JIF Exhibit 1

Curriculum Vitae of Jeremy I. Fisher, PhD

Jeremy Fisher, Ph.D., Principal Associate

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PROFESSIONAL EXPERIENCE

Synapse Energy Economics, Cambridge MA. *Principal Associate*, 2013 – present, *Scientist*, 2007 – 2013.

Consulting on economic analysis of climate change and energy, carbon, and emissions policies. Quantitative evaluations of regional climate change impact, energy efficiency programs, long- and short-term electric industry planning, carbon reduction planning, and emissions compliance programs.

Tulane University, New Orleans, LA. *Ecology and Evolutionary Biology Postdoctoral Research Scientist*, 2006 –2007.

Determining Hurricane Katrina's impact on Gulf Coast ecosystems using satellite and field data.

University of New Hampshire, Durham, NH. *Earth, Oceans, and Space Postdoctoral Research Scientist*, 2006 –2007.

Organizing team synthesis review of causes and rates of natural rainforest loss in the Amazon basin.

Brown University Watson Institute for International Studies, Providence, RI. *Visiting Fellow*, 2007 – 2008.

Designing study to examine migratory bird response to climate variability in the Middle East.

Brown University Department of Geological Sciences, Providence, RI. *Research Assistant*, 2001 –2006.

Tracking impact of climate change on New England forests from satellites. Working with West African communities to determine impact of climate change and practice on landscape. Modeling coastal power plant effluent from satellite data.

EDUCATION

Brown University, Providence, RI
Doctor of Philosophy in Geological Sciences, 2006

Brown University, Providence, RI
Master of Science in Geological Sciences, 2003

University of Maryland, College Park, MD
Bachelor of Science in Geography and Geology, 2001

FELLOWSHIPS & AWARDS

- *Visiting Fellow*, Watson Institute for International Studies, Brown University, 2007
- *Finalist*, Congressional Fellowship, American Institute of Physics and Geological Society of America, 2007
- *Fellow*, National Science Foundation East Asia Summer Institute (EASI), 2003
- *Fellow*, Henry Luce Foundation at the Watson Institute for International Studies, Brown University, 2003

REPORTS

Luckow, P., E.A. Stanton, S. Fields, W. Ong, B. Biewald, S. Jackson, J. Fisher. 2016. *Spring 2016 National Carbon Dioxide Price Forecast*. Synapse Energy Economics.

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Luckow, P., E. A. Stanton, B. Biewald, S. Fields, S. Jackson, J. Fisher, F. Ackerman. 2014. *CO_2 Price Report, Spring 2014: Includes 2013 CO_2 Price Forecast.* Synapse Energy Economics.

Daniel, J., T. Comings, J. Fisher. 2014. *Comments on Preliminary Assumptions for Cleco's 2014/2015 Integrated Resource Plan.* Synapse Energy Economics for Sierra Club.

Fisher, J., T. Comings, and D. Schlissel. 2014. *Comments on Duke Energy Indiana's 2013 Integrated Resource Plan*. Synapse Energy Economics and Schlissel Consulting for Mullet & Associates, Citizens Action Coalition of Indiana, Earthjustice, and Sierra Club.

Fisher, J., P. Knight, E. A. Stanton, and B. Biewald. 2014. *Avoided Emissions and Generation Tool (AVERT): User Manual*. Version 1.0. Synapse Energy Economics for the U.S. Environmental Protection Agency.

Luckow, P., E. A. Stanton, B. Biewald, J. Fisher, F. Ackerman, E. Hausman. 2013. *2013 Carbon Dioxide Price Forecast.* Synapse Energy Economics.

Knight, P., E. A. Stanton, J. Fisher, B. Biewald. 2013. *Forecasting Coal Unit Competitiveness: Coal Retirement Assessment Using Synapse's Coal Asset Valuation Tool (CAVT).* Synapse Energy Economics for Energy Foundation.

Takahashi, K., P. Knight, J. Fisher, D. White. 2013. *Economic and Environmental Analysis of Residential Heating and Cooling Systems: A Study of Heat Pump Performance in U.S. Cities*. Proceeding of the 7th International Conference on Energy Efficiency in Domestic Appliances and Lighting (EEDAL'13), September 12, 2013.

Fagan, R., J. Fisher, B. Biewald. 2013. *An Expanded Analysis of the Costs and Benefits of Base Case and Carbon Reduction Scenarios in the EIPC Process.* Synapse Energy Economics for the Sustainable FERC Project.

Fisher, J. *Sierra Club's Preliminary Comments on PacifiCorp 2013 Integrated Resource Plan.* Oregon Docket LC 57. Synapse Energy Economics for Sierra Club.

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Fisher, J., F. Ackerman. 2011. *The Water-Energy Nexus in the Western States: Projections to 2100*. Synapse Energy Economics for Stockholm Environment Institute.

Averyt, K., J. Fisher, A. Huber-Lee, A. Lewis, J. Macknick, N. Madden, J. Rogers, S. Tellinghuisen. 2011. *Freshwater use by US power plants: Electricity's thirst for a precious resource.* Union of Concernered Scientists for the Energy and Water in a Warming World Initiatve.

White, D. E., D. Hurley, J. Fisher. 2011. *Economic Analysis of Schiller Station Coal Units*. Synapse Energy Economics for Conservation Law Foundation.

Fisher, J., R. Wilson, N. Hughes, M. Wittenstein, B. Biewald. 2011. *Benefits of Beyond BAU: Human, Social, and Environmental Damages Avoided Through the Retirement of the US Coal Fleet*. Synapse Energy Economics for Civil Society Institute.

Fisher, J., B. Biewald. 2011. *Environmental Controls and the WECC Coal Fleet: Estimating the forward-going economic merit of coal-fired power plants in the West with new environmental controls.* Synapse Energy Economics for Energy Foundation and Western Grid Group.

Hausman, E., V. Sabodash, N. Hughes, J. Fisher. 2011. *Economic Impact Analysis of New Mexico's Greenhouse Gas Emissions Rule*. Synapse Energy Economics for New Energy Economy.

Fisher, J. 2011. *A Green Future for Los Angeles Department of Water and Power: Phasing out Coal in LA by 2020.* Synapse Energy Economics for Sierra Club.

Fisher, J., J. Levy, Y. Nishioka, P. Kirshen, R. Wilson, M. Chang, J. Kallay, C. James. 2010*. Co-Benefits of Energy Efficiency and Renewable Energy in Utah: Air Quality, Health and Water Benefits.* Synapse Energy Economics, Harvard School of Public Health, Tufts University for State of Utah Energy Office.

Biewald, B., D. White, J. Fisher, M. Chang, L. Johnston. 2009. *Incorporating Carbon Dioxide Emissions Reductions in Benefit Calculations for Energy Efficiency: Comments on the Department of Energy's Methodology for Analysis of the Proposed Lighting Standard.* Synapse Energy Economics for the New York Office of Attorney General.

