2015 Carbon Dioxide Price Forecast

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1. EXECUTIVE SUMMARY

Prudent and reasonable planning requires electric utilities and other stakeholders in carbon-intensive industries to use a reasonable estimate of the future price of carbon dioxide (CO_2) emissions when evaluating resource investment decisions with multi-decade lifetimes. However, forecasting a CO_2 price can be difficult. The federal government is moving forward with regulations to limit CO_2 emissions from new and existing power plants, but a regulation is not yet finalized. To make sound investment decisions, utilities must consider existing, proposed, and expected future regulations.

Although the lack of a defined policy setting a price on carbon poses a challenge in CO_2 price forecasting, an assumption that there will be no CO_2 price in the long run is not, in our view, reasonable. The scientific basis for attributing climatic changes to human-driven greenhouse gas emissions is irrefutable, as are the type and scale of damages expected to both infrastructure and ecosystems. The need for a comprehensive U.S. effort to reduce greenhouse gas emissions is clear. While the Clean Power Plan proposed by the U.S. Environmental Protection Agency (EPA) in June 2014 does not specify a price on carbon, any policy requiring or leading to greenhouse gas emission reductions in the electric sector will result in higher costs to the generating resources that emit CO_2.

This 2015 report updates Synapse's Spring 2014 CO_2 Price Report with the most recent information on federal regulatory measures, state and regional climate policies, and utility CO_2 price forecasts, and provides an updated CO_2 price forecast. [1] The Synapse CO_2 price forecast is designed to provide a reasonable range of price estimates for use in utility integrated resource planning (IRP) and other electricity resource planning analyses. We have reviewed and updated our summary of the key regulatory developments and data from utility IRPs, which are frequently changing and crucial to understanding the impetus for a carbon price forecast and the number of utilities that have adopted one for planning purposes.

1.1. Key Assumptions

This report includes updated information on federal regulations, state and regional climate policies, and utility CO_2 price forecasts, as well as our own analysis of the proposed Clean Power Plan, EPA's proposed rule to regulate CO_2 emissions under Section 111(d) of the Clean Air Act. The Low, Mid, and High Synapse CO_2 price forecasts presented here are similar to those in our Spring 2014 report. This is the first Synapse CO_2 price forecast that we extend to 2050, to reflect long-term climate targets. Synapse's CO_2 price forecast reflects our expert judgment that near-term regulatory measures to reduce

[1] Luckow P., E. Stanton, B. Biewald, S. Fields, J. Fisher, F. Ackerman. 2014. *CO_2 Price Report, Spring 2014*. Synapse Energy Economics.

greenhouse gas emissions, coupled with longer-term cap-and-trade or carbon tax legislation passed by Congress, will result in significant pressure to decarbonize the electric power sector. Key assumptions of our forecast include:

- Near-term climate policy actions reflect a regulatory approach; for example, under Section 111(d) of the Clean Air Act.
- A federal program establishing a price for greenhouse gases is probable in the long run as it provides an efficient, least-cost path to emissions reduction.
- Future federal legislation setting a price on emissions through a cap-and-trade policy or a carbon tax will likely be prompted by one or more of the following factors:
    - New technological opportunities that lower the cost of carbon mitigation;
    - A series of executive actions taken by the President that spur demand for congressional action;
    - The inability of executive actions to meet long-term emissions goals;
    - A Supreme Court decision making it possible for states to sue companies within their boundaries that own high-carbon-emitting resources, and creating a financial incentive for energy companies to act; and
    - Mounting public outcry in response to increasingly compelling evidence of human-driven climate change.

Given the growing interest in reducing greenhouse gas emissions by states and municipalities throughout the nation, a lack of timely, substantive federal action will result in the enactment of diverse state and local policies. Heterogeneous—and potentially incompatible—sub-national climate policies would present a challenge to any company seeking to invest in CO_2-emitting power plants, both existing and new. Historically, there has been a pattern of states and regions leading with energy and environmental initiatives that have in time been superseded at the national level. It seems likely that this will be the dynamic going forward: a combination of state and regional actions, together with federal regulations, that are eventually eclipsed by a comprehensive federal carbon price.

We expect that federal regulatory measures together with regional and state policies will lead to the existence of a cost associated with greenhouse gas reductions in the near term. Prudent and reasonable utility planning requires that utilities take this cost into account when engaging in resource planning, even before a federal carbon price is enacted.

1.2. Study Approach

In this report, Synapse reviews several key developments that have occurred over the past 12 months. These include:

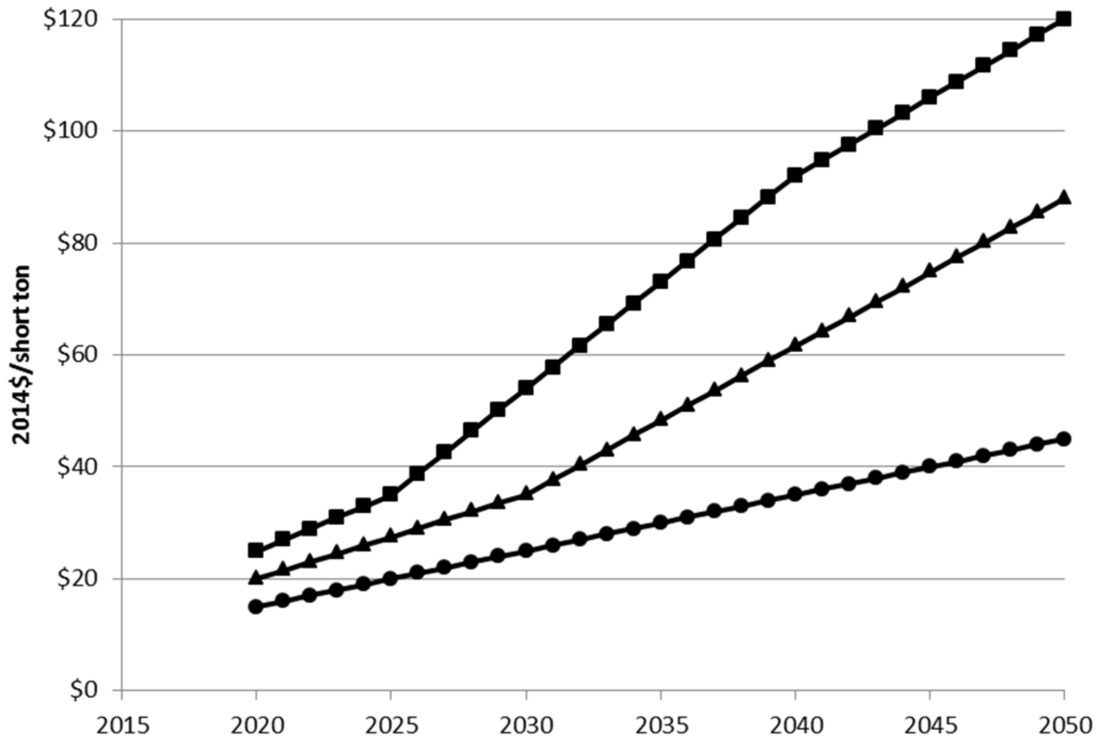
- Proposed federal regulatory measures to limit CO_2 emissions from existing power plants and an updated proposal for new power plants;
- Continuation of the Northeast's Regional Greenhouse Gas Initiative (RGGI) CO_2 policy and the most recent auctions under both RGGI and California's AB 32 Cap-and-Trade program; and
- Synapse's collection and analysis of carbon price forecasts from 115 recent utility filings.

1.3. Synapse's 2015 CO_2 Price Forecast

Based on analyses of the sources described in this report, and relying on our own judgment and experience, Synapse developed Low, Mid, and High case forecasts for CO_2 prices from 2015 to 2050. In these forecasts, the proposed Clean Power Plan together with other existing and proposed federal regulatory measures place economic pressure on CO_2-emitting resources in the next several years, such that it is relatively more expensive to operate a high-carbon-emitting power plant. These pressures are followed later by a broader federal policy, such as cap and trade. In any state other than the RGGI region and California, we assume a zero carbon price through 2019; beginning in 2020, we expect Clean Power Plan compliance will put economic pressure on carbon-emitting power plants throughout the United States. All annual allowance prices and levelized values are reported in 2014 dollars per short ton of CO_2.

- The **Low case** forecasts a CO_2 price that begins in 2020 at $15 per ton, and increases to $25 in 2030 and $45 in 2050, representing a $26 per ton levelized price over the period 2020-2050. This forecast represents a scenario in which the final version of the Clean Power Plan is relatively lenient and readily achieved, and a similar level of stringency is assumed after 2030.
- The **Mid case** forecasts a CO_2 price that begins in 2020 at $20 per ton, and increases to $35 in 2030 and $85 in 2050, representing a $41 per ton levelized price over the period 2020-2050. This forecast represents a scenario in which federal policies are implemented with significant but reasonably achievable goals. The stated goals of the Clean Power Plan are achieved and science-based climate targets are enacted mandating at least an 80 percent reduction in electric section emissions from 2005 levels by 2050.
- The **High case** forecasts a CO_2 price that begins in 2020 at $25 per ton, and increases to approximately $53 in 2030 and $120 in 2050, representing a $52 per ton levelized price over the period 2020-2050. This forecast is consistent, in the short term, with a more stringent version of the Clean Power Plan, as well as a recognition that achieving science-based emissions goals by 2050 requires significant near-term reductions. In recognition of this difficulty, implementation of standards more aggressive than the Clean Power Plan may begin as early as 2025. New regulations may mandate that electric-sector emissions are reduced to 90 percent or more below 2005 levels by 2050, in recognition of lower-cost emission reduction measures expected to be available in this sector. Other factors that may increase the cost of achieving emissions goals include: greater restrictions on the use of offsets; restricted availability or high cost of technology alternatives such as nuclear, biomass, and carbon capture and sequestration; and more aggressive international actions (thereby resulting in fewer inexpensive international offsets available for purchase by U.S. emitters).

Figure ES-1: Synapse 2015 CO_2 Price Trajectories



2. STRUCTURE OF THIS REPORT

This report presents Synapse's 2015 Low, Mid and High CO_2 price forecasts, along with the evidence assembled to inform these forecasts, including developments from the past 12 months:

- Section 3 discusses broader concepts of CO_2 pricing.
- Section 4 provides an overview of existing state and federal legislation, including EPA's proposed Clean Power Plan.
- Section 5 discusses our recommendations for planning for the Clean Power Plan, a review of existing studies of compliance cost, and Synapse's modeling of compliance with the Plan.
- Section 6 provides a range of current CO_2 price forecasts used by utilities.
- Section 7 gives a summary of the evidence that has guided the development of the Synapse forecasts.
- Section 8 presents Synapse's 2015 Low, Mid, and High CO_2 price forecast, along with a comparison to recent utility forecasts.

- Appendix A presents additional graphs comparing the 2015 forecast with past Synapse forecasts and utility forecasts.

Unless otherwise indicated, all prices are in 2014 dollars and CO_2 emissions are given in short tons.

3. WHAT IS A CARBON PRICE?

There are several co-existing meanings for the term “carbon price” or “CO_2 price”: each of these meanings is appropriate in its own context. Here we give a brief introduction to five common types of carbon prices, along with a quick guide to which of the carbon price estimates reviewed in this report are based on which of these meanings. (Note that the definition of an additional term—the “price of carbon”—is ambiguous because it can at times mean several of the following.)

Carbon allowances (sometimes called credits or certificates, and best known for their use in policies called “cap and trade”): Allowances are certificates that give their holder the right to emit a unit of a particular pollutant. A fixed number of carbon allowances are issued by a government, some sold and, perhaps, some given away.[2] Subsequent trade of allowances in a secondary market is common to this policy design. The price that firms must pay to obtain allowances increases their cost of doing business, thereby giving an advantage to firms with cleaner, greener operations, and creating an incentive to lower emissions whenever it can be done for less than the price of allowances. The number of allowances—the “cap” in the cap-and-trade system—reflects the required society-wide emission reduction target. A greater reduction target results in a lower cap and a higher price for allowances. In the field of economics, pricing emissions is called “internalizing an externality”: the external (not borne by the polluting enterprise) cost of pollution damages is assigned a market price (thus making it internal to the enterprise).

In this report: The Northeast’s RGGI and California’s Cap-and-Trade Program are both carbon allowance trading systems. In addition, the Kerry-Lieberman, Waxman-Markey, and Cantwell-Collins bills all proposed policy measures that included carbon allowance trading.

