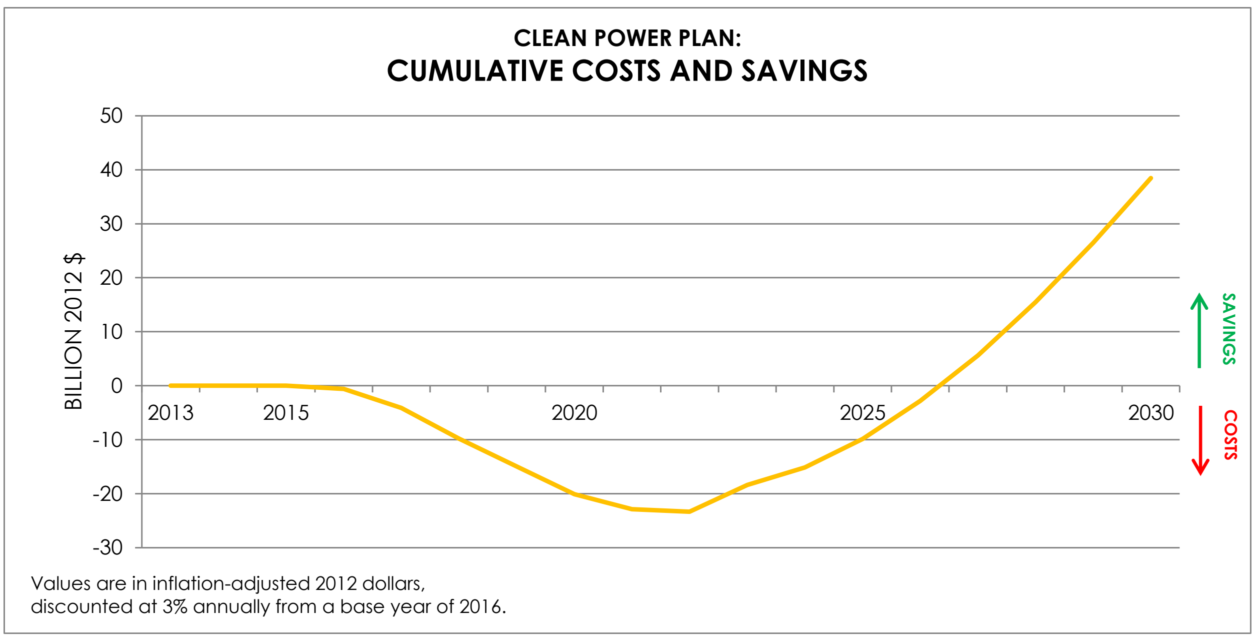
[7] See http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_energy-savings-report_jan-2012.pdf, Table ES-1

The Electric Power Research Institute estimates industry could achieve an eight percent improvement in energy intensity by 2030,[8] so the CPP scenario setting is quite realistic.

BUILDING CLEAN POWER

Demand is expected to decline somewhat by 2030 under the CPP scenario, but America will still need to replace some of the power plants that retire under the Plan. Building renewable energy is a cost-effective way to meet our nation's remaining energy needs under the CPP.[9] Specifically, Energy Innovation recommends a renewable portfolio standard (RPS) along with increased transmission.

A 25 percent national average RPS can drive significant growth in clean power. Under the CPP scenario, wind grows to 227 GW in 2030 (25 GW above business-as-usual) while solar photovoltaics grow to 162 MW in 2030 (49 GW above business-as-usual). To ensure this renewable energy reaches consumers, the CPP scenario also includes a five percent increase in transmission capacity by 2030. This expansion is below projected transmission growth from the National Association of Regulatory Utility Commissioners, which estimates a 10 percent increase in transmission capacity will be needed by 2030.



The Clean Power Plan can help decarbonize America's power sector, while keeping citizens healthier and safer. Energy Innovation's CPP scenario demonstrates the pollution reductions can be achieved while saving the U.S. economy billions of dollars.