Hausman, E., J. Fisher, L.A. Mancinelli, B. Biewald. 2009. *Productive and Unproductive Costs of CO_2 Cap-and-Trade: Impacts on Electricity Consumers and Producers.* Synapse Energy Economics for the National Association of Regulatory Utility Commissioners, The National Association of State Utility Consumer Advocates (NASUCA), The National Rural Electric Cooperative Association (NRECA), The American Public Power Association (APPA).

Biewald, B., J. Fisher, C. James, L. Johnston, D. Schlissel, R. Wilson. 2009. *Energy Future: A Green Energy Alternative for Michigan*. Synapse Energy Economics for Sierra Club.

James, C., J. Fisher, K. Takahashi. 2009. "Energy Supply and Demand Sectors." *Alaska Climate Change Strategy's Mitigation Advisory Group Final Report: Greenhouse Gas Inventory and Forecast and Policy Recommendations Addressing Greenhouse Gas Reduction in Alaska. Submitted to the Alaska Climate Change Sub-Cabinet.* Synapse Energy Economics for the Center for Climate Strategies.

James, C., J. Fisher, K. Takahashi, B. Warfield. 2009. *No Need to Wait: Using Energy Efficiency and Offsets to Meet Early Electric Sector Greenhouse Gas Targets*. Synapse Energy Economics for Environmental Defense Fund.

James, C., J. Fisher. 2008. *Reducing Emissions in Connecticut on High Electric Demand Days (HEDD)*. Synapse Energy Economics for the Connecticut Department of Environmental Protection and the US Environmental Protection Agency.

Napoleon, A., J. Fisher, W. Steinhurst, M. Wilson, F. Ackerman, M. Resnikoff. 2008. *The Real Costs of Cleaning up Nuclear Waste: A Full Cost Accounting of Cleanup Options for the West Valley Nuclear Waste Site.* Synapse Energy Economics et al.

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Fisher, J.I., G.C. Hurtt, J.Q. Chambers, Q. Thomas. 2008. "Clustered disturbances lead to bias in large-scale estimates based on forest sample plots." *Ecology Letters* 11 (6): 554–563.

Chambers, J.Q., J.I. Fisher, H. Zeng, E.L. Chapman, D.B. Baker, and G.C. Hurtt. 2007. "Hurricane Katrina's Carbon Footprint on US Gulf Coast Forests." *Science* 318 (5853): 1107. DOI: 10.1126/science.1148913.

Fisher, J.I., A.D. Richardson, and J.F. Mustard. 2007. "Phenology model from surface meteorology does not capture satellite-based greenup estimations." *Global Change Biology* 13:707–721.

Fisher, J.I., J.F. Mustard. 2007. “Cross-scalar satellite phenology from ground, Landsat, and MODIS data.” *Remote Sensing of Environment* 109:261–273.

Fisher, J.I., J.F. Mustard, and M. Vadeboncoeur. 2006. “Green leaf phenology at Landsat resolution: Scaling from the field to the satellite.” *Remote Sensing of Environment* 100 (2): 265–279.

Fisher, J.I., J.F. Mustard. 2004. “High spatial resolution sea surface climatology from Landsat thermal infrared data.” *Remote Sensing of Environment* 90:293–307.

Fisher, J.I., J. F. Mustard, and P. Sanou. 2004. “Policy imprints in Sudanian forests: Trajectories of vegetation change under land management practices in West Africa.” *Submitted, International Remote Sensing.*

Fisher, J.I., S.J. Goetz. 2001. “Considerations in the use of high spatial resolution imagery: an applications research assessment.” Proceedings at the American Society for Photogrammetry and Remote Sensing (ASPRS) Conference in St. Louis, MO.

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Fisher, J.I., A.D. Richardson, and J.F. Mustard. “Phenology model from weather station meteorology does not predict satellite-based onset.” *American Geophysical Union.* San Francisco, CA. December 2006.

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Fisher, J.I., J.F. Mustard. “Constructing a high resolution sea surface climatology of Southern New England using satellite thermal imagery.” *New England Estuarine Research Society.* Fairhaven, MA. May, 2003.

Fisher, J.I., J.F. Mustard. “High spatial resolution sea surface climatology from Landsat thermal infrared data.” *Ecological Society of America Conference.* Savannah, GA. August, 2003.

Fisher, J.I., S.J. Goetz. “Considerations in the use of high spatial resolution imagery: an applications research assessment.” *American Society for Photogrammetry and Remote Sensing (ASPRS) Conference Proceedings*, St. Louis, MO. March, 2001.

SEMINARS AND PRESENTATIONS

Fisher, J. 2015. “Planning for Clean Power Plan: Top Five Points for States.” Presentation at the National Governor’s Association Policy Academy on Clean Power Plan in Salt Lake City, UT, October 14, 2015.

Fisher, J. 2015. “Environmental Regulations in Integrated Resource Planning.” Presentation at EUCI Conference in Atlanta, GA, May 14, 2015.

Fisher, J.I., R. DeYoung. 2015. “EPA's AVERT: Avoiding Emissions from the Electric Sector through Efficiency and Renewable Energy.” Presentation at the 18th Annual Energy, Utility & Environment Conference & Expo (EUEC2015) in San Diego, CA, February 17, 2015.

Fisher, J. 2014. “Planning in Vertically Integrated Utilities.” Presentation to the U.S. Environmental Protection Agency in Washington, DC, May 22, 2014.

Fisher, J. 2013. “IRP Best Practices Stakeholder Perspectives.” Presentation at Indiana Utility Regulatory Commission Emerging Issues in IRP conference. October 17, 2013.

Fisher, J., P. Knight. 2013. Avoided Emissions and Generation Tools (AVERT): An Introduction.” Presentation for EPA and various state departments of environmental quality/protection.

Takahashi, K., J. Fisher. 2013. “Greening TVA: Leveraging Energy Efficiency to Replace TVA’s Highly Uneconomic Coal Units.” Presentation at the ACEEE National Conference on Energy Efficiency as a Resource, September 23, 2013.

Fisher, J. 2011. “Emissions Reductions from Renewable Energy and Energy Efficiency in California Air Districts.” Presentation for EPA State Climate and Energy Program, June 14, 2011.

Fisher, J., B. Biewald. 2011. "WECC Coal Plant Retirement Based On Forward-Going Economic Merit." Presentation for Western Grid Group, January 10, 2011.

Fisher, J. 2010. "Protecting Electricity and Water Consumers in a Water-Constrained World." Presentation to the National Association of State Utility Consumer Advocates, November 16, 2010.

James, C., J. Fisher, D. White, and N. Hughes. 2010. "Quantifying Criteria Emissions Reductions in CA from Efficiency and Renewables." CEC / PIER Air Quality Webinar Series, October 12, 2010.

Fisher, J. 2008. "Climate Change, Water, and Risk in Electricity Planning." Presentation at National Association of Regulatory Utility Commissioners (NARUC) Conference in Portland, OR, July 22, 2008.

Fisher, J., E. Hausman, and C. James. 2008. "Emissions Behavior in the Northeast from the EPA Acid Rain Monitoring Dataset." Presentation at Northeast States for Coordinated Air Use Management (NESCAUM) conference in Boston, MA, January 30, 2008.