Carbon tax: A carbon tax also internalizes the externality of carbon pollution, but instead of selling or giving away rights to pollute (the allowance approach), a carbon tax creates an obligation for firms to pay a fee for each unit of carbon that they emit. In theory, if the value of damages were known with certainty, a tax could internalize the damages more accurately, by setting the tax rate equal to the damages; in practice, the valuation of damages is typically uncertain. In contrast to the government issuance of allowances, with a carbon tax there is no fixed amount of possible emissions (no “cap”). A

[2] Regardless of whether allowances are initially given away for free or sold, they represent an opportunity cost of emissions to the holder.

cap-and-trade system specifies the amount of emission reduction, allowing variation in the price; a tax specifies the price on emissions, allowing variation in the resulting reductions. In both cases there is an incentive to reduce emissions whenever it can be done for less than the prevailing price. In both cases there is the option to continue emitting pollution, at the cost of either buying allowances or paying the tax. While some advocates have claimed that a tax is administratively simpler and reduces bureaucratic, regulatory, and compliance costs, a general aversion to new taxes has meant that no carbon tax proposals have received substantial support in recent policy debate.

Effective price of carbon (sometimes called the notional, hypothetical, or voluntary price): Carbon allowances and carbon taxes internalize the climate change externality by making polluters pay. However, many other types of climate policies work not by making polluting more expensive *per se*, but instead by requiring firms to use one technology instead of another, or to maintain particular emission limitations in order to avoid legal repercussions. Non-market-based emission control regulatory policies are called “command and control.” For any such non-market policy there is an “effective” price: a market price that—if instituted as an allowance or tax—would result in the identical emission reduction as the non-market policy. An effective price may be used internally within a firm, government agency, or other entity to represent the effects of command and control policies for the purpose of improved decision making. Renewable Portfolio Standards, energy efficiency measures, and other policies designed to mitigate CO_2 emissions impose an effective price on carbon.

In this report: Utility carbon price forecasts are effective prices used for state-required IRPs and internal planning purposes. EPA’s proposed carbon pollution standard for new sources of electric generation is a non-market-based policy that would result in an effective price of carbon; similarly, building blocks 1, 3, and 4 of the Clean Power Plan (coal plant efficiency improvements, renewable energy, and demand-side management) are also fundamentally non-market policies that result in an imputed cost of mitigation.

Marginal abatement cost of carbon: An abatement cost refers to an estimate of the expected cost of reducing emissions of a particular pollutant. Estimation of a marginal abatement cost requires the construction of a “supply curve”: all of the possible solutions to controlling emissions (these may be technologies or policies) are lined up in order of their cost per unit of pollution reduction. Then, starting from the least expensive option, one tallies up the pollution reduction from various solutions until the desired total reduction is achieved, and then asks: What would it cost to reduce emissions by the last unit needed to achieve the target? The answer is the “marginal” cost of that level of pollution reduction; a greater reduction target would have a higher marginal cost. The marginal abatement cost of carbon is not a market price used to internalize an externality. Rather, it is a method for estimating the price that, if it were applied as a market price, would have the effect of achieving a given emission reduction target. In a well-functioning cap-and-trade system, the allowance price would tend towards the marginal abatement cost of carbon.

In this report: We do not analyze any marginal abatement costs in this report—see the *2012 Synapse Carbon Dioxide Price Forecast* for further information.[3] McKinsey & Company has been a consistent producer of this type of analysis (see, for example, its 2010 report *Impact of the Financial Crisis on Carbon Economics: Version 2.1 of the Global Greenhouse Gas Abatement Cost Curve)*.[4]

Average policy cost versus marginal abatement cost: Many policy analyses compare the total benefits of a policy to the total costs—this represents the net cost (or benefit) of the policy. The average cost of the policy is the net cost divided by the expected tons of emissions abated. This value is fundamentally different than the marginal cost of compliance, which is the cost to reduce the last ton of emissions (i.e., the most expensive ton actually abated). For example, a policy may result in total net benefits, but require reductions through a trading mechanism wherein the market price is set by the marginal cost of emissions. In this case, the net (and average) policy cost are negative, but the marginal cost of abatement is positive.

In this report: Most prices in this report, including are CO_2 price forecast, are expressed in terms of marginal abatement costs.

Social cost of carbon: Whereas the marginal abatement cost estimates the price of stopping pollution, the social cost of carbon estimates the cost, per unit of emissions, of allowing pollution to continue. The social cost of carbon is the societal cost of current and future damages related to climate change resulting from the emission of one additional unit of pollutant. Estimating the uncertain costs of uncertain future damages from uncertain future climatic events is, of course, a tricky business. If enough information were available, a marginal abatement cost for each level of future emissions (the supply of emission reductions) could be compared to a social cost of carbon for each level of future emissions (the demand for emission reductions) to determine an "optimal" level of pollution (such that the next higher unit of emission reduction would cost more to achieve than its value in reduced damages). More commonly, the social cost of carbon is used as part of the calculation of benefits of emission-reducing measures.

In this report: The U.S. federal government's internal carbon price for use in policy making is intended to be an estimate of the social cost of carbon.

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[3] Wilson et al. 2012. *2012 Carbon Dioxide Price Forecast.* Synapse Energy Economics. Available at: http://www.synapse-energy.com/project/synapse-carbon-dioxide-price-forecast.

[4] McKinsey & Company. 2010. *Impact of the Financial Crisis on Carbon Economics: Version 2.1 of the Global Greenhouse Gas Abatement Cost Curve*. Page 8.

4. FEDERAL CLIMATE ACTION IS EXTREMELY LIKELY

In the near term, comprehensive federal climate legislation appears unlikely to come out of a Republican-controlled Congress. The Executive Branch, however, is moving forward with regulatory actions to limit greenhouse gas emissions. Following a directive issued by President Obama,[5] EPA released revised CO_2 performance standards for new power plants on September 20, 2013,[6] and on June 2, 2014, used its Clean Air Act authority to propose CO_2 standards for existing power plants.[7] Beyond the realm of electric-sector CO_2 policies (which are the focus of this report), similar regulatory measures have been proposed for the transportation, buildings, and industrial sectors; policies enacted in other sectors include vehicle efficiency standards set to rise to 54.5 miles per gallon by 2025 for new cars and light-duty trucks, and new energy efficiency standards for federal buildings set to reduce energy consumption by nearly 20 percent below the previous standard.[8,9] Still other rules aimed at reducing methane emissions from oil and gas production and CO_2 from aircrafts are currently under development.[10,11]

We continue to expect that a federal cap-and-trade program for greenhouse gases is the most likely policy outcome in the long term, because it enables participants to find the most cost-effective method of emissions abatement among many alternatives, rather than regulating a limited subset of alternatives. While state and regional policies combined with federal regulatory actions appear to be more likely than a federal cap-and-trade policy in the near term, according to a World Resources Institute (WRI) analysis, these local measures are unlikely to be able to meet long-term goals of reducing

[5] Memorandum from President Obama to Administrator of the Environmental Protection Agency, Power Sector Carbon Pollution Standards (June 25, 2013). Available at: http://www.whitehouse.gov/the-press-office/2013/06/25/presidential-memorandum-power-sector-carbon-pollution-standards.

[6] EPA. 2013. “2013 Proposed Carbon Pollution Standard for New Power Plants.” *Carbon Pollution Standards.* Available at: http://www2.epa.gov/carbon-pollution-standards/2013-proposed-carbon-pollution-standard-new-power-plants.

[7] EPA. “Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units.” *Carbon Pollution Standards.* Available at: http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule.

[8] Vlasic, Bill. August 28th, 2012. “US Sets Higher Fuel Efficiency Standards.” *The New York Times*. Available at: http://www.nytimes.com/2012/08/29/business/energy-environment/obama-unveils-tighter-fuel-efficiency-standards.html.

[9] U.S. Department of Energy. 2013. “Energy Efficiency Design Standards for New Federal Commercial and Multi-Family High-Rise Residential Buildings.” A Rule by the Department of Energy. July 9th, 2013. Available at: https://www.federalregister.gov/articles/2013/07/09/2013-16297/energy-efficiency-design-standards-for-new-federal-commercial-and-multi-family-high-rise-residential#h-9.

[10] See “Fact Sheet: EPA’s Strategy for Reducing Methane and Ozone-Forming Pollution from the Oil and Natural Gas Industry.” Available at: http://www.epa.gov/airquality/oilandgas/pdfs/20150114fs.pdf.

[11] See “U.S. Aircraft Greenhouse Gas Rulemaking Process.” Available at: http://www.epa.gov/otaq/documents/aviation/us-ghg-endangerment-ip-9-3-14.pdf.

total greenhouse gas emissions to 83 percent below 2005 levels by 2050, even in the most aggressive of scenarios.[12]

4.1. Regulatory Measures for Reducing Greenhouse Gas Emissions

There are a number of federal regulations that directly and indirectly mandate a reduction in greenhouse gas emissions in the power sector. These are summarized in Table 1 and described in detail below.

[12] See WRI's analysis of these scenarios in the 2013 report "Can the U.S. Get There From Here?: Using Existing Federal Laws and State Action to Reduce Greenhouse Gas Emissions." Available at: http://www.wri.org/publication/can-us-get-there-here.

Table 1: Summary of power sector regulatory measures that may result in reduced greenhouse gas emissions

Rule	Current Status as of Release	Next Deadline(s)	Pollutants Covered
Federal Regulations			
Clean Air Act, Section 111	EPA released a revised 111(b) rule, New Source Performance Standards for GHGs from new sources, in September 2013	Awaiting final rule; expected before or in conjunction with release of final 111(d) rule	CO_2 and other greenhouse gases
	EPA released a draft 111(d) rule controlling GHGs from existing sources on June 2, 2014	June 2015: EPA must finalize standards for existing power plants June 2016: States must submit state compliance plans to EPA	
National Ambient Air Quality Standards (NAAQS)	1-Hour SO_2 NAAQS was finalized in June 2010	Initial designations based on monitoring data were made in June 2013; additional designations expected by or before 2017	Sulfur dioxide; nitrogen dioxide; carbon monoxide; ozone; particulate matter; and lead
	PM2.5 annual NAAQS was finalized on December 2012	Final designations announced December 18, 2014; SIPs due in April 2018 with attainment required by 2020	
	EPA proposed to strengthen the 8-Hour Ozone NAAQS on November 24, 2014	SIPs for the existing (2008) standard are due in spring of 2015	
		Revisions to the 2008 standard must be finalized by October 1, 2015	
Cross State Air Pollution Rule (CSAPR)	The U.S. Supreme Court reinstated CSAPR in April 2014, finding that EPA had not exceeded its authority in crafting the rule	Court lifted stay of CSAPR on October 23, 2014; on November 21, 2014, EPA published rules tolling CSAPR deadlines three years – Phase I began January 1, 2015 and Phase II begins January 1, 2017	Nitrogen oxides and sulfur dioxide
Mercury and Air Toxics Standards (MATS)	Finalized in December 2011	April 16, 2015: Compliance deadline (rule allows for a one-year extension if certain conditions are met)	Mercury, metal toxins, organic and inorganic hazardous air pollutants, and acid gases
Coal Combustion Residuals (CCR) Disposal Rule	EPA issued final rule regulating CCR on December 19, 2014	Compliance timeline is structured to take into account overlap with yet-to-be-determined ELG compliance obligations	Coal combustion residuals (ash)
Steam Electric Effluent Guidelines (ELGs)	EPA released a proposed rule with eight regulatory options in June 2013	Final rule for release of toxins into waterways must be finalized by September 30, 2015	Toxins entering waterways
Cooling Water Intake Structure (316(b)) Rule	EPA released a final rule for implementation of Section 316(b) of the Clean Water Act on May 19, 2014	Final rule became effective October 14, 2014 and requirements will be implemented in NPDES permits as they are renewed	Cooling water
Regional Haze Rule	Regional Haze Rule issued in July 1999	States must file SIPs and install the Best Available Retrofit Technology (BART) controls within 5 years of SIP approval	Sulfur oxides, nitrogen oxides, and particulate matter

The Clean Air Act

As a result of the 2007 Supreme Court finding in *Massachusetts v. EPA*, greenhouse gas emissions were determined to be subject to the Clean Air Act and (in a later ruling) to contribute to air pollution anticipated to endanger public health and welfare. In 2009, EPA issued an "endangerment finding," obligating the agency to regulate emissions of greenhouse gases from stationary sources such as power plants.[13] In compliance with Section 111(b) of the Clean Air Act, EPA released draft New Source Performance Standards (NSPS) for the electric sector in April 2012 and revised NSPS standards in September 2013. The revised standards limit CO_2 emissions from new fossil-fuel power plants to 1,000-1,100 pounds of CO_2 per MWh (lbs/MWh)—a level achievable by a new natural gas combined-cycle plant. The exact limit of CO_2 emissions within that range depends on the type of plant and period over which the emission rate would be averaged.[14]

Under Section 111(d) of the Clean Air Act, once EPA has set standards under Section 111(b) for new sources of a pollutant that is not covered by another section of the Act (in this case, CO_2), EPA must propose standards for *existing* sources of that pollutant as well. On June 2, 2014, EPA proposed what it is calling the Clean Power Plan under Section 111(d) of the Clean Air Act. The Clean Power Plan aims to regulate emissions of CO_2 from existing fossil fuel-fired power plants by setting binding, state-specific carbon emission reduction goals for all affected electric generating units. These emissions reduction goals reflect the degree of emissions reductions achievable through the application of the "best system of emission reduction." States will be required to reduce their average CO_2 emission rate for affected generating units from a 2012 baseline rate to a lower target rate by 2030. Overall, EPA expects the Clean Power Plan will yield CO_2 reductions of approximately 30 percent below 2005 levels by 2030.