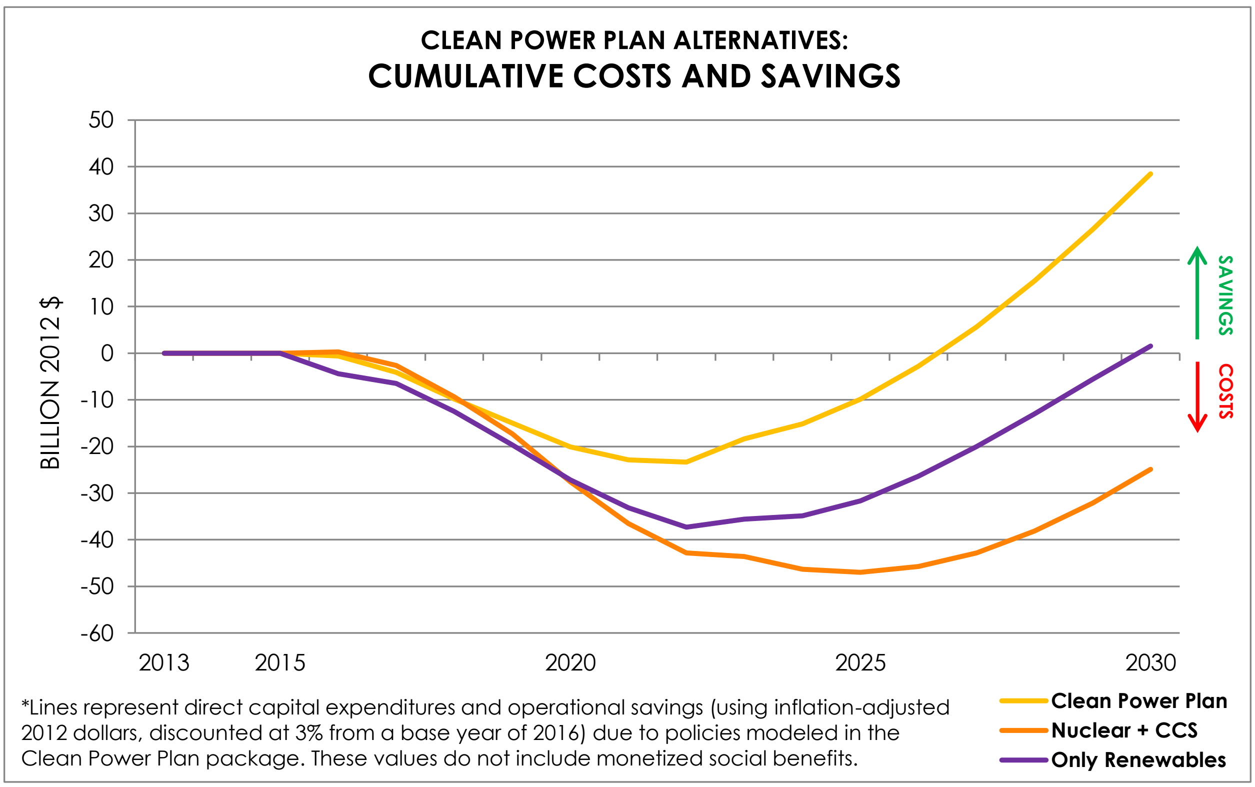
[8] See http://www.edisonfoundation.net/iee/Documents/EPRI_SummaryAssessmentAchievableEEPotential0109.pdf

[9] See http://www2.epa.gov/cleanpowerplan/fact-sheet-overview-clean-power-plan

THE CLEAN POWER PLAN CAN LOOK CHEAP, OR COSTLY

The policies included in the scenario above were selected after analyzing more than 10,000 policy combinations to identify the most cost-effective set at a national average scale. Selecting policies based on political preference is likely to produce more costly packages that may meet the Clean Power Plan but end up costing money or leaving potential savings on the table.

The chart below compares three policy packages that each meet the Clean Power Plan—“Nuclear + CCS,” “Only Renewables,” and the cost-effective “Clean Power Plan” package described above. The Nuclear + CCS package includes fewer coal retirements, but assumes the U.S. can reach its full potential for carbon capture and storage.[10] Nuclear + CCS also boosts the build out of nuclear generation capacity.[11] The Only Renewables package retires nuclear and coal, and supports renewables with a $15/MWh subsidy for wind and solar without any transmission expansion. Demand response and non-hydro grid storage are also increased in this scenario.



Policymakers have a choice in front of them – choose policies that encourage the least-cost path to America’s emissions goals, or leave money on the table by picking particular technologies.