Fisher, J.I., J.F. Mustard, and M. Vadeboncoeur. 2006. "Climate and phenological variability from satellite data. Ecology and Evolutionary Biology," Presentation at Tulane University, March 24, 2006.

Fisher, J.I., J.F. Mustard, and M. Vadeboncoeur. 2005. "Anthropogenic and climatic influences on green leaf phenology: new observations from Landsat data." Seminar presentation at the Ecosystems Center at the Marine Biological Laboratory in Woods Hole, MA, September 27, 2005.

Fisher, J.I., J.F. Mustard, "High resolution phenological modeling in Southern New England." Seminar at the Woods Hole Research Center in Woods Hole, MA, March 16, 2005.

TESTIMONY

Oregon Public Utility Commission (Docket UM-1712): Direct testimony regarding PacifiCorp's application for approval of Deer Creek Mine transaction. On behalf of Sierra Club. March 5, 2015.

Oklahoma Corporation Commission (Case No. PUD 201400): Direct and rebuttal testimony comparing the modeling performed by Oklahoma Gas & Electric in support of its request for authorization and cost recovery of a Clean Air Act compliance plan and Mustang modernization against best practices in resource planning. On behalf of Sierra Club. December 16, 2014 and January 26, 2015.

New Mexico Public Regulation Commission (Case 12-00390-UT): Direct and surrebuttal testimony evaluating the economic modeling performed by Public Service Company of New Mexico in support of its application for certificate of public convenience and necessity for the acquisition of San Juan Generating Station and Palo Verde units. On behalf of New Energy Economy. August 29, 2014; December 29, 2014.

Wyoming Public Service Commission (Docket No. 20000-446-ER-14): Direct testimony in the matter of the application of Rocky Mountain Power for authority to increase its retail electric utility service rates in Wyoming approximately $36.1 million per year or 5.3 percent. On behalf of Sierra Club. July 25, 2014.

Indiana Utility Regulatory Commissions (Cause No. 44446): Direct testimony evaluating the economic modeling performed on behalf of Vectren South in support of its application for certificate of public convenience and necessity for various retrofits at Brown 1 & 2, Culley 3 and Culley plant, and Warrick 4. On behalf of Sierra Club, Citizens Action Coalition, and Valley Watch. May 28, 2014.

Utah Public Service Commission (Docket No. 13-035-184): Direct testimony In the matter of the application of Rocky Mountain Power for authority to increase its retail electric utility service rates in Utah and for approval of its proposed electric service schedules and electric service regulations. On behalf of Sierra Club. May 1, 2014.

Louisiana Public Service Commission (Docket No. U-32507): Direct and cross answering testimony regarding the application of Cleco Power LLC for: (i) authorization to install emissions control equipment at certain of its generating facilities in order to comply with the federal national emissions standards for hazardous air pollutants from coal and oil-fired electric utility steam generating units rule; and (ii) authorization to recover the costs associated with the emissions control equipment in LPSC jurisdictional rates. On behalf of Sierra Club. November 8, 2013 and December 9, 2013.

Nevada Public Utilities Commission (Docket No. 13-07021): Direct testimony regarding a joint application of Nevada Power Company d/b/a NV Energy, Sierra Pacific Power Company d/b/a NV Energy (referenced together as "NV Energy, Inc.") and MidAmerican Energy Holdings Company ("MidAmerican") for approval of a merger of NV Energy, Inc. with MidAmerican. On behalf of Sierra Club. October 24, 2013.

Indiana Utility Regulatory Commission (Cause No. 44339): Direct testimony in the matter of Indianapolis Power & Light Company's application for a Certificate of Public Convenience and Necessity for the construction of a combined cycle gas turbine generation facility. On behalf of Citizens Action Coalition of Indiana. August 22, 2013.

Indiana Utility Regulatory Commission (Cause No. 44242): Direct and surrebuttal testimony regarding Indianapolis Power & Light Company's petition for approval of clean energy projects and qualified pollution control property. On behalf of Sierra Club. January 28, 2013; April 3, 2013.

Wyoming Public Service Commission (Docket 2000-418-EA-12): Direct testimony regarding the application of PacifiCorp for approval of a certificate of public convenience and necessity to construct selective catalytic reduction systems on the Jim Bridger Units 3 and 4. On behalf of Sierra Club. February 1, 2013.

Public Service Commission of Wisconsin (Docket No. 6690-CE-197): Direct, rebuttal, and surrebuttal testimony regarding Wisconsin Public Service Corporation's application for authority to construct and place in operation a new multi-pollutant control technology system for Unit 3 of Weston Generating Station. On behalf of Clean Wisconsin. Direct testimony submitted November 15, 2012, rebuttal testimony submitted December 14, 2012, surrebuttal testimony submitted January 7, 2013.

Utah Public Service Commission (Docket 12-035-92): Direct, surrebuttal, and cross-answering testimony regarding Rocky Mountain Power's request for approval to construct Selective Catalytic Reduction systems at Jim Bridger units 3 and 4. On behalf of Sierra Club. November 30, 2012.

Oregon Public Utility Commission (Docket UE 246): Direct testimony in the matter of PacifiCorp's filing of revised tariff schedules for electric service in Oregon. On behalf of Sierra Club. June 20, 2012.

Kentucky Public Service Commission (Docket 2011-00401): Direct testimony regarding the application of Kentucky Power Company for approval of its 2011 environmental compliance plan, for approval of its amended environmental cost recovery surcharge tariff, and for the granting of a certificate of public convenience and necessity for the construction and acquisition of related facilities. On behalf of Sierra Club. March 12, 2012.

Kentucky Public Service Commission (Dockets 2011-00161/2011-00162): Direct testimony regarding the application of Kentucky Utilities/Louisville Gas and Electric Company for certificates of public convenience and necessity and approval of its 2011 compliance plan for recovery by environmental surcharge. On behalf of Sierra Club and Natural Resources Defense Council (NRDC). September 16, 2011.

Kansas Corporation Commission (Docket 11-KCPE-581-PRE): Direct testimony in the matter of the petition of Kansas City Power & Light (KCP&L) for determination of the ratemaking principles and treatment that will apply to the recovery in rates of the cost to be incurred by KCP&L for certain electric generating facilities under K.S.A. 66-1239. On behalf of Sierra Club. June 3, 2011.

Utah Public Service Commission (Docket 10-035-124): Direct testimony in the matter of the application of Rocky Mountain Power for authority to increase its retail electric utility service rates in Utah and approval of its proposal electric service schedules and electric service regulations. On behalf of Sierra Club. May 26, 2011.

Wyoming Public Service Commission (Docket 20000-384-ER-10): Direct testimony in the matter of the application of Rocky Mountain Power for authority to increase its retail electric utility rates in Wyoming approximately $97.9 million per year or an average overall increase of 17.3 percent. On behalf of Powder River Basin Resource Council. April 11, 2011.

Resume dated January 2016

JIF Exhibit 2 PD

Response to Staff 1-31, Attachments A & B

This exhibit has been redacted in its entirety.