The Clean Power Plan's reach is broad and seeks to explicitly impact electric power planning, dispatch, and procurement, with provisions that encourage switching from high-emitting coal to lower-emitting gas, renewable energy procurement, and increased energy efficiency. The proposed rule provides for flexibility in state compliance, including options for states to meet fleet-wide emission rate limits (in tons of CO_2 per MWh) or mass-based emissions targets (in tons) through heat rate improvements at coal-fired generators, increased dispatch of more efficient combined cycle natural gas generating resources, renewable energy programs, energy efficiency, and/or cap-and-trade programs. States can act independently, or enter into regional agreements with other states to achieve compliance.

EPA is currently reviewing the nearly 4 million comments it received on the proposed Clean Power Plan, and the final rule is anticipated in mid-summer of this year. The exact requirements of the final rule are

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[13] EPA. 2013. "Endangerment and Cause or Contribute Findings for Greenhouse Gases under Section 202(a) of the Clean Air Act." *Climate Change.* Available at: http://www.epa.gov/climatechange/endangerment/.

[14] EPA. "Standards of Performance for Greenhouse Gas Emissions from New Stationary Sources: Electric Utility Generating Units." Available at: http://www2.epa.gov/carbon-pollution-standards/2013-proposed-carbon-pollution-standard-new-power-plants.

still uncertain at this time, but it is very likely that renewable energy and end-use energy efficiency will be an important part of a comprehensive compliance strategy. Many states will be able to achieve compliance at a lower cost through the structures of their existing renewable portfolio and energy efficiency resource standards.

The precise means of demonstrating compliance with the final rule is also still being determined, but EPA's proposal involves a process similar to Section 110 of the Clean Air Act, under which states will be required to submit plans that specify how they intend to comply with the Clean Power Plan. States can develop individual plans or create a multi-state compliance strategy. EPA will then decide whether a proposed plan meets the terms of the regulation. If a state fails to submit a plan, or the submitted plan does not meet the requirements of the rule, then EPA can impose a federal compliance plan.

Under the schedule proposed by EPA, both new source performance standards under Section 111(b) and existing source performance standards under Section 111(d) will be finalized by mid-summer 2015. Under Section 111(d), states would then be required to submit compliance plans to EPA within one year, with the possibility of an extension for an additional year. States that collaborate on a multi-state plan would get an additional two years to submit their plan.

These pending performance standards for new and existing sources will affect decisions made by utilities regarding operation, expansion, and retirements. Enforcement of the Clean Air Act creates an opportunity cost of greenhouse gas abatement: prudent utilities will take Clean Air Act compliance into consideration in their planning, either explicitly as a maximum allowable emissions rate, or implicitly as an effective CO_2 price. Section 5 of this report discusses several independent analyses of the compliance cost of the Clean Power Plan. While costs vary depending on the assumptions used by the modeling teams, 2030 compliances costs tend to hover around $30 per short ton.

Other regulatory measures put economic pressure on carbon-intensive power plants

A suite of current and proposed EPA regulations require pollution-intensive power plants to install environmental controls for compliance. The cost of complying with environmental regulations reduces the profitability of the worst polluters, sometimes rendering them uneconomic. These policies demonstrate momentum towards appropriately regulating or pricing environmentally harmful activities in the electric sector. To the extent that plants with high emissions of other pollutants also have high carbon emissions, these policies would tend to *lower* the future CO_2 price necessary to achieve a given reduction; as more pollution-intensive plants retire in response to other EPA regulations, the necessary carbon price is reduced. Specific regulatory measures include:

- *National Ambient Air Quality Standards (NAAQS)* set maximum health-based air quality limitations that must be met at all locations across the nation. EPA has established NAAQS for six pollutants: sulfur dioxide (SO_2), nitrogen dioxides (NO_2), carbon monoxide (CO), ozone, particulate matter—measured as particulate matter less than or equal to 10 micrometers in diameter (PM10) and particulate matter less than or equal to 2.5 micrometers in diameter (PM2.5)—and lead.

- *The Cross State Air Pollution Rule (CSAPR)* establishes the obligations of each affected state to reduce emissions of NO_X and SO_2 that significantly contribute to another state's PM2.5 and ozone non-attainment problems. Implementation of CSAPR was delayed when the rule was vacated by the U.S. Court of Appeals for the District of Columbia in August 2012; it was then reinstated by the Supreme Court on April 29, 2014. Significantly, the Supreme Court found that EPA had not exceeded its authority in crafting an emission control program that utilized cap and trade and considered cost as a factor where the language of the Clean Air Act was ambiguous in addressing the complex problem of interstate transport of pollution.
- *Mercury and Air Toxics Standards (MATS)*: The final MATS rule, approved in December 2011, sets stack emissions limits for mercury and other metal toxins, organic and inorganic hazardous air pollutants, and acid gases. Compliance with MATS is required by 2015, with a potential extension to 2016. Many utilities have already committed to capital improvements at their coal plants to comply with the standard. In fact, the U.S. Energy Information Administration (EIA) recently found that approximately 70 percent of U.S. coal-fired power plants already comply with MATS.[15]
- *Coal Combustion Residuals (CCR) Disposal Rule:* On December 19, 2014, EPA issued a final rule regulating CCR under Subtitle D of the Resource Conservation and Recovery Act. In the final rule, EPA designates coal ash as municipal solid waste, rather than hazardous waste, which allows its continued "beneficial reuse" in products such as cement, wallboard, and agricultural amendments. The rule applies to new and existing landfills and ash ponds and establishes minimum siting and construction standards for new CCR facilities, requires existing ash ponds at operating coal plants to either install liners and ground water monitoring or permanently retire, and sets standards for long-term stability and closure care. The rule also establishes a number of requirements for facilities to make monitoring data and compliance information available to the public online, which is significant as the Subtitle D designation makes the CCR regulations "self-implementing," meaning EPA has no formal role in implementing or enforcing the regulations. Instead, enforcement is expected to be achieved through citizen suits under the Solid Waste Disposal Act. States may—but are not required to—incorporate the federal CCR requirements into their own solid waste management plans.
- *Steam Electric Effluent Limitation Guidelines (ELGs):* On June 7, 2013, EPA released eight regulatory options for new, proposed steam-electric ELGs to reduce or eliminate the release of toxins into U.S. waterways. A final rule is required by September 30, 2015.[16]

[15] See U.S. Energy Information Administration website. Accessed February 4, 2015. Available at: http://www.eia.gov/todayinenergy/detail.cfm?id=15611.

[16] See U.S. Environmental Protection Agency website. Accessed February 4, 2014. Available at: http://water.epa.gov/scitech/wastetech/guide/steam-electric/amendment.cfm.

New requirements will be implemented in 2015 to 2020 through the five-year National Pollutant Discharge Elimination System permit cycle.[17]

- *Cooling Water Intake Structure (§316(b)) Rule:* In March 2011, EPA proposed a long-expected rule implementing the requirements of Section 316(b) of the Clean Water Act at existing power plants that withdraw large volumes of water from nearby water bodies. Under this rule, EPA would set new standards to reduce the impingement and entrainment of fish and other aquatic organisms from cooling water intake structures at electric generating facilities. The final rule was released on May 19, 2014. The requirements of the rule will be implemented through renewal of a facility's NPDES permit, which must be renewed every five years, and will be determined on a case-by-case basis.[18]

- *Regional Haze Rule:* The Regional Haze Rule, released in July 1999, requires states to develop state implementation plans (SIPs) for reducing emissions that impair visibility at pristine areas such as national parks. The rule also requires periodic SIP updates to ensure progress is being made toward improving visibility. The initial development of SIPs, which is just now being completed, requires Best Available Retrofit Technology (BART) controls for SO_X, NO_X, and PM emissions on large emission sources built between 1962 and 1977 that are found to be contributing to visibility impairment. BART controls must be installed within five years of SIP approval.

4.2. Proposed Cap-and-Trade Legislation

Over the past decade, there have been several congressional proposals to legislate cap-and-trade programs, with the goal of reducing greenhouse gas emissions by more than 80 percent below recent levels by 2050 through a federal cap. Such programs would allow trading of allowances to promote least-cost reductions in greenhouse gas emissions.

Comprehensive climate legislation was passed by the House in 2009: the American Clean Energy and Security Act, also known as Waxman-Markey or H.R. 2454. However, the Senate did not vote on either of the two climate bills before it in the 2009-2010 session (Kerry-Lieberman APA 2010 and Cantwell-Collins S. 2877). Waxman-Markey was a cap-and-trade program that would have required a 17 percent

[17] See U.S. Environmental Protection Agency. Steam Electric ELG Rulemaking. UMRA and Federalism Implications: Consultation Meeting. October 11, 2011. Available at: http://water.epa.gov/scitech/wastetech/guide/upload/Steam-Electric-ELG-Rulemaking-UMRA-and-Federalism-Implications-Consultation-Meeting-Presentation.pdf.

[18] See U.S. Environmental Protection Agency website. Accessed May 21, 2014. Available at: http://water.epa.gov/lawsregs/lawsguidance/cwa/316b/index.cfm.

reduction in emissions from 2005 levels by 2020, and an 83 percent reduction by 2050.[19] Further analysis of these proposals is provided in Synapse's *2012 Carbon Dioxide Price Forecast*.[20]

Congressional interest in climate policy has been ongoing. In March 2012, Senator Bingaman introduced the Clean Energy Standard Act of 2012 (S. 2146), which would have required larger utilities to meet a percentage of their sales with electric generation from sources that produce fewer greenhouse gas emissions than a conventional coal-fired power plant. Credits generated by these clean technologies would have been tradable with a market price. In February 2013, Senators Sanders and Boxer introduced new comprehensive climate change legislation, the Climate Protection Act of 2013. This bill proposed a fee of $20 per ton of CO_2 or CO_2-equivalent content of methane, rising at 5.6 percent per year over a ten-year period. Finally, in November 2014, Senators Whitehouse and Schatz introduced the American Opportunity Carbon Fee Act, which would assess a fee for every ton of CO_2 pollution emitted by all coal, oil, and natural gas produced in or imported to the United States. The bill would also cover large emitters of non-carbon greenhouse gases (such as methane) and CO_2 from non-fossil-fuel sources. The fee would start at $38 per short ton in 2015 and increase annually by an inflation-adjusted 2 percent, following the Obama Administration's estimate of the social cost of carbon. All revenue generated by the bill would be returned to the American people through an as-yet undetermined mechanism. The bill has not yet been brought to a vote.[21]

As discussed earlier, we expect that federal cap-and-trade legislation will eventually be enacted but that it is unlikely to happen in the near term. Federal carbon regulations are in effect or under development today, and the economic pressure—or opportunity cost—that they create may be represented as an effective price of greenhouse gas emissions. Regulatory measures are unlikely to meet long-term goals of reducing total greenhouse gas emissions to approximately 80 percent below 2005 levels by 2050, and a broader approach will be increasingly attractive in order to meet these goals at lower costs. Our judgment indicates this is most likely to take the form of a federal cap-and-trade system.

4.3. State and Regional Policies

There are two regional and state cap-and-trade programs in the United States today: the Northeast's Regional Greenhouse Gas Initiative (RGGI) and California's Cap-and-Trade Program under the state's

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[19] U.S. Energy Information Administration (EIA); Energy Market and Economic Impacts of the American Power Act of 2010 (July 2010). Available at http://www.eia.gov/oiaf/servicerpt/kgl/index.html. EIA; Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009 (August 2009). Available at http://www.eia.doe.gov/oiaf/servicerpt/hr2454/index.html.

[20] Wilson et al. 2012. *2012 Carbon Dioxide Price Forecast*. Synapse Energy Economics. Available at: http://www.synapse-energy.com/project/synapse-carbon-dioxide-price-forecast.

[21] "Introducing the American Opportunity Carbon Fee Act" (November 2014). Available at: http://www.whitehouse.senate.gov/news/release/introducing-the-american-opportunity-carbon-fee-act.