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[10] The potential for carbon capture and storage comes from http://www.iea.org/publications/freepublications/publication/TechnologyRoadmapCarbonCaptureandStorage.pdf

[11] Note that this rate of additional nuclear deployment could not be achieved using subsidies of any level in the Energy Policy Simulator. Instead, the capacity expansion was mandated. The simulator results still include the direct cost of building nuclear.

http://energyinnovation.org/wp-content/uploads/2015/11/CleanPowerPlan-Alternatives.pdf

APPENDIX A

The following table provides additional detail on the differences between the Clean Power Plan policies described throughout this document, and the Nuclear + CCS and Only Renewables packages used in this comparative analysis.

	"Clean Power Plan"	**Nuclear + CCS**	**Only Renewables**
Nuclear	-	5 GW *built* p.a.	1 GW *retired* p.a.
Renewables	25% by 2030	-	$15/MWh subsidy for wind and solar PV
Transmission	5% additional by 2030	-	-
CCS	-	100% of potential	-
Coal	3 GW retired p.a.	1.5 GW retired p.a.	1.5 GW retired p.a.
Storage	-	-	6.6 GW additional by 2030
Demand Response	-	-	4.9 GW additional added p.a.
2030 Cumulative Costs/Savings	$38 billion *savings*	$25 billion *costs*	$1.5 billion *savings*

APPENDIX B

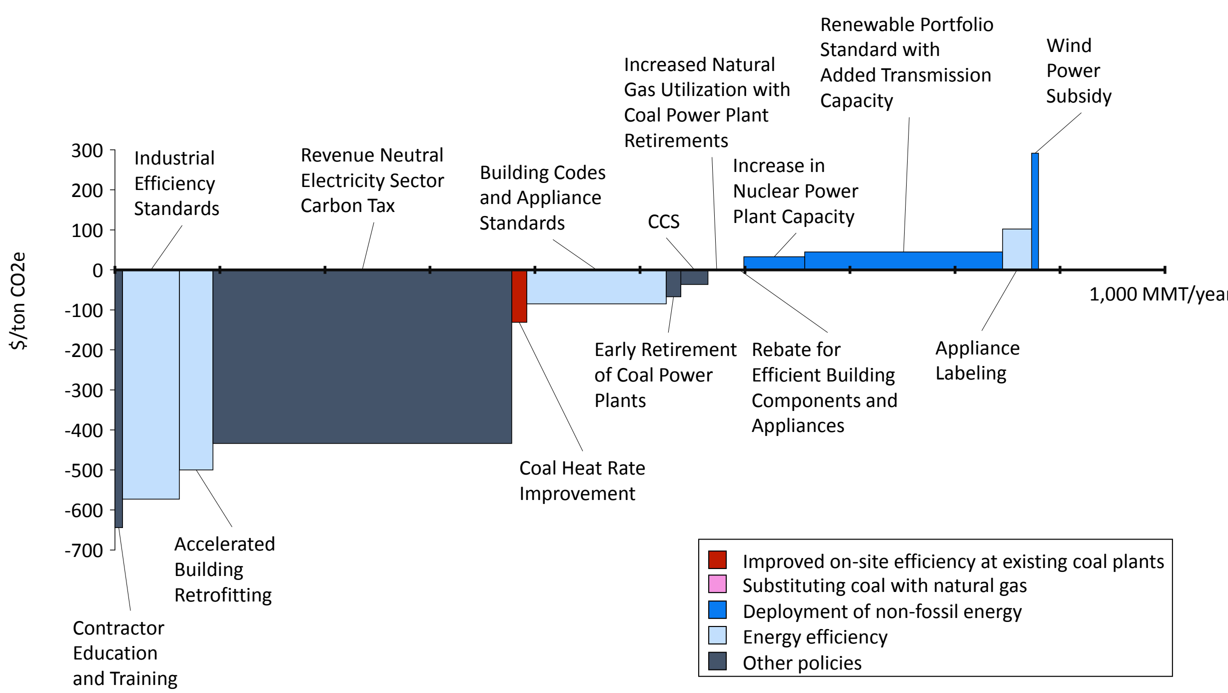
In order to determine cost-effective policies to highlight in this analysis, we examined the relative costs and abatement potential of about 20 policies that could be used for Clean Power Plan compliance (including policies affecting electricity supply and end-use efficiency). Cost curves are a useful tool to visualize and compare the relative effects of a set of policies. McKinsey & Co. first popularized cost curves as a way to visualize and compare the effects of *technologies*, whereas these charts represent *policies.*

Each box on these policy cost curves represents a different policy. The width of each box, along the x-axis, represents the greenhouse gas emissions reductions achieved by that policy. The height of each box, along the y-axis, represents the cost-effectiveness of that policy, in dollars per ton CO_2-equivalent greenhouse gas emissions abated. Boxes appearing above the x-axis cost money, and boxes below the x-axis save money.