JIF Exhibit 3

Response to Staff 6-29

STF-6-29

Question:

Refer to the Georgia Power Unit Retirement Study. For each unit in the study, provide all assumptions related to compliance with environmental regulations:

- Mercury and Air Toxics Standards ("MATS") rule
- Coal Combustion Residuals ("CCR") rule
- Section 316(b) Cooling Water Intake Structure rule of the Clean Water Act ("316(b)")
- National Pollutant Discharge Elimination System thermal compliance
- Steam Electric Effluent Limitation Guidelines ("ELG")
- National Ambient Air Quality Standards ("NAAQS")

Include in this response detailed assumptions, by unit, of the costs of compliance for each rule, as well as any operational impacts on the unit (capacity, capacity factor, etc.).

Response:

The analyses submitted for the Unit Retirement Studies were performed on a plant level basis. Consistent with the Company's past practice, units were logically grouped based on operational synergies and economies of scale. Incremental environmental assumptions for each plant are detailed in Sections 1.6.1 to 1.6.8 of the Unit Retirement Study. For additional information regarding compliance with environmental regulations, please refer to the 2016 Environmental Compliance Strategy, found in Technical Appendix Volume 2.

Within the Unit Retirement Study, Appendix A, Table A.1 provides the In-Service costs for the environmental controls assumed for each plant. The table below shows which controls are assumed for each environmental regulation:

Control Types	Environmental Regulation
316(b) Studies	316(b)
Activated Carbon Injection	MATS
CCR Ash Management	CCR
CCR Wastewater Management	CCR
Continuous Emissions Monitor	MATS
Cooling Tower	316(a), 316(b), NPDES - WQS
Dry Sorbent Injection	MATS
Electrostatic Precipitator Optimization	MATS
ELG Wastewater Management	ELG
Ground Water Monitoring	CCR

Control Types	Environmental Regulation
Intake Screens / Structures	316(b)
New Landfill - Phase 1	CCR
New Landfill - Phase 2	CCR
New Landfill - Phase 3	CCR
Selective Non-Catalytic Reduction	NAAQS

The Unit Retirement Studies assumed no operational impacts to the maximum and minimum capacity, capacity factor, or heat rate degradation due to the addition of the environmental controls.

JIF Exhibit 4

Spring 2016 National Carbon Dioxide Price Forecast, Synapse Energy Economics

Spring 2016 National Carbon Dioxide Price Forecast

Updated March 16, 2016

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AUTHORS' NOTE

On February 9, 2016, shortly after the release of the original version of this report, the U.S. Supreme Court issued a stay on the Clean Power Plan—an unprecedented step as litigation against the rule had not yet been heard at the D.C. Circuit Court of appeals. A stay is essentially a judicial pause on the implementation of a regulation while challenges work their way through the court system.

The stay on the Clean Power Plan does not impact Synapse's long-run forecast of carbon dioxide prices, but could affect the price in earlier years. Despite the substantial uncertainty posed by the stay, many states and system operators have continued Clean Power Plan planning activities. At this point we have not found sufficient evidence to change the forecast presented in this report. This note regarding the stay on the Clean Power Plan is the only change from the original report.

CONTENTS

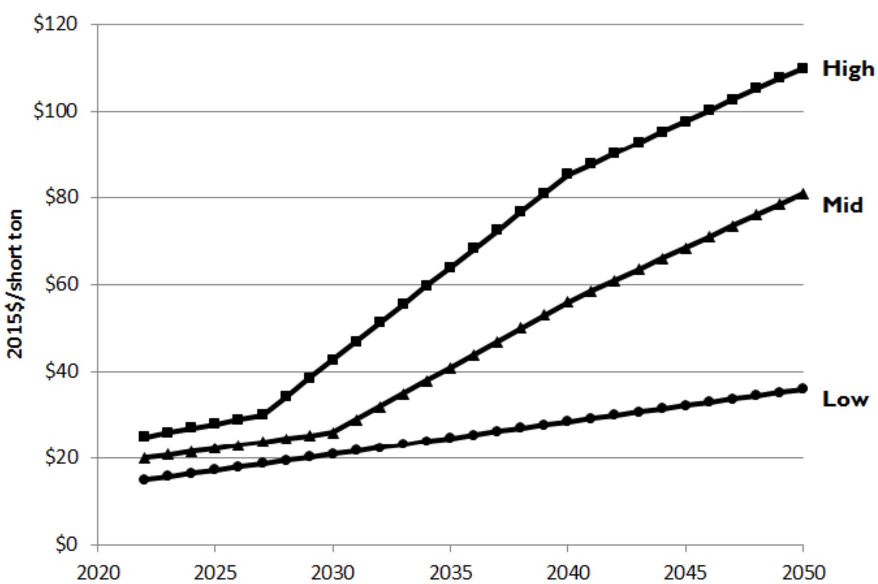
EXECUTIVE SUMMARY

Prudent and reasonable planning requires electric utilities and other stakeholders in carbon-intensive industries to make their best efforts to estimate the future price of carbon dioxide (CO_2) emissions when evaluating resource investment decisions with multi-decade lifetimes. In the regulatory context, this means assigning a number to the future costs of compliance with emissions-related policies. However, forecasting a CO_2 price can be difficult. Federal government limits on CO_2 emissions from new and existing power plants, regional and state policies, other environmental regulation of power plants, and future regulations necessary to meet science-based climate goals all impact the cost of fossil fuel-powered electric generation. A CO_2 price forecast acts as a proxy for these expected costs.

The scientific basis for attributing climatic changes to human-driven greenhouse gas emissions is irrefutable. Such environmental changes are expected to result in damages to both infrastructure and ecosystems. The need for a comprehensive U.S. effort to reduce greenhouse gas emissions is clear, and policymakers have been responding accordingly. To make sound investment decisions, utilities must follow suit by considering existing, proposed, and expected future regulations. First and foremost among these is the Clean Power Plan, the U.S. Environmental Protection Agency's (EPA) regulation of CO_2 emissions from existing power plants under Section 111(d) of the Clean Air Act finalized by the in October 2015. While the Plan does not specify a price on CO_2 *per se*, it nonetheless will result in an "effective" price of CO_2—an important consideration in planning for both utilities and states.

Synapse developed Low, Mid, and High case forecasts for CO_2 prices from 2022 to 2050. In these forecasts, the Clean Power Plan together with other existing and proposed federal regulatory measures place economic pressure on CO_2-emitting resources. The stringency of these forecasts is explained later.

Figure ES-1: Synapse 2016 CO_2 Price Trajectories



Source: Synapse Energy Economics, Inc. 2016.

This 2016 report provides an updated CO_2 price forecast and supplements Synapse's 2015 Carbon Dioxide Price Forecast with the most recent information on federal regulatory measures, state and regional climate policies, and new Synapse modeling analysis.[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 in the past year, including not only the Clean Power Plan but a number of complementary policies.