Global Warming Solutions Act (Assembly Bill 32). In addition, a total of 20 states plus the District of Columbia have set greenhouse gas emissions targets as low as 80 percent below 1990 levels by 2050.[22]

Regional Greenhouse Gas Initiative

RGGI is a cap-and-trade greenhouse gas program for power plants in the northeastern United States. Current participant states are Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont. RGGI has had more than six years of successful CO_2 allowance auctions, with Auction 26 in December 2014 resulting in a clearing price of $5.21 per ton.[23] RGGI is designed to reduce electricity sector CO_2 emissions to at least 45 percent below 2005 levels by 2020.[24] RGGI is also a potential avenue for Clean Power Plan compliance for these states.

When RGGI was established in 2007, the expectation was that the CO_2 emissions allowance auction would generate revenues for consumer benefit programs such as energy efficiency, renewable energy, and clean energy technologies. While RGGI has provided significant revenues for consumer benefit, its allowance prices have generally remained near the statutory minimum price until recently. External influences, including changes to fuel prices, caused a shift from coal and oil to lower-carbon natural gas generation. Compared to those external factors, the effect of the original RGGI cap requirements were relatively minor in meeting the goals of reducing CO_2 emissions in the power sector.[25]

In 2012 and 2013, the RGGI states evaluated a number of plans for tighter emissions caps with the goal of raising allowance prices. In February of 2013, participating states agreed to lower the CO_2 cap from 165 million to 91 million short tons in 2014, to be reduced by 2.5 percent each year from 2015 to 2020. RGGI analysis indicated that with these lower caps, allowance prices will rise to $10.60 per short ton by 2020.[26]

In March 2014, the first auction under the new cap cleared at $4 per short ton. This auction used all available "cost containment reserve" allowances for the year—a fixed additional supply of allowances (above the cap) at a fixed price ($4 in 2014, rising to $10 in 2017) used to prevent rapid increases in the allowance price when auction prices rise above a set trigger. No more cost containment reserve

[22] Center for Climate and Energy Solutions. "Greenhouse Gas Emissions Targets." *U.S. Climate Policy Maps.* Accessed September 13, 2013. Available at: http://www.c2es.org/us-states-regions/policy-maps/emissions-targets.

[23] RGGI Auction 23 results available at: http://rggi.org/market/co2_auctions/results/Auction-23.

[24] RGGI. 2013. "RGGI States Propose Lowering Regional CO_2 Emission Cap 45%, Implementing a More Flexible Cost-Control Mechanism." Press Release. Available at: http://www.rggi.org/docs/PressReleases/PR130207_ModelRule.pdf.

[25] Environment Northeast. 2010. "RGGI at One Year: An Evaluation of the Design and Implementation of the Regional Greenhouse Gas Initiative." Available at: http://www.usclimatenetwork.org/resource-database/rggi-at-one-year-an-evaluation-of-the-design-and-implementation-of-the-regional-greenhouse-gas-initiative/.http://www.env-ne.org/public/resources/pdf/ENE_2009_RGGI_Evaluation_20100223_FINAL.pdf.

[26] RGGI. 2013. "RGGI States Propose Lowering Regional CO2 Emission Cap 45%, Implementing a More Flexible Cost-Control Mechanism." Press Release. Available at: http://www.rggi.org/docs/PressReleases/PR130207_ModelRule.pdf. Allowances prices have been converted to 2014 dollars.

allowances were available for the remaining three auctions in 2014, and prices rose to $5.21 per short ton by the end of the year.

The December 2014 clearing price was the highest-ever clearing price at a RGGI auction. In 2015, the number of cost containment reserve allowances will rise from 5 million to 10 million, alongside an increase in the trigger price from $4 to $6 per short ton. We expect this to result in a continuation of the slow but steady rise in RGGI allowance prices.

California's Cap-and-Trade-Program under AB32

With the goal of reducing the state's emissions to 1990 levels by 2020, California's Global Warming Solutions Act (AB32) has created the world's second largest carbon market, after the European Union's Emissions Trading System. The first compliance period for California's Cap-and-Trade Program began on January 1, 2013 and covers electricity generators, CO_2 suppliers, large industrial sources, and petroleum and natural gas facilities emitting at least 27,600 short tons of CO_2 equivalents per year.[27] This first phase of the program included electricity generators and large industrials. Phase II began in 2015, and also includes transportation fuels, natural gas suppliers, and smaller industrial sources. In 2015 the annual allowance budget rises to 434 million short tons, from 176 million short tons, due to the increasing scope of the policy.[28]

On January 1, 2014, California and Québec formally linked their carbon markets. The first joint auction was held in November 2014 and cleared at $10.98 per short ton.[29] The second joint auction was held on February 18, 2015, and cleared at $11.08. This was the first auction to include transportation fuels, and sold 73.6 million allowances, as compared to only 23 million allowances in the prior November 2014 auction.[30]

While the current cap-and-trade program in California only runs through 2020, several bills were introduced in 2014 suggesting direction through 2030. While none were taken to a final vote, there is an

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[27] California Air Resources Board. 2013. "California Cap on Greenhouse Gas Emissions and Market-Based Compliance Mechanisms to Allow for the Use of Compliance Instruments by Linked Jurisdictions." Available at: http://www.arb.ca.gov/cc/capandtrade/ctlinkqc.pdf. Legislated value is 25,000 metric tons, converted here to short tons.

[28] CARB AB 32 Final Regulation Order. Available at: http://www.arb.ca.gov/cc/capandtrade/capandtrade/unofficial_c&t_012015.pdf.

[29] California Air Resources Board. 2015. California Cap and Trade Program Summary of Auction Results. Updated 1/12/2015. Available at: http://www.arb.ca.gov/cc/capandtrade/auction/results_summary.pdf.

[30] California Air Resources Board. 2015. *California Cap and Trade Program and Quebec Cap and Trade System February 2015 Joint Auction #2 Summary Results Report*. Available at: http://www.arb.ca.gov/cc/capandtrade/auction/feb-2015/summary_results_report.pdf.
Auctions clear in dollars per metric tons – values here have been converted to short tons.

expectation that they will be reconsidered in 2015.[31] ICIS industries forecasts California CO_2 allowance prices to hit $45 per short ton by 2030.[32]

4.4. Assessment of CO_2 Price for Federal Rulemaking

In 2010, the U.S. federal government began including a carbon cost in regulatory rulemakings to account for the climate damages resulting from each additional ton of greenhouse gas emissions;[33] updated values were released in 2013.[34] The 2013 Economic Report of the President acknowledges that these values will continue to be updated as scientific understanding improves.[35]

An Interagency Working Group on the Social Cost of Carbon—composed of members of the Department of Agriculture, Department of Commerce, Department of Energy, Environmental Protection Agency, Department of Transportation, and Office of Management and Budget, among others—was tasked with developing a consistent value for the social benefits of climate change abatement. Four values were developed (see Section 3 for more explanation of the "social cost of carbon" methodology). These values—$11, $36, $57, and $103 per short ton of CO_2 in 2013, and rising over time—represent average (most likely) damages at three discount rates, along with one estimate at the 95th percentile of the assumed distribution of climate impacts.[36] While subject to significant uncertainty, this multi-agency

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[31] Environmental Defense Fund. "Carbon Market California – Year Two: 2014." Available at: http://www.edf.org/sites/default/files/content/carbon-market-california-year_two.pdfhttp://www.edf.org/sites/default/files/content/carbon-market-california-year_two.pdf.

[32] ICIS. 2015. "ICIS launches 2030 Forecast for California Carbon Allowances." Press Release. January 2015. Available at: http://www.icis.com/press-releases/icis-launches-2030-forecast-for-california-carbon-allowances/. Forecast in metric tons, value here converted to short tons.

[33] Interagency Working Group on the Social Cost of Carbon, U. S. G. 2010. "Appendix 15a. Social cost of carbon for regulatory impact analysis under Executive Order 12866." In *Final Rule Technical Support Document (TSD): Energy Efficiency Program for Commercial and Industrial Equipment: Small Electric Motors*. U.S. Department of Energy. Available at: http://go.usa.gov/3fH.

[34] Interagency Working Group on the Social Cost of Carbon. 2013. *Technical Support Document – Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis – Under Executive Order 12866*. Available at: http://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf. Reported values have been converted to 2014 dollars per short ton.

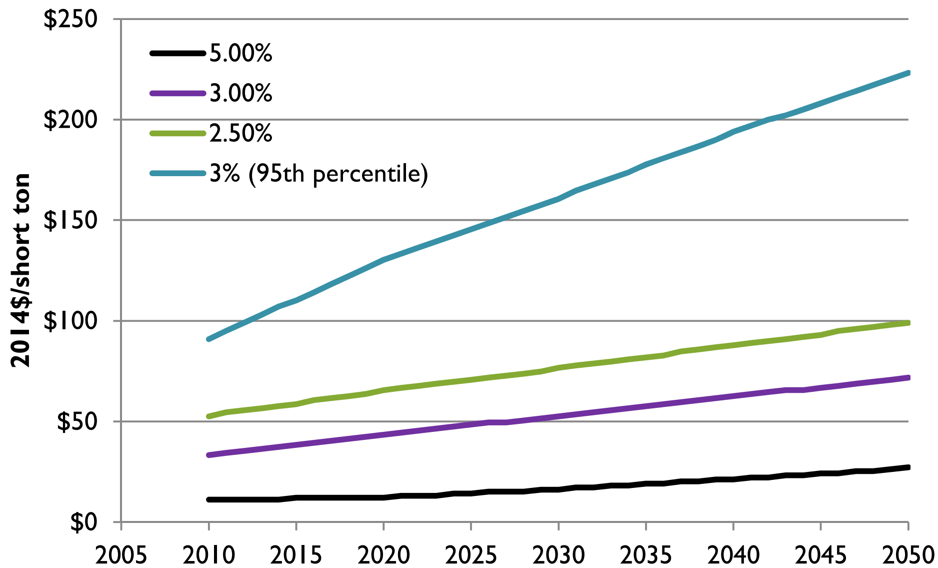
[35] The White House. 2013."Climate Change and the Path Toward Sustainable Energy Sources." *2013 Economic Report of the President*. Available at: http://www.whitehouse.gov/sites/default/files/docs/erp2013/ERP2013_Chapter_6.pdf.

[36] In a 2012 paper, Ackerman and Stanton modified the Interagency Working Group's assumptions regarding uncertainty in the sensitivity of temperature change to emissions, the expected level of damages at low and high greenhouse gas concentrations, and the assumed discount rate, and found values for the social cost of carbon ranging from the Working Group's level up to more than an order of magnitude greater [Frank Ackerman and Elizabeth A. Stanton. 2012. "Climate Risks and Carbon Prices: Revising the Social Cost of Carbon." *Economics: The Open-Access, Open-Assessment E-Journal*, Vol. 6, 2012-10. http://dx.doi.org/10.5018/economics-ejournal.ja.2012-10]. Similarly, Laurie Johnson and Chris Hope modified discount rates and methodologies and found results up to 12 times larger than the Working Group's central estimate [Laurie T. Johnson, Chris Hope. 2012. "The social cost of carbon in U.S. regulatory impact analyses: an introduction and critique." *Journal of Environmental Studies and Sciences*; DOI: 10.1007/s13412-012-0087-7].

effort represents an initial attempt at incorporating the benefits associated with CO_2 abatement into federal policy. These values are presented in Figure 1.

These estimates continue to be used in federal government rulemakings for the purpose of calculating costs and benefits of new and updated policies. While a CO_2 price for federal rulemaking assessments is a fundamentally different kind of cost metric than the others discussed in this report, it nonetheless represents a dollar value for greenhouse gas emissions currently in use by the U.S. federal government.

Figure 1: Range of Federal CO_2 Prices for Rulemakings, by discount rate



5. The Cost of Implementing EPA's Clean Power Plan

In Section 4, we discuss the EPA's Clean Power Plan in the context of federal climate legislation that may result in reduced greenhouse gas emissions. As the proposal aims to regulate CO_2 emissions directly and represents a significant change in near-term climate policy certainty as compared to our previous CO_2 price forecast, we examine it more fully in this section. We discuss factors that will affect states' implementation methods, as well as the expected costs of compliance as modeled by EPA, Synapse, and third-party analysts.

5.1. Issues in Implementing the Clean Power Plan for Utility Planning

The Clean Power Plan is EPA's proposal to meet CO_2 emissions limitations from existing sources using a Best System of Emissions Reductions ("BSER"). EPA has structured the Clean Power Plan around four fundamental "building blocks" that represent possible means for achieving the established emissions standard: (1) increasing existing coal plant efficiency, (2) displacing coal generation with existing natural gas, (3) increasing renewable energy acquisitions, and (4) implementing energy efficiency programs.

Taken together, EPA estimates that these programs will reduce emissions by a certain amount in each state. EPA's targets for each state are set as a rate, measured in pounds of CO_2 per megawatt-hour (lbs/MWh). The rate has been a source of confusion to many parties: it represents both projected emissions from existing sources, as well as generation from new renewable energy and energy efficiency programs.