Two different policy cost curves are included here. It is important to note that each box on the cost curve will change in size and shape according to the stringency of the chosen policy setting (the same in both of the following charts), as well as which other policies are enabled as part of the package being examined (different in each of the two following charts).

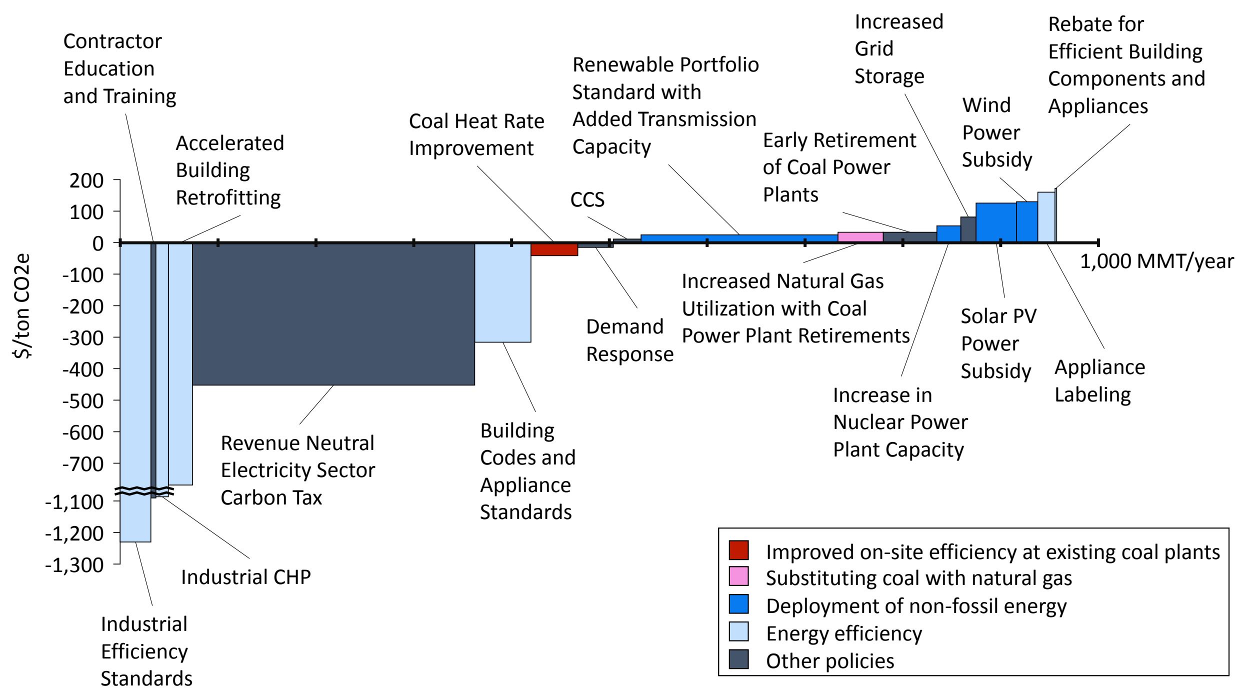
The first chart shows the relative contribution of each policy in the context of a package including all the other policies shown. One could think of this as a proxy for the relative importance of each policy in a region that already has a progressive set of decarbonization policies.

Policy Cost Curve in the Context of the Full Package of Policies



The second chart shows the relative contribution of each policy in the absence of any other policies beyond business-as-usual. One could think of this as a proxy for the relative importance of each policy in a region without many decarbonization policies in place.

Policy Cost Curve in the Context of No Other Policies



The similarities and differences between these two cost curves illuminate some important considerations for designing effective policy packages.

Similarities between the two cost curves

In both of these charts, efficiency-oriented policies appear on the left-hand side, below the x-axis, since they may require upfront capital investment but often more than pay for themselves in fuel savings by 2030. It is worth noting that the savings associated with efficiency policies are likely underrepresented here, since the fuel savings induced by pre-2030 investments will continue to accumulate post-2030. Energy supply decarbonization policies and emissions pricing fall in the middle of the chart, close to zero on the x-axis, since they are cost-effective. Policies that cost money on a per-ton basis by 2030 appear on the right-hand side of the cart, above the x-axis, and include policies like subsidies and rebates.