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 final Clean Power Plan. The Low, Mid, and High Synapse CO_2 price forecasts presented here have some similarity to those in our 2015 report and 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 greenhouse gas emissions, coupled with longer-term legislation passed by Congress to reach science-based emissions targets, 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 Sections 111(b) and 111(d) of the Clean Air Act.
- A federal program establishes targets more stringent than the Clean Power Plan.
- Future federal legislation sets 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;
    - Lower gas prices that reduce the costs of potential policies;
    - A continuation 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.

[1] Luckow P., E.A. Stanton, S. Fields, B. Biewald, S. Jackson, J. Fisher, R. Wilson. 2015. *2015 Carbon Dioxide Price Forecast.* Synapse Energy Economics. Available at: http://www.synapse-energy.com/project/synapse-carbon-dioxide-price-forecast.

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 the combination of federal regulatory measures and 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, particularly for investment of capital in long lived assets.

Study Approach

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

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

Synapse's 2016 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 2022 to 2050. In these forecasts, the 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. The likely result will be relatively more expensive operating costs for high-carbon-emitting power plants. In any state other than the RGGI region and California, we assume a zero carbon price through 2021. Beginning in 2022, we expect Clean Power Plan compliance will put economic pressure on carbon-emitting power plants throughout the United States. We assume smooth allowance trading among large groups of states. The Clean Power Plan is followed later by a more stringent federal policy in the Mid and High cases. The CO_2 prices presented here are forecasts of "effective" prices of CO_2 which may or may not take the form of market-based allowances (see Section 3 for a discussion of different types of CO_2 prices).

- The **Low case** forecasts a CO_2 price that begins in 2022 at $15 per ton.[2] It increases to $21 in 2030 and $36 in 2050, representing a $23 per ton levelized price over the period 2022-2050. 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 natural gas as compared to coal, as indicated in the Energy Information Administration's 2015 Annual Energy Outlook.

- The **Mid case** forecasts a CO_2 price that begins in 2020 at $20 per ton. It increases to $26 in 2030 and $81 in 2050, representing a $38 per ton levelized price over the period 2022-2050. This forecast represents a scenario in which federal policies are implemented with challenging but reasonably achievable goals. Clean Power Plan compliance is achieved and science-based climate targets mandate 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 2022 at $25 per ton. It increases to approximately $43 in 2030 and $110 in 2050, representing a $55 per ton levelized price over the period 2022-2050. 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 2027. 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).

[2] "Tons" refer to short tons throughout this report.

1. OVERVIEW

Estimating the future costs of complying with policies and regulations related to carbon dioxide (CO_2) emissions is now firmly accepted best practice for prudent and reasonable energy planning. Electric utilities and other stakeholders in carbon-intensive industries have the responsibility to capture these costs to the best of their abilities when evaluating resource investment decisions with multi-decade lifetimes. The most prevalent way to do this is through the use of a CO_2 price forecast, an undertaking that is inherently difficult due to uncertainty about the future. To make sound investment decisions, utilities must consider existing regulations as well as proposed and expected future regulations.

To facilitate good planning practices, Synapse develops its CO_2 price forecasts based on the data sources and information presented below. The forecasts reflect a reasonable range of expectations regarding future efforts to limit greenhouse gas emissions. The current forecast contains updates to Synapse's 2015 CO2 price report based on developments from the past 12 months including, importantly, the U.S. Environmental Protection Agency's (EPA) newly finalized Clean Power Plan. Released under Section 111(d) of the Clean Air Act, the Clean Power Plan regulates CO_2 emissions from existing power plants.

The following evidence has guided the development of the Synapse 2016 forecasts:

- **Regulatory measures limiting CO_2 emissions from new and existing power plants have been finalized**. In October 2015, EPA finalized emissions standards for new and existing power plants under Section 111(b) and 111(d) of the Clean Air Act. New Source Performance Standards limit fossil fuel-powered generation built after January 8, 2014. The Clean Power Plan applies to existing fossil fuel-powered electric generation with the goal of reducing electric-sector emissions between 2022 and 2030. These actions represent an effective price on CO_2 that will affect utility planning and operational decisions.

- **Ongoing analysis of the Clean Power Plan suggests a wide range of possible CO_2 prices.** Important factors include the level of regional cooperation, the availability of renewable energy and energy efficiency, and natural gas prices.

- **Environmental regulation can, and often does, evolve incrementally over time**. Initial awareness of environmental damages, followed successively by measurement and study 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. In our view, the trends are likely to continue as increasingly apparent risks demand regulatory and policy responses.

- **State and regional action limiting CO_2 emissions is ongoing and growing more stringent**. In the Northeast, the Regional Greenhouse Gas Initiative (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 AB 32 Cap-and-Trade Program, which represents an even larger carbon market than RGGI, has held many 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 required in federal rulemakings.** The federal government has demonstrated a commitment to considering the benefits of CO_2 abatement by including a "social cost of carbon" in rulemakings such as fuel economy and appliance standards.
- **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 suggests that many utilities believe that by 2020 there will likely be significant economic pressure towards low-carbon electric generation.

This report presents Synapse's 2016 Low, Mid and High carbon dioxide (CO2) price forecasts, along with the evidence assembled to inform these forecasts. It is organized in the following sections:

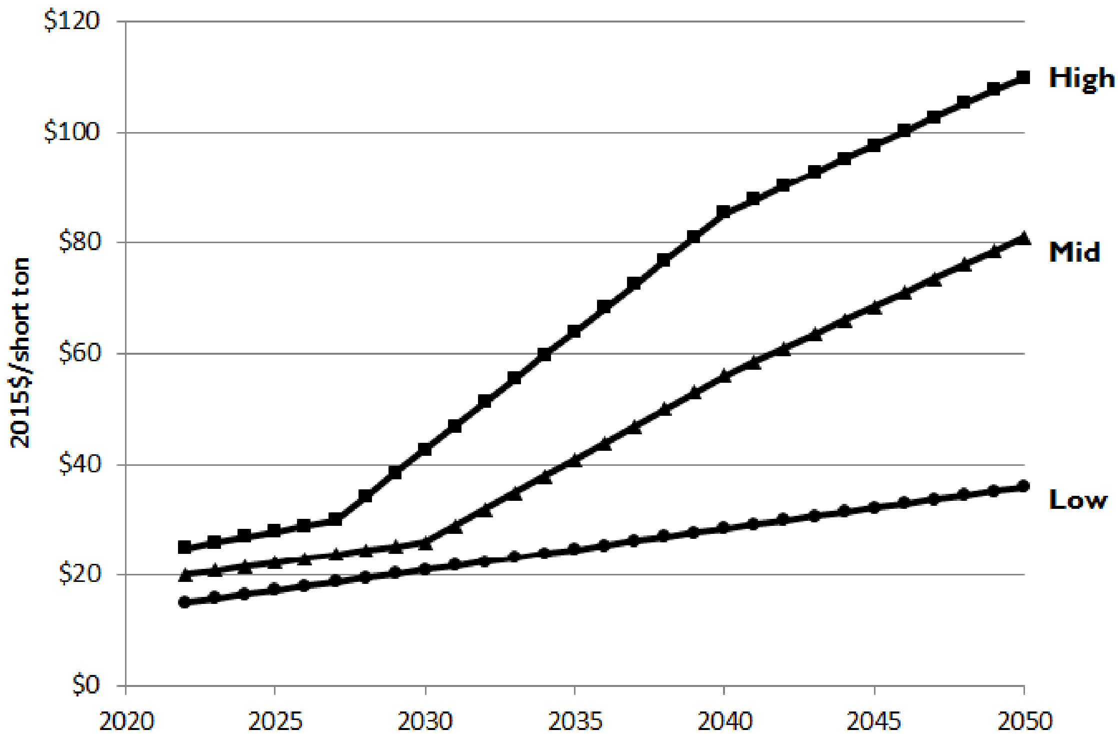
- Section 2 presents Synapse's 2016 CO_2 price forecasts.
- Section 3 discusses broader concepts of CO_2 pricing.
- Section 4 provides an overview of existing state and federal legislation, including the Environmental Protection Agency's (EPA) proposed Clean Power Plan.
- Section 5 discusses our recommendations 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.
- Appendix A presents additional graphs comparing the 2015 forecast with past Synapse forecasts and utility forecasts.
- Appendix B presents complementary policies reducing the cost of CO_2