EPA's proposal allows states to choose the metric by which they measure compliance: states can either meet the rate-based target using a combination of the building blocks or other programs, or meet an alternate mass-based target, measured in total tons of CO_2.

The mass-based compliance route is fundamentally a cap on sectoral emissions on a state-by-state basis. It is not unreasonable to assume that implementing states might choose to use a cap-and-trade scheme, such as is currently employed for national SO_2 emissions under the Acid Rain Program, regionally for NO_X budget trading program, and for CO_2 in California and RGGI states. Planning and modeling under a mass-based cap is fairly well understood; it involves a marginal abatement cost applied to electric sector emissions reduces emissions. The price is adjusted either by the market or an administrative body such that total emissions hit the required target. Modeling mass-based compliance effectively requires finding a price (either real or shadow) for CO_2 that maintains emissions under the cap. Utilities may elect to either review their pro-rata share of mass-based emissions reductions under the cap, or model the impact of mass compliance on the state fleet to determine an effective CO_2 price. For utilities that trade electricity bilaterally or on the open market, the market price of electricity should also account for the CO_2 price impacts.

The rate-based compliance mechanism sets a rate target for individual states based on an (outwardly) simple formula, in which emissions from existing generators are divided by generation from existing generators plus generation from renewable energy and energy efficiency (EERE). States or utilities seeking to model the impact of the Clean Power Plan under a rate-based compliance scheme need to find a least-cost solution that reduces the emissions rate of existing fossil generators while including the amount of EERE as an additional factor in that emissions rate. Effectively, modeling a rate-based compliance mechanism requires utilities (and states) to simultaneously optimize power plant operations and EERE, while also accounting for how compliance in neighboring utilities (and states) impacts generators and the price for market electricity. States with different rate targets (or different rate-based mechanisms) may impose different restrictions on fossil generators, and thus significantly impact market electricity prices.

5.2. Expected Pricing and Stringency of EPA's Clean Power Plan

As of the date of publication of this report, the Clean Power Plan is still a proposal and leaves numerous open questions and ambiguities. While it is expected that many of these ambiguities will be resolved by the time the final rule is published, the exact implications of the rule are still difficult to fully resolve. Depending on interpretations of various open questions, including the role of new gas and the treatment of EERE, the rule may prove to be fairly low-cost, or higher cost. It is possible to envision high-and low-cost scenarios for both high and low efficacy rule implementations. All estimates in this section have been converted to 2014 dollars per short ton.

EPA's Estimates

Several studies have attempted to quantify the costs and benefits of implementing the proposed Clean Power Plan.[37] In developing the proposed rule, EPA estimated the average compliance cost for each of the building blocks.[38] EPA found that:

- Heat rate improvements at existing coal-fire units (Building Block 1) would have net costs between $6 and $11 per short ton
- Substituting generation from existing natural gas plants for generation from existing coal plans (Building Block 2) would have net costs of about $283 per short ton
- Encouraging new renewable energy and discouraging the retirement of existing nuclear power plants (Building Block 3) would have costs between $9 and $38 per short ton
- Demand-side energy efficiency (Building Block 4) would range from $15 to $23 per short ton

EPA also used the IPM electricity capacity expansion model to analyze compliance in a more integrated framework, finding average compliance costs of $28 per short ton in 2030 (ranging from zero to $106 per ton depending on the state). They also modeled a regional compliance approach, where nearby states could work together to reduce costs. This approach resulted in average costs of $29 per short ton in 2030 (ranging from $26 to $34 per ton depending on the region).

Independent Analyses

The Rhodium Group and CSIS Energy used the EIA's NEMS model to project the effects of the proposed Clean Power Plan. NEMS is a model that considers not only the electricity sector, but other elements of the energy economy, including transportation, industrial, commercial, and residential uses. They found simple state-by-state compliance to be highly unlikely, and as a result compared a national compliance approach (with a single rate- or mass-based standard) to a more fragmented 22-region approach. With the inclusion of energy efficiency, they found expenditures on electricity decreased by 2.4 percent under a national compliance approach relative to a base case without the Clean Power Plan. Under regional

[37] Results from public modeling analyses were converted to 2014 dollars using price deflators taken from the U.S. Bureau of Economic Analysis, and are available at: http://www.bea.gov/national/nipaweb/SelectTable.asp.

[38] EPA. 2014. *Clean Power Plan Proposed Rule (June 2014 release)*. Available at: http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule.

compliance, electricity expenditures increased 0.6 percent.[39] This small change in expenditures indicates that Clean Power Plan compliance can be implemented at a relatively modest cost. The use of an economy-wide energy model also allowed this study to demonstrate the impacts on national gas demand; Rhodium Group and CSIS Energy projected total national gas demand to increase 10.9 billion cubic feet per day by 2030, as compared to a no policy case. This higher gas demand resulted in an increase in Henry Hub gas prices of $0.48 per MMBtu.

SNL Energy completed modeling of the proposed rule using AuroraXMP, a high-resolution electric sector model incorporating both capacity expansion and dispatch. They modeled the policy as a mass-based target, including emissions from new builds, with regional compliance across five regions in the Eastern Interconnect. SNL imposed a CO_2 constraint, and reported the resulting shadow prices. Their values ranged from $13 to $29 per short ton for the 2020-2029 average targets, rising to $21 to $33 per short ton in 2030. This analysis implied that the RGGI states could largely meet their target under the existing RGGI system, PJM could comply at a cost of $21 per ton (well below the prices implied in the EPA IPM analysis), and other regions could comply at costs quite similar to those assumed by EPA under regional cooperation.[40]

Energy Ventures Analysis conducted a similar study for the National Mining Association, using the same model as SNL but focusing on state, rather than regional, compliance. They found average CO_2 prices over the 2020-2030 period ranging from $10 to $31 per short ton for most states, although prices in Arizona, Nevada, Oregon, and Washington were much higher: $55 per ton, $83 per ton, $54 per ton, and $70 per ton, respectively.[41]

Several independent system operators (ISOs) are in the process of conducting their own analyses. MISO used the EGEAS electricity capacity expansion model to consider compliance approaches directly following EPA's building blocks, as well as a generic CO_2 constraint based on EPA's mass-based targets.[42] The building block approach resulted in an overall CO_2 cost of $60 per ton reduced, while the more flexible mass-based approach cost $38 per ton reduced. The MISO analysis only focused on existing-source CO_2 emissions—any emissions from new gas plants to be regulated under 111(b) are not counted. As a result, the mass-based approach above may create a loophole in the proposed policy design whereby new gas combined-cycle plants could replace generation from old gas combined-cycle

[39] Larsen et al. 2014. *Remaking American Power: Potential Energy Market Impacts of EPA's Proposed GHGH Emission Performance Standards for Existing Electric Power Plants*. CSIS and Rhodium Group. Available at: http://csis.org/publication/remaking-american-power.

[40] Gelbaugh et al. 2014. *Critical Mass: An SNL Energy Evaluation of Mass-based compliance under the EPA Clean Power Plan*. Available at: http://center.snl.com/Resources/Whitepaper.aspx?id=4294973757.

[41] Energy Ventures Analysis. 2014. *EPA Clean Power Plan: Costs and Impacts on US Energy Mark*ets. Energy Ventures Analysis for National Mining Association. Available at: http://www.countoncoal.org/assets/Executive-Summary-EPA-Clean-Power-Plan-Costs-Impacts.pdf.

[42] MISO. 2014. "GHG Regulation Impact Analysis – Initial Study Results." September 17, 2014. Available at: http://www.eenews.net/assets/2014/09/18/document_ew_01.pdf.

plants to reduce emissions under the 111(d) umbrella without actually reducing overall system emissions. It is likely that EPA will address such potential limitations in the final rule.

PJM used the PROMOD hourly production cost model to review the cost of compliance under mass-based targets, assuming that new gas units are regulated under Clean Air Act section 111(b).[43] PJM analyzed a number of different scenarios of renewable energy and energy efficiency implementation and gas prices. Required CO_2 prices ranged from $5 to $30 per short ton in 2030, except for scenarios with high natural gas prices which ranged from $35 to $55 per short ton.

Other studies have focused on modeling the rate-based provisions of the Clean Power Plan and reported changes in total system costs and electricity prices, but not CO_2 prices. The Missouri utility Ameren found an incremental cost of $4 billion to achieve the Clean Power Plan goals, as compared to its latest IRP that would achieve the same goals by 2035.[44] A NERA Economic Consulting report found incremental costs of $366 billion (in $2013 present value) nationwide, or $479 billion without the availability of energy efficiency and renewable energy.[45] The PJM study cited above found incremental costs in 2029 of $0.1 billion to $3.5 billion in the high natural gas price case for the PJM system as a whole.

Synapse Analysis: What Would the Cost Be with Nationwide Cooperation?

Synapse used the ReEDS (Regional Energy Deployment System) model, built by the National Renewable Energy Lab, to estimate expected allowance prices under two scenarios of full national cooperation in meeting the Clean Power Plan. ReEDS selects the types of power generation to build and operate in different parts of the country with the goal of achieving the least total cost; it draws many of its assumptions from the EIA's 2014 Annual Energy Outlook. Our Clean Power Plan scenarios included a cap on CO_2 emissions consistent with EPA's mass-based targets.[46] Modeling results were produced using both "annual" and "average" assumed targets. The annual approach matches the EPA mass-based targets in each year beginning in 2020, while the average approach matches the 2020-2029 average mass. Figure 2 reports yearly emissions for both types of targets. As shown in Figure 3, allowance prices typically range from $16 to $25 per short ton (in 2012 dollars) throughout the 2020-2030 timeframe.

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[43] Sotkiewics, Paul and Abdur-Rahman, Muhsin. 2014. "EPA's Clean Power Plan Proposal Review of PJM Analyses Preliminary Results." PJM Members Committee Webinar November 17, 2014. Available at: http://www.pjm.com/~/media/documents/reports/20141117-epas-clean-power-plan-proposal-review-of-pjm-analyses-preliminary-results.ashx.

[44] Ameren. 2015. *Ameren's Alternative to the EPA's proposed Greenhouse Gas Rules*. Available at: https://www.ameren.com/-/media/Corporate-Site/Files/aboutameren/amerens-alternative-ghg-white-paper.pdf?la=en.

[45] NERA Economic Consulting. 2014. *Potential Energy Impacts of the EPA Proposed Clean Power Plan*. Available at: http://americaspower.org/sites/default/files/NERA_CPP%20Report_Final_Oct%202014.pdf.

[46] EPA. 2014. "Clean Power Plan Proposed Rule: Translation of State-Specific Rate-Based CO2 Goals to Mass-Based Equivalents." November 6, 2014. Available at: http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule-translation-state-specific-rate-based-co2.

Using the average targets, prices start lower in 2020 before gradually rising as the policy becomes more stringent. These two cases can be seen as a low-end estimate for the cost of compliance with the Clean Power Plan. Less cooperation between states would result in higher costs by reducing the number of low-cost compliance options available to each state.