In terms of abatement potential (box width), the top two policies are the same across both of the cost curves. The electricity sector carbon tax (set to grow to $50/ton by 2030) is the policy with the largest abatement potential in both cases. The renewable portfolio standard with added transmission capacity has the second largest abatement potential in both scenarios.

Increasing the use of existing natural gas facilities was tested as part of this package, and is included on of these charts. However, it is important to note that increased gas use is explicitly paired with coal power plant retirements because it increases overall emissions on its own if least-cost dispatch is assumed. This is an important dynamic—without complementary policy, increased natural gas use may replace efficiency and renewables rather than coal, resulting in an increase in overall emissions.

Differences between the two cost curves

Comparing the two charts illuminates some important interactions between policies. The total emissions reduction potential is lower in the first chart, reflecting real interactions between the policies—for example, an efficiency policy reduces fewer emissions when the electricity supply is cleaner.

With higher levels of renewables, grid flexibility becomes an important consideration. In the Energy Policy Simulator, flexibility can be provided by demand response, non-hydro storage (e.g. batteries) or flexible power plants, for example natural gas plants. In the context of no other policies, demand response and grid storage are each associated with some emissions abatement because they allow increased utilization of renewables, which begin to require additional grid flexibility in later years. In the full package of policies scenario, ample flexibility is provided by the increased deployment of natural gas power plants, and therefore, demand response and non-hydro storage are associated with only very minimal reductions in emissions. However, it's important to note that demand response and non-hydro storage, in the absence of significantly increased natural gas, provide a large amount of additional flexibility, which results in significant carbon abatement.

Policy Settings Tested in Both Cost Curves[12]

Policy	Setting	Implementation Schedule
Rebates for Efficient Building Components	On	Rebate offered starting in 2016 and offered through 2030
Building Codes and Appliance Standards	-20% improvement in heating equipment -20% improvement in cooling equipment -15% improvement in building envelope -50% improvement in lighting -20% improvement in appliances -20% improvement in other building equipment	Phased in linearly between 2016 and 2030
Improved Labeling of Appliance Energy Efficiency	On	Improved labeling starts in 2016 and extends through 2030
Improved Contractor Education and Training	On	Improved education and training starts in 2016 and extends through 2030
Accelerated Building Retrofitting	2% additional commercial floor space retrofit each year	Equal improvement every year between 2016 and 2030
Renewable Portfolio Standard with Additional Transmission Capacity	-30% electricity generation from renewable resources by 2030 -10% increase in transmission capacity by 2030	Phased in linearly between 2016 and 2030
Demand Response	14 GW/year of additional demand response	Phased in linearly between 2016 and 2030
Wind Power Subsidy	$20/MWh	Subsidy offered beginning in 2016 and extending through 2030

[12] Note that some policies are not included on both graphs because some policies are no longer significantly carbon abating when many policies are turned on together.

Solar PV Power Subsidy	$20/MWh	Subsidy offered beginning in 2016 and extending through 2030
Early Retirement of Coal Power Plants	1.1 GW/year of additional retirements	Equal retirements every year between 2016 and 2030
Increased Grid Storage Capacity	1.4 GW/year of additional storage capacity through 2030 (on average)	Phased in linearly between 2016 and 2030
Improved Heat Rate at Coal Power Plants	3.7% improvement of complete fleet by 2030	Phased in linearly between 2016 and 2030
Increased Utilization of Natural Gas Plants with Coal Power Plant Retirements	1.1 GW/year coal replaced with a 5% increase in existing CCGT fleet efficiency by 2030	Annual coal retirements; CCGT efficiency phased in linearly
Increased Nuclear Power Plant Capacity	720 MW/year of additional nuclear	Equal additions every year between 2016 and 2030
Increased Cogeneration and Waste Heat Recovery	3.9% decrease in industrial fuel use by 2030	Phased in linearly between 2016 and 2030
Industrial Energy Efficiency Standards	10% decrease in industrial fuel use by 2030	Phased in linearly between 2016 and 2030
Electricity Sector Carbon Tax	$50/ton $CO2_e$ by 2030	Phased in linearly between 2016 and 2030
Increased CCS	35 million metric tons of additional CO_2 sequestered per year	Phased in linearly between 2016 and 2030

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