Unless otherwise indicated, all prices are in 2015 dollars and CO_2 emissions are given in short tons.

2. Synapse 2016 CO_2 Price Forecasts

Based on the evidence discussed in this report, Synapse has developed Low, Mid, and High case forecasts for CO_2 prices from 2022 to 2050. These forecasts reflect our best understanding of Clean Power Plan compliance costs, as well as future expected costs 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 1 and Table 1 present Synapse's forecasts over the 2022-2050 period.[3]

Figure 1: Synapse 2016 CO_2 national price forecasts



Source: Synapse Energy Economics, Inc. 2016.

[3] Figure 12 compares Synapse's 2016 and 2015 CO2 price forecasts. These forecasts do not differ substantially. Two key differences are a tighter range of prices in 2020 resulting from greater policy certainty, and higher 2015 forecasts for the Mid and High cases, resulting from the indicated stringency of the Clean Power Plan. The 2015 forecast was the first Synapse forecast to extend to 2050.

Figure 12

Table 1: Synapse 2016 CO_2 price forecasts (2015 dollars per short ton CO_2)

Year	Low Case	Mid Case	High Case
2020	$0.00	$0.00	$0.00
2021	$0.00	$0.00	$0.00
2022	$15.00	$20.00	$25.00
2023	$15.75	$20.75	$26.00
2024	$16.50	$21.50	$27.00
2025	$17.25	$22.25	$28.00
2026	$18.00	$23.00	$29.00
2027	$18.75	$23.75	$30.00
2028	$19.50	$24.50	$34.25
2029	$20.25	$25.25	$38.50
2030	$21.00	$26.00	$42.75
2031	$21.75	$29.00	$47.00
2032	$22.50	$32.00	$51.25
2033	$23.25	$35.00	$55.50
2034	$24.00	$38.00	$59.75
2035	$24.75	$41.00	$64.00
2036	$25.50	$44.00	$68.25
2037	$26.25	$47.00	$72.50
2038	$27.00	$50.00	$76.75
2039	$27.75	$53.00	$81.00
2040	$28.50	$56.00	$85.25
2041	$29.25	$58.50	$87.75
2042	$30.00	$61.00	$90.25
2043	$30.75	$63.50	$92.75
2044	$31.50	$66.00	$95.25
2045	$32.25	$68.50	$97.75
2046	$33.00	$71.00	$100.25
2047	$33.75	$73.50	$102.75
2048	$34.50	$76.00	$105.25
2049	$35.25	$78.50	$107.75
2050	$36.00	$81.00	$110.00
Levelized 2022-2050	$23.02	$38.13	$55.27

Note: Levelized price based on a discount rate of 5 percent.

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 2022 to 2050. In these forecasts, the 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. In any state other than the

RGGI region and California, we assume a zero carbon price through 2019. Beginning in 2022, we expect Clean Power Plan compliance will put economic pressure on carbon-emitting power plants throughout the United States. We assume smooth allowance trading among large groups of states. The Clean Power Plan is followed later by a more stringent federal policy in the Mid and High cases. The CO_2 prices presented here are forecasts of "effective" prices of CO_2 which may or may not take the form of market-based allowances (see Section 3 for a discussion of different types of CO_2 prices).

- The **Low case** forecasts a CO_2 price that begins in 2022 at $15 per ton.[4] It increases to $21 in 2030 and $36 in 2050, representing a $23 per ton levelized price over the period 2022-2050. 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 natural gas as compared to coal, as indicated in the Energy Information Administration's 2015 Annual Energy Outlook.

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- The **High case** forecasts a CO_2 price that begins in 2022 at $25 per ton. It increases to approximately $43 in 2030 and $110 in 2050, representing a $55 per ton levelized price over the period 2022-2050. 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 2027. 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).

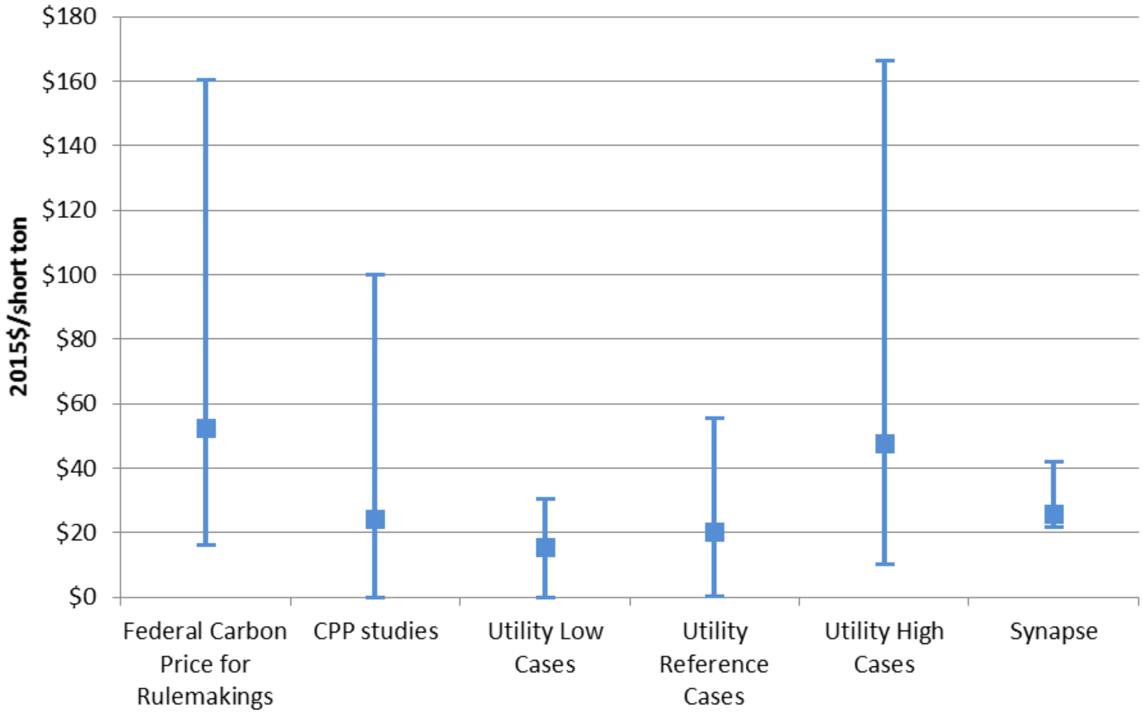
Synapse' price forecasts are presented for planning purposes, so that a reasonable range of emissions costs can be used to investigate the likely costs of alternative resource plans. We expect an actual CO_2 price incurred by utilities in all states to fall somewhere between the low and high estimates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

In Figure 2, 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 (see Section 4 through 6 for a discussion of these studies). In

[4] "Tons" refer to short tons throughout this report.

addition, Synapse 2016 forecasts are also compared to the reference case utility forecasts, the Synapse 2015 forecasts in Appendix A.