Figure 2: U.S. CO_2 emissions under two ReEDS Clean Power Plan scenarios (million short tons)

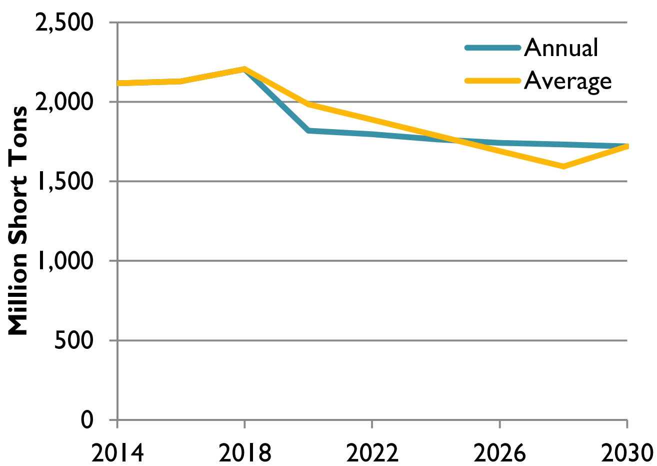
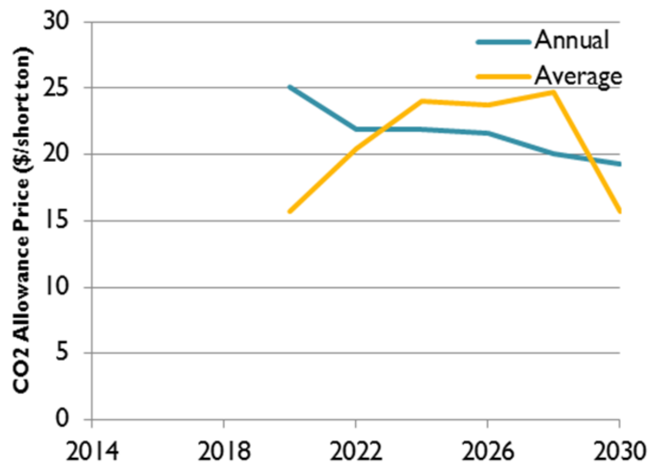


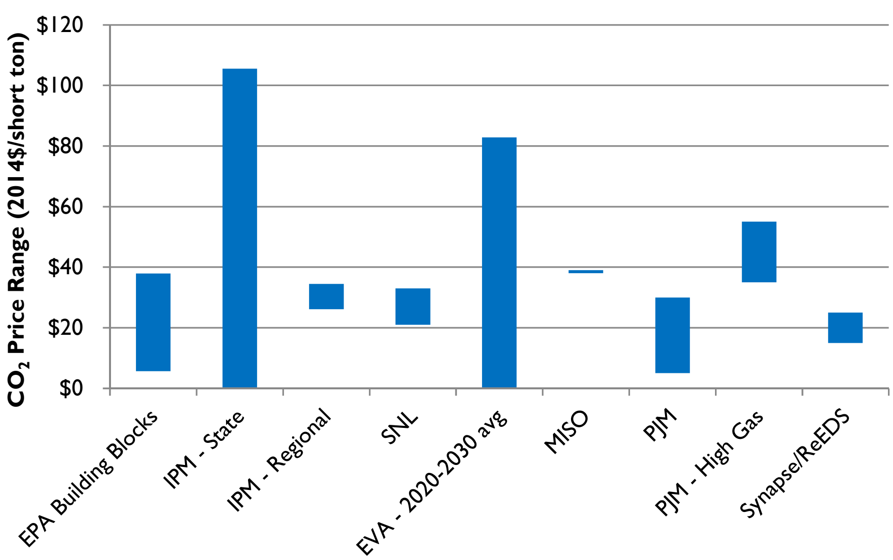
Figure 3: U.S. CO_2 allowance prices under two ReEDS Clean Power Plan scenarios ($/short ton)



Comparison of Price Estimates

Figure 4 below compares Synapse's nationwide analysis (referred to as Synapse/ReEDS) to the range of other analyses discussed in this section. The Synapse analysis falls well within this range. Modeled compliance costs depend on a number of factors, including assumptions about cooperation, fuel prices, renewable and energy efficiency costs, and retirements.

Figure 4: Summary of Clean Power Plan study CO_2 price estimates (2014 dollars per short ton)



6. CO_2 PRICE FORECASTS IN UTILITY IRPS

A growing number of electric utilities include projections of the expected costs associated with greenhouse gas emissions in their resource planning. In addition to the pool of recent IRPs reviewed for this forecast, which are characterized below, Synapse has previously conducted an extensive study of resource plans dating back to 2003:

- None of the 15 IRPs published from 2003-2007 that we reviewed included a CO_2 price forecast.
- Of the 56 IRPs from 2008-2011 that we reviewed, 23 included a CO_2 price forecast. This jump in the inclusion of carbon price projections in IRPs from 2008 onwards coincided with the introduction of the Waxman-Markey bill in Congress, which sought to legislate a cap-and-trade system. As a result of this bill, the inclusion of carbon pricing sensitivities in IRPs became paramount to prudent planning beginning in 2008; a majority of the IRPs in our 2015 review reflect an understanding that inclusion of a methodology to reflect future environmental regulations is prudent planning.
- Of the 115 IRPs released in 2012-2015 reviewed by Synapse (referred to below as our "current sample"), 66 include a CO_2 price in at least one scenario, including 61 with a CO_2 price in their reference case scenario (53 percent).
- Moreover, of the 24 IRPs released in 2014-2015 reviewed by Synapse, 20 include a CO_2 price in at least one scenario, of which 19 include a CO_2 price in their reference case scenario (79 percent).

These data show that the resource plans in the current sample includes a similar fraction of IRPs with a CO_2 price forecast as the 2008-2011 sample, when major climate bills were actively under consideration (57 percent in 2012-2015 as compared to 50 percent in 2008-2011).

Table 2: IRP database summary statistics

	Number of IRP Reviewed	Number of IRPs with CO_2 considered
2003-2007	15	0
2008-2011	56	23
2012-2015	115	66
2012-2013	91	46
2014-2015	24	20

How well does our current sample represent utility planning across the United States? A total of 3,412 utilities operated in the United States in 2012.[47] In terms of generation, the top 5 percent—170

[47] EIA Form 860, 2012 (Released Oct. 10, 2013).

utilities—accounted for 77 percent of total U.S. generation in 2012. Our sample includes IRPs from 33 utilities within this largest 5 percent. Of those 33, 29 utilities have IRPs with non-zero CO_2 prices. This means that almost all of the IRPs we reviewed from the largest utilities in the country include a non-zero CO_2 price in their planning process.

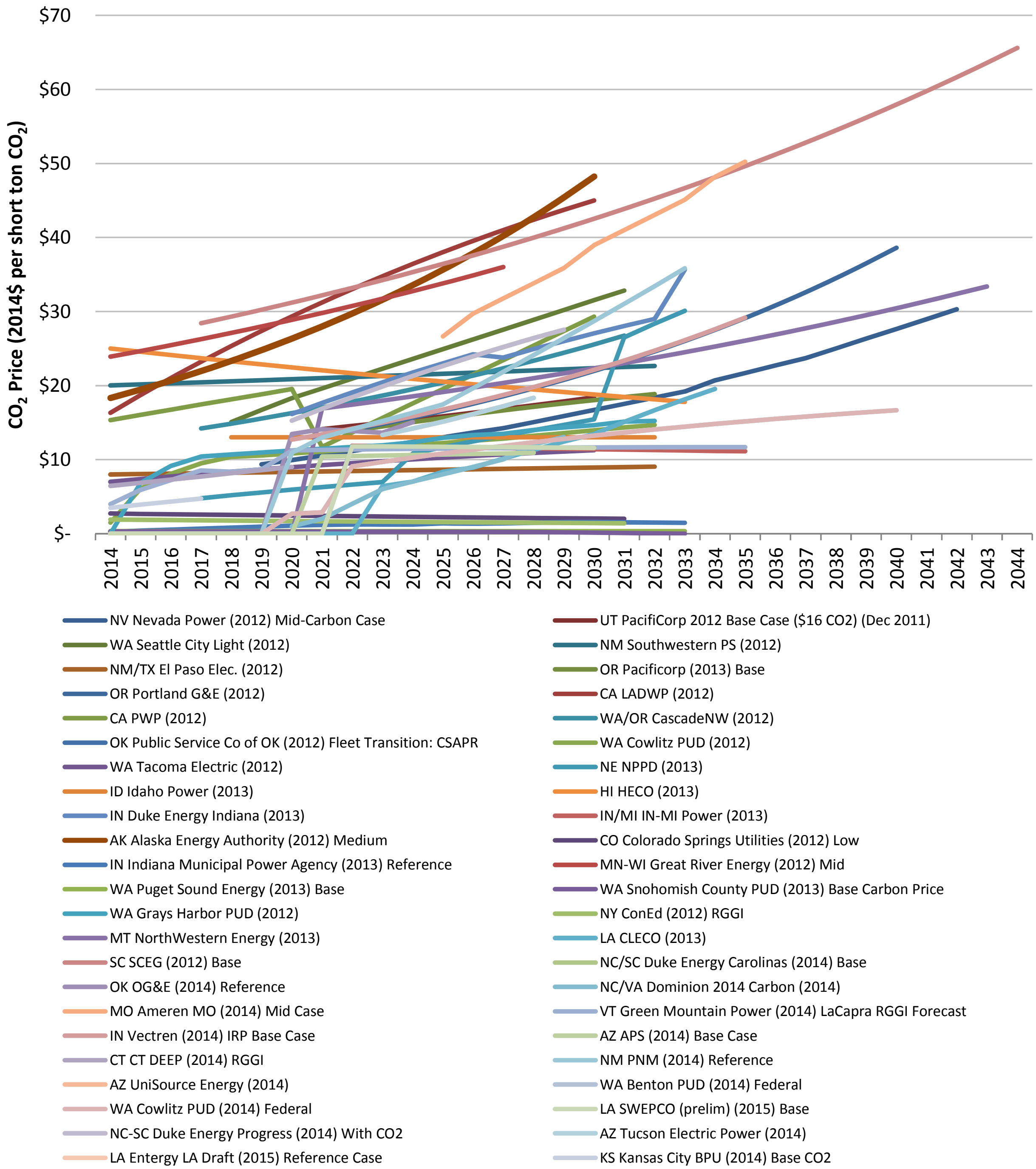
Not all utilities produce IRPs. In fact, 11 states have no filing requirements for long-term planning, while 10 other states require long-term plans, but not IRPs.[48] While long-term planning is an important part of the procurement process in regions with wholesale energy markets, traditional utility-centric IRPs are less common. As a result, regions with wholesale markets are not well represented in our sample.

Figure 5 below displays non-zero reference case CO_2 price forecasts from 46 utility IRPs over the period of 2014-2044.[49] Although we refer above to 61 non-zero CO_2 price reference case forecasts in the current sample, fifteen of these forecasts are excluded from this chart for various reasons. In some cases, our sample includes IRPs from companies in 2012 *and* 2014, in which case we only include the most recent forecast. The remaining non-zero forecasts that are not included in the figure below are from companies that operate in multiple states but produce the same CO_2 forecast, are confidential, or forecast a price that begins following the end of the IRP planning period.

[48] See: Wilson, R. and B. Biewald. *Best Practices in Electric Utility Integrated Resource Planning*. June 1, 2013. Synapse Energy Economics. Available at: http://www.synapse-energy.com/Downloads/SynapseReport.2013-06.RAP.Best-Practices-in-IRP.13-038.pdf.

[49] We also provide a figure showing only forecasts produced in 2014 and 2015 in Appendix A. These forecasts do not appear materially different than the range of 2012 to 2015 forecasts shown below.

Figure 5: Utility non-zero and non-confidential reference case forecasts from 2012-2015[50]



[50] A number of non-zero, non-confidential reference case forecasts are excluded, discussed further on page 24.

Four of the utility forecasts displayed in Figure 5 are particularly low in the context of the other forecasts. Two IRPs from the Northeast—Commonwealth Edison of New York and the Connecticut Department of Energy and Environmental Protection—base their reference case forecasts on RGGI prices before the recent RGGI revisions discussed in Section 4, resulting in prices just under $2 per short ton. Two other IRPs—Puget Sound Energy and Snohomish County PUD—use a Washington State mandated CO_2 price of $0.32 per short ton for their base case analyses.

The five utilities that assume a $0 CO_2 price in their reference cases also consider several additional non-zero scenarios. These are provided in Appendix A.[51]

Table 3 summarizes the range of CO_2 prices forecasted for 2020 and 2030. Not all forecasts start by 2020, and those that do are generally below $20 per ton. Of the utilities with a non-zero CO_2 price, all but four assume a price in 2025.

Table 3: Number of utility CO_2 Forecasts from 2012-2015 in several price ranges in 2020 and 2030

	Compliance Year	
	2020	**2030**
>$0 - <$10	14	5
$10 - $20	17	18
$20 - $30	6	11
$30 - $40	2	2
>$40	0	4

7. OVERVIEW OF THE EVIDENCE FOR A FUTURE CO_2 PRICE

Our CO_2 price forecasts are developed based on the data sources and information presented above and reflect a reasonable range of expectations regarding future efforts to limit greenhouse gas emissions. The following evidence has guided the development of the Synapse forecasts:

- **Regulatory measures limiting CO_2 emissions from power plants will be finalized in the near term**. The EPA has proposed emissions standards for new and existing power plants under Section 111(d) of the Clean Air Act, to be finalized by mid-summer 2015. These actions represent an effective price that will affect utility planning and operational decisions.

- **Environmental regulation can, and often does, evolve incrementally over time**. Initial awareness of environmental damages, followed successively by measurement and study

[51] Indianapolis Power & Light's "Environmental Case" CO_2 forecast is provided only as a trajectory with no values on its axes, and is excluded from Appendix A.

of the damages and initial attempts to regulate the responsible sources (and associated debate and legal challenges), are eventually followed by more detailed or nuanced regulations. For climate change and greenhouse gas emissions from the electric power sector in the United States, this process has been in progress for several decades, and in our view the trends are likely to continue, as risks are increasingly apparent and regulatory and policy response to address the risks is demanded.