Figure 2: Synapse 2016 CO_2 forecasts for 2030 compared to other sources



Source: Synapse Energy Economics, Inc. 2016.

3. WHAT IS A CARBON PRICE?

There are several meanings for the term “carbon price” or “CO_2 price,” each of which 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, carbon allowances are 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 CO_2 allowances are issued by a government and then sold or given away. Regardless of whether allowances are initially given away for free or sold, they represent an opportunity cost of emissions to the holder. If sold at auction, allowance revenues represent a new source of revenues for public uses and may fund energy efficiency and renewable energy programs (as is the case with most revenues from RGGI). They may also be used to defray existing taxes or be rebated to electric consumers. If, instead, these allowances are given away to polluting power generators, these same revenues are a windfall to private interests.

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. This gives an advantage to firms with cleaner, greener operations and also creates 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 emission reduction goal 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 Clean Power Plan’s mass-based compliance pathways include an option for states to create markets for the purchase and sale of emission allowances denominated in tons of CO_2. The Northeast’s RGGI and California’s AB 32 Cap-and-Trade Program are both CO_2 allowance trading systems. In addition, the Kerry-Lieberman, Waxman-Markey, and Cantwell-Collins federal climate bills all proposed policy measures that included CO_2 allowance trading. While closely related to the various price instruments described here, the Clean Power Plan’s rate-based “Emission Rate Credits” are denominated in megawatt-hours and, therefore, do not constitute a type of carbon price.

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 CO_2 that they emit. If the value of damages were known with certainty, a tax could internalize the damages accurately by setting the tax rate equal to the damages; in practice, the value of damages is uncertain. In contrast to the government issuance of allowances, with a carbon tax there is no fixed amount of possible emissions (no “cap”). A 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 common 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 a shadow, notional, hypothetical, or voluntary price, the effective price of carbon results from non-market policies. 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 integrated resource planning (IRP) and internal planning purposes. EPA's proposed CO_2 pollution standard for new sources of electric generation under Section 111(b) of the Clean Air Act is a non-market-based policy that would result in an effective price of carbon; similarly, the Clean Power Plan's "state measures" pathways for compliance 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" in which 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. Next, 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.

Note that many policy analyses estimate the net costs (or benefits), comparing the total benefits of a policy to its total costs. The average cost of a policy is its net cost divided by its 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 average policy cost is negative (a net benefit), but the marginal cost of abatement is positive (a cost for the most expensive units of emission reduction needed to achieve the goal).

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.[5] ExxonMobil recently updated their marginal abatement cost curve in its 2016 Energy Outlook.[6]

Social cost of carbon: The marginal abatement cost estimates the price of stopping pollution. In contrast, 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 CO_2. 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.[7]

4. State and Federal CO_2 Policies

In October 2015, the United States Environmental Protection Agency (EPA) released the final version of the Clean Power Plan under Section 111(d) of the Clean Air Act, aiming to reduce emissions from existing power pants. At the same time, EPA released New Source Performance Standards for new power plants. These federal regulations are in addition to a suite of complementary policies impacting emitting resources, including standards on regional haze, mercury, and coal waste. Many states had

[5] 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.

[6] ExxonMobil. 2016. "The Outlook for Energy: A view to 2040." Available at: http://corporate.exxonmobil.com/en/energy/energy-outlook/charts-2016/united-states-c02-abatement-costs.

[7] U.S. EPA. 2015. *EPA Fact Sheet: Social Cost of Carbon.* Available at http://www3.epa.gov/climatechange/Downloads/EPAactivities/social-cost-carbon.pdf.

their own emissions goals and standards in advance of these regulations. In its 2016 "Outlook for Energy", ExxonMobil assumes such state and federal policies will result in an effective price of $73 per short ton by 2040.[8]

4.1. Clean Air Act CO_2 Regulations

As part of the Administration's Climate Action Plan, which aims to significantly reduce greenhouse gas emissions from all sectors of the U.S. economy, President Obama directed EPA to issue emission standards for new and existing fossil fuel-fired electricity generators using its authority under the Federal Clean Air Act.

New Source Performance Standards

In October 2015, EPA released final New Source Performance Standards aimed at reducing CO_2 from new, modified, and reconstructed fossil fuel power plants under Section 111(b) of the federal Clean Air Act. These New Source Performance Standards are based on EPA's assessment of available technologies and they establish emission performance standards using the maximum allowable emissions of CO_2 per unit of electricity generated (i.e., lbs CO_2 per MWh) for all fossil fuel power plants on which construction commenced after January 8, 2014. The final standards were set at 1,400 lbs CO_2 per MWh for new coal-fired power plants and 1,000 lbs CO_2 per MWh for new, baseload gas-fired plants.

The standards for modified and reconstructed coal and gas units were finalized at the same time. These are existing coal or gas resources that undergo physical or operational changes that increase the maximum hourly CO_2 emissions rate (for modified resources) or that replace components to such an extent that the capital cost of the new components exceeds 50 percent of the capital cost of an entirely new comparable facility (for reconstructed resources). Coal plant modifications that result in an increase of hourly CO_2 emissions of more than 10 percent will be required to meet an emission rate limit consistent with that plant's best historical annual performance since 2002.

Reconstructed coal plants would be required to meet an emission limit of 1,800 lbs CO_2 per MWh.[9] Reconstructed gas plants must meet the same emission limits as new gas plants, while EPA deferred a decision on limits for modified gas plants until it can gather additional information.