- **State and regional action limiting CO_2 emissions is ongoing and growing more stringent**. In the Northeast, the RGGI CO_2 cap has been tightened, and recent auctions have used all available cost-containment reserves, resulting in higher CO_2 prices for electric generators in the region. California's Cap-and-Trade Program, which represents an even larger carbon market than RGGI, has held many successful allowance auctions, has been successfully defended against numerous legal challenges, and was expanded to include natural gas and transportation fuels in 2015.

- **A price for CO_2 is already being factored into federal rulemakings.** The federal government has demonstrated a commitment to considering the benefits of CO_2 abatement in rulemakings such as fuel economy and appliance standards.

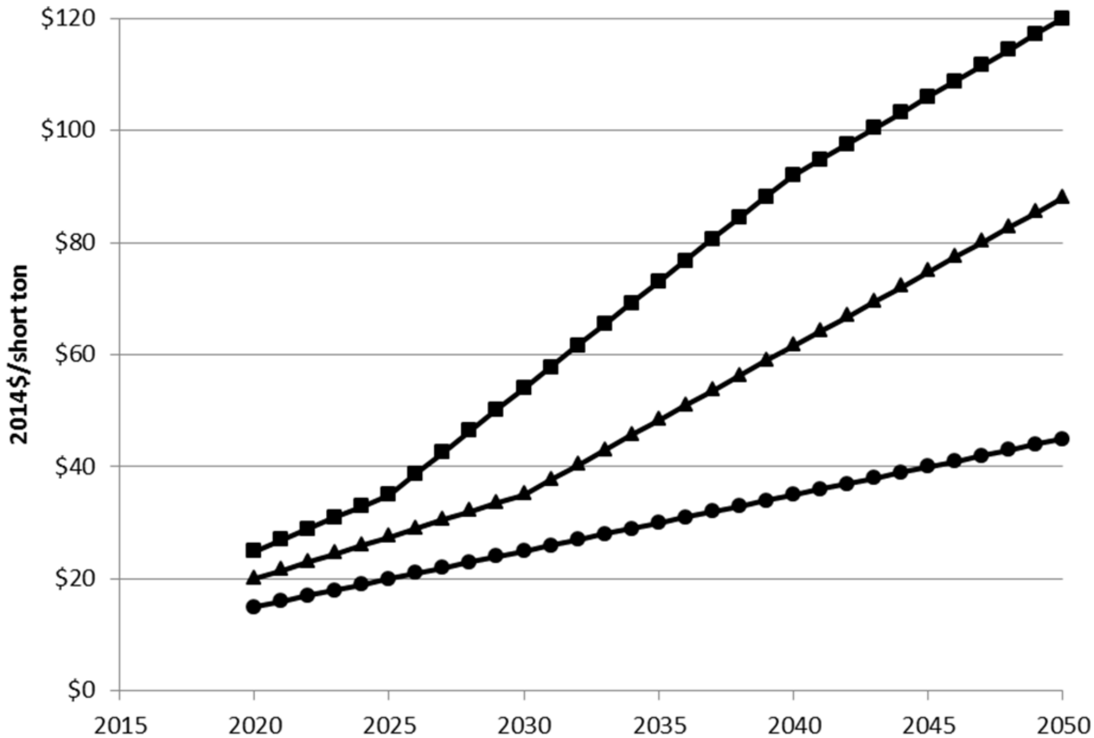
- **Ongoing analysis of the Clean Power Plan proposal suggests a wide range of possible prices.** Important factors include the level of regional cooperation, the availability of renewable energy and energy efficiency, and natural gas prices.

- **Electric suppliers continue to account for the opportunity cost of CO_2 abatement in their resource planning.** Prudent planning requires utilities to consider adequately the potential for future policies. The range of CO_2 prices reported in Section 6 indicates that many utilities believe that by 2020 there will likely be significant economic pressure towards low-carbon electric generation.

8. SYNAPSE 2015 CO_2 PRICE FORECAST

Based on the evidence discussed in this report, Synapse has developed Low, Mid, and High case forecasts for CO_2 prices from 2015 to 2050. These forecasts reflect our best understanding of Clean Power Plan compliance costs, as well as future expected costs after 2030 to meet science-based emissions targets. We believe it is highly likely that neighboring states with large disparities in mitigation costs will work together to their mutual benefit to reduce overall compliance costs. EPA has indicated it is open to such cooperation. As a result, we provide a single national-level CO_2 price and do not attempt to provide state-level forecasts. Figure 6 and Table 4 show the Synapse forecasts over the 2015-2050 period.[52]

Figure 6: Synapse 2015 CO_2 Price Trajectories



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[52] Figure 11 in Appendix A also provides a comparison of this updated Synapse CO_2 forecast to the 2013 Synapse forecast. These forecasts do not differ substantially. Two key differences are a tighter range of prices in 2020 resulting from greater policy certainty, as well as higher 2015 forecasts for the mid and high cases, resulting from the indicated stringency of the Clean Power Plan. The 2015 forecast is also the first Synapse forecast to extend to 2050.

Table 4: Synapse 2015 CO_2 price projections (2014 dollars per short ton CO_2)

Year	Low Case	Mid Case	High Case
2020	$15.00	$20.00	$25.00
2021	$16.00	$21.50	$27.00
2022	$17.00	$23.00	$29.00
2023	$18.00	$24.50	$31.00
2024	$19.00	$26.00	$33.00
2025	$20.00	$27.50	$35.00
2026	$21.00	$29.00	$38.80
2027	$22.00	$30.50	$42.60
2028	$23.00	$32.00	$46.40
2029	$24.00	$33.50	$50.20
2030	$25.00	$35.00	$54.00
2031	$26.00	$37.65	$57.80
2032	$27.00	$40.30	$61.60
2033	$28.00	$42.95	$65.40
2034	$29.00	$45.60	$69.20
2035	$30.00	$48.25	$73.00
2036	$31.00	$50.90	$76.80
2037	$32.00	$53.55	$80.60
2038	$33.00	$56.20	$84.40
2039	$34.00	$58.85	$88.20
2040	$35.00	$61.50	$92.00
2041	$36.00	$64.15	$94.80
2042	$37.00	$66.80	$97.60
2043	$38.00	$69.45	$100.40
2044	$39.00	$72.10	$103.20
2045	$40.00	$74.75	$106.00
2046	$41.00	$77.40	$108.80
2047	$42.00	$80.05	$111.60
2048	$43.00	$82.70	$114.40
2049	$44.00	$85.35	$117.20
2050	$45.00	$88.00	$120.00
Levelized 2020-2050	$26.24	$41.64	$59.35

In these forecasts, the Clean Power Plan, together with other federal regulatory measures, place economic pressure on CO_2-emitting resources in the next several years, such that it is relatively more expensive to operate a high-carbon-emitting power plant. These pressures are followed later by a broader federal policy, such as cap and trade. In any state other than the RGGI region and California, we assume a zero carbon price through 2019; beginning in 2020, we expect Clean Power Plan compliance will put economic pressure on carbon-emitting power plants throughout the United States. All annual allowance prices and levelized values are reported in 2014 dollars per short ton of CO_2.

- The **Low case** forecasts a CO_2 price that begins in 2020 at $15 per ton, and increases to $25 in 2030 and $45 in 2050, representing a $26 per ton levelized price over the period 2020-2050. This forecast represents a scenario in which Clean Power Plan compliance is relatively easy, and a similar level of stringency is assumed after 2030. Low case prices are also representative of the incremental cost to produce electricity with gas over coal, as indicated in the EIA's 2014 Annual Energy Outlook.

- The **Mid case** forecasts a CO_2 price that begins in 2020 at $20 per ton, and increases to $35 in 2030 and $88 in 2050, representing a $42 per ton levelized price over the period 2020-2050. This forecast represents a scenario in which federal policies are implemented with significant but reasonably achievable goals. Clean Power Plan compliance is achieved and science-based climate targets are enacted mandating at least an 80 percent reduction in electric section emissions from 2005 levels by 2050.

- The **High case** forecasts a CO_2 price that begins in 2020 at $25 per ton, and increases to approximately $54 in 2030 and $120 in 2050, representing a $59 per ton levelized price over the period 2020-2050. This forecast is consistent with a stringent level of Clean Power Plan targets that recognizes that achieving science-based emissions goals by 2050 will be difficult. In recognition of this difficulty, implementation of standards more aggressive than the Clean Power Plan may begin as early as 2025. New regulations may mandate that electric-sector emissions are reduced to 90 percent or more below 2005 levels by 2050, in recognition of lower-cost emission reduction measures expected to be available in this sector. Other factors that may increase the cost of achieving emissions goals include: greater restrictions on the use of offsets; restricted availability or high cost of technology alternatives such as nuclear, biomass, and carbon capture and sequestration; and more aggressive international actions (thereby resulting in fewer inexpensive international offsets available for purchase by U.S. emitters).

These price trajectories are designed for planning purposes, so that a reasonable range of emissions costs can be used to investigate the likely costs of alternative resource plans. We expect an actual CO_2 price incurred by utilities in all states to fall somewhere between the low and high estimates throughout the forecast period.

In Figure 7, the Synapse forecasts are shown in comparison to the reference case utility forecasts presented earlier. In Figure 8, the Synapse forecasts are compared to a summary of the other evidence presented in this report, including the federal CO_2 price for rulemakings; existing Clean Power Plan studies; and utility reference, low , and high scenarios. The forecasts are also compared to the Synapse 2013 forecasts and the federal CO_2 price for rulemakings in Appendix A.

Figure 7: Synapse forecast compared to recent utility reference case forecasts

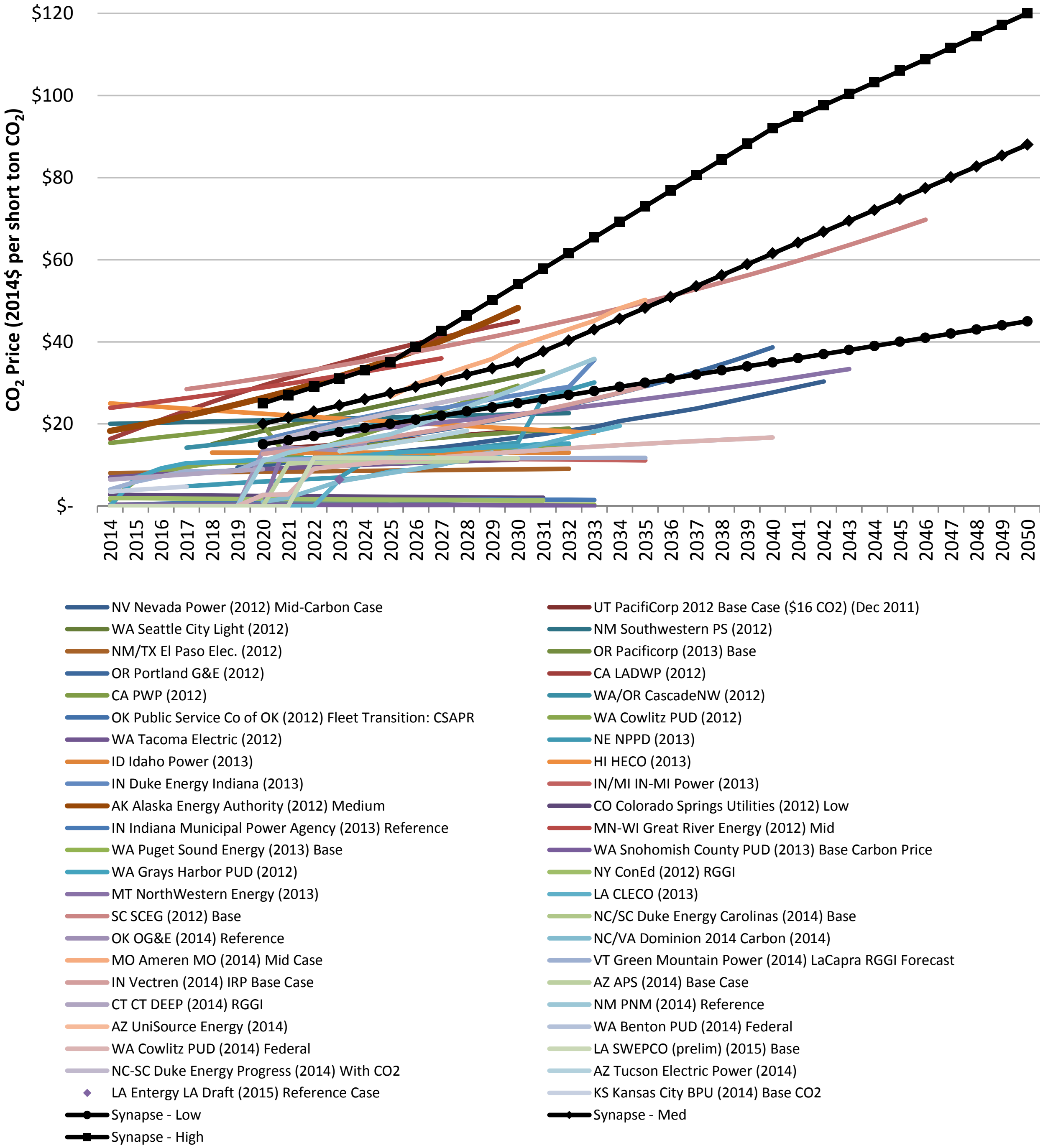
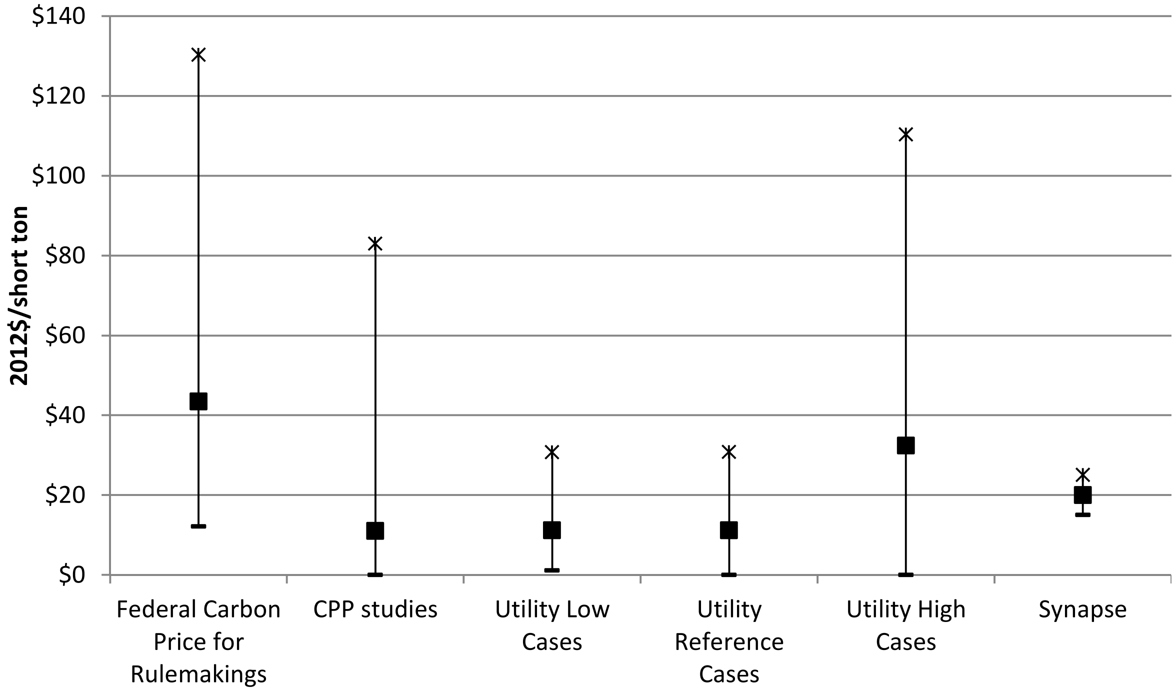
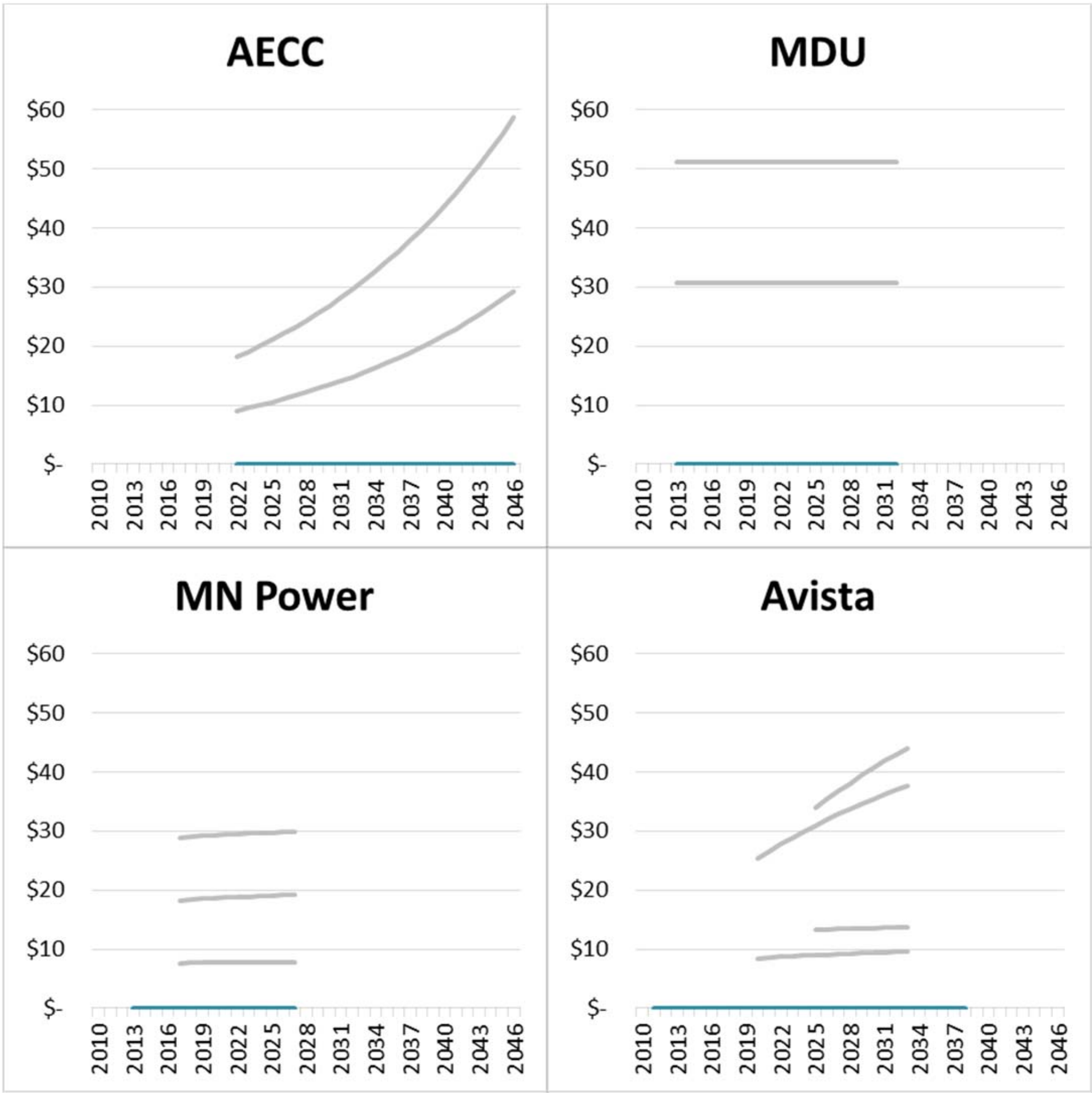


Figure 8: Synapse CO_2 forecasts for 2020 compared to other sources



9. Appendix A: Synapse Forecasts Compared to Utility Forecasts and Past Synapse Forecasts

Figure 9: Range of CO_2 price scenarios for utilities with $0 reference cases (2014$/short ton)



Note: Reference forecasts are presented in blue. All other sensitivities are in grey.

Figure 10: 2014 and 2015 utility reference case forecasts

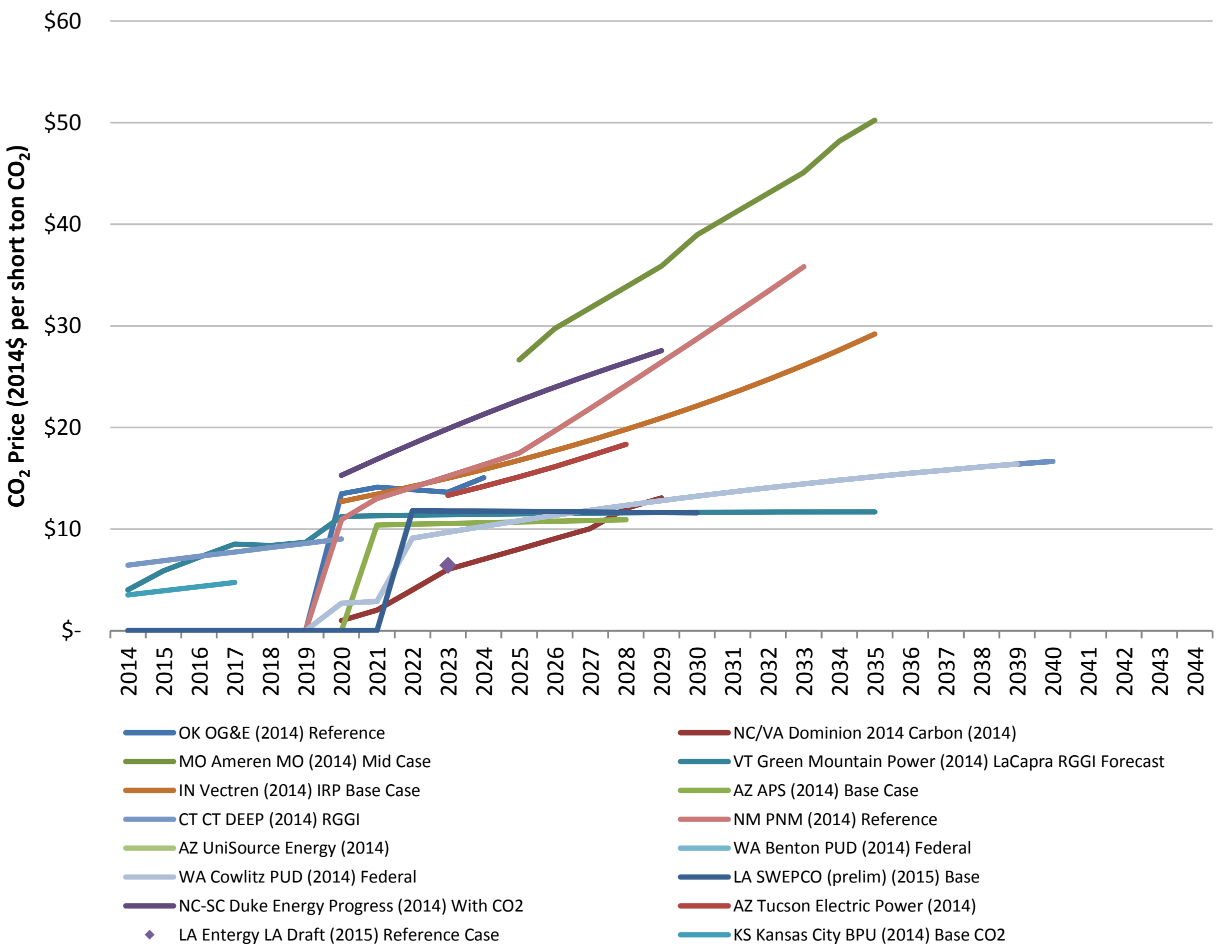


Figure 11: Comparison of 2013 and 2015 Synapse CO_2 price forecasts

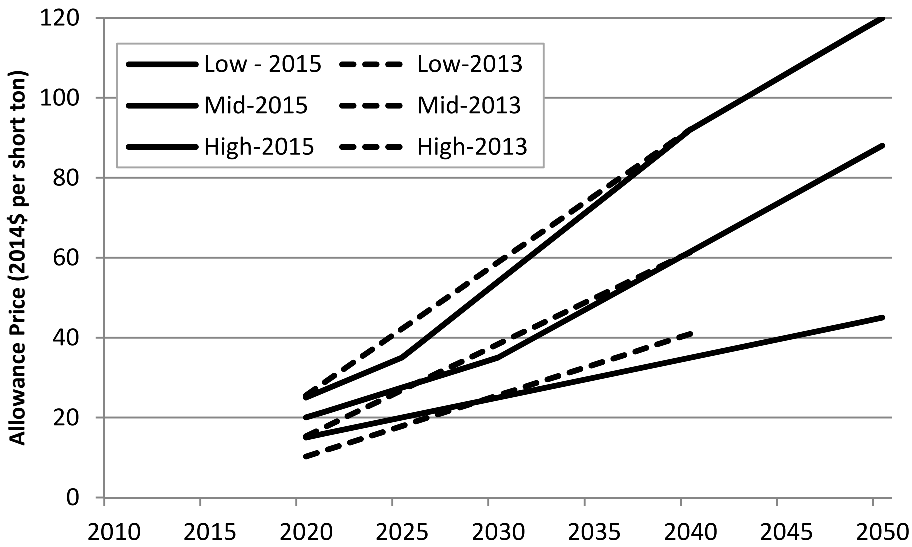


Figure 12: Synapse Mid case compared to federal CO_2 price for rulemakings (3% discount rate)