Existing Sources under the Clean Power Plan

In October 2015, EPA also released its Clean Power Plan aimed at existing sources. Under the Clean Power Plan, the electric sector—which is the single largest producer of greenhouse gases—is expected

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[8] ExxonMobil. "The Outlook for Energy: A view to 2040." January 2016. Available at: http://corporate.exxonmobil.com/en/energy/energy-outlook/download-the-report/download-the-outlook-for-energy-reports

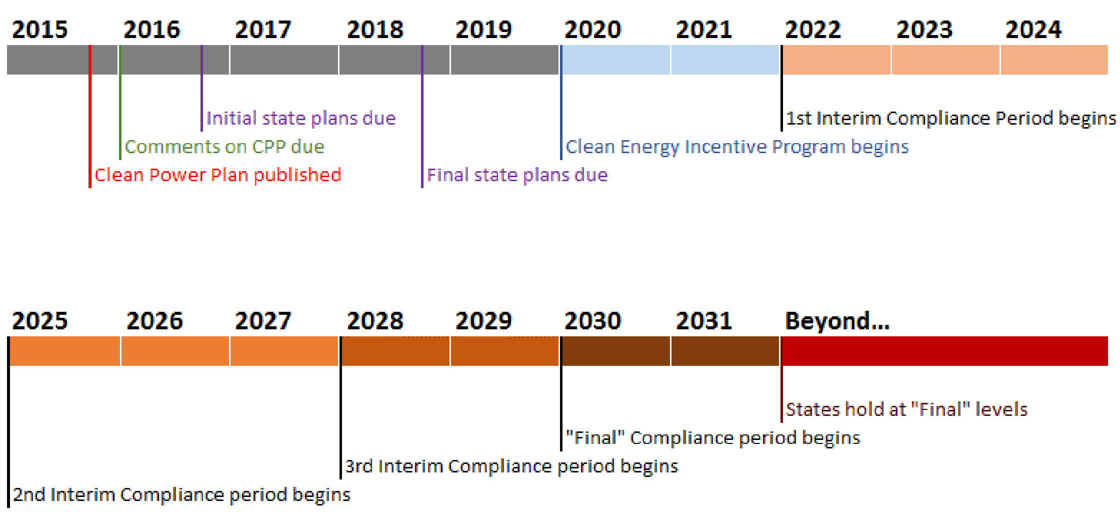
[9] Smaller coal plants (those with a heat input of less than 2,000 MMBtu per hour) would be required to meet an emission limit of 2,000 lbs CO_2 per MWh.

to reduce CO_2 emissions from 2005 levels by about 32 percent nationwide by 2030. To reduce CO_2 emissions from existing power plants, EPA established emission performance standards for two electric generating technology types—fossil steam (mainly coal and some oil) and stationary combustion turbines (mainly natural gas combined-cycle, or NGCC, plants)—based on the degree of emission reductions achievable through what is called the "best system of emission reduction" or BSER. BSER includes not only upgrades and operational changes to power plants, but also measures such as increased renewable energy and shifting generation from higher-emitting resources to lower-emitting resources. An example of the latter would be a shift in generation from coal-fired plants to natural gas plants. For a detailed discussion of the Clean Power Plan targets and compliance options see the Synapse 2015 *Clean Power Plan Handbook.*[10]

States may choose among different manners of complying with the rule: they can comply using either a rate-based or a mass-based approach; they can include just existing sources, or both existing and new sources; and they can use targets based on technology type (i.e., fossil steam versus NGCC) or state averages.

States must now develop compliance plans to submit to EPA. Initial draft compliance plans or requests for extension with demonstrations of progress are due September 6, 2016, and final plans are due no later than September 6, 2018 (see Figure 3). During plan development, states may follow the approaches outlined by EPA during target setting, or they may design their own strategies to comply with the targets.

Figure 3. Clean Power Plan compliance timeline



[10] Jackson et al. 2015. "Clean Power Plan Handbook: A Guide to the Final Rule for Consumer Advocates." Prepared by Synapse Energy Economics for the National Association of State Utility Consumer Advocates. Available at: http://www.synapse-energy.com/sites/default/files/Clean-Power-Plan-Handbook.pdf.

Source: Synapse Energy Economics, Inc. 2016.

In their plans states must demonstrate that their compliance strategy achieves an emission rate (lbs/MWh) or mass (tons) equal to or better than the targets set by EPA for the three interim compliance periods (2022-2024, 2025-2027, and 2028-2029), a final compliance period (2030-2031), and biennially thereafter. Depending on the compliance approach a state chooses, these demonstrations may be more or less complex.

Throughout the rule, EPA emphasizes regional cooperation and coordinated planning as one of the best approaches for compliance. The agency provides extensive guidance on the development and use of emission trading programs, and states that the larger the region over which trading occurs, the more effective—and cost-effective—compliance will be. To date, there are several emission trading programs that exist in the United States and abroad, including RGGI in the Northeast and California's AB 32 Cap-and-trade program. These existing programs take a mass-based approach to trading in which CO_2 allowances representing the ability to emit one ton of CO_2 are traded with eligible partners throughout a defined region.

States that choose a mass-based compliance approach can establish trading programs in which electricity generators have the opportunity to trade allowances. One allowance represents one short ton of CO_2. Every generator subject to the Clean Power Plan must procure allowances equal to the quantity of CO_2 it emits during the compliance period. The total number of allowances that are distributed in a state, i.e., the state's emission budget, is equal to the state's mass-based goal.

Existing mass-based trading programs, including RGGI in the Northeast, use an auction process to distribute some or all allowances. Auctions have many potential benefits, including providing incentive for early action, avoiding indirect subsidies that can prolong operation of uneconomic resources, and lowering policy and consumer costs through revenue recycling.

States that choose a rate-based approach to compliance—which may include those with large new nuclear units expected to come online before the first Clean Power Plan compliance period (South Carolina, Tennessee, and Georgia)—might require a separate effective CO_2 price forecast.

4.2. Complementary Federal Policies

In addition to the Clean Power Plan and New Source Performance Standards for CO_2 emission reductions, there are a number of federal environmental regulations that limit or add costs to fossil fuel-powered electric generation. By doing so, they indirectly lead to an effective price of CO_2. These complementary policies are summarized in Table 2 and described in detail in Appendix B. The cost of complying with environmental regulations reduces the profitability of the worst polluters, sometimes rendering them uneconomic—causing a reduction in generation from these facilities or even leading to their retirement. Federal regulation of pollutants from power plants are evidence of momentum towards more stringent control of environmentally harmful activities in the electric sector. To the extent that electric generators with high emissions of non-CO_2 pollutants also have high CO_2 emissions, these policies represent an effective price on CO_2 that would *lower* the incremental CO_2 price necessary to achieve a given system-wide emission reduction; as more pollution-intensive plants retire in response to other EPA regulations, the incremental CO_2 price necessary to achieve science-based climate goals is reduced. Synapse's CO_2 forecast is the incremental effective CO_2 price over and above the impacts of non-CO_2-related policies.

Table 2: Summary of power sector environmental regulations 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	New Source Performance Standards for GHGs from new sources under 111(b) was finalized on August 3, 2015	Applies to sources that begin construction on or after January 8, 2014	CO_2 and other greenhouse gases
	New Source Performance Standards for GHGs from modified or reconstructed sources under 111(b) was finalized on August 3, 2015	Applies to sources that were modified or reconstructed after June 28, 2014	
	Clean Power Plan for reducing CO_2 from existing sources under 111(d) was finalized in October 2015	States must submit compliance plans or initial plan and request for extension to EPA by September 6, 2016	
National Ambient Air Quality Standards (NAAQS)	1-Hour SO_2 NAAQS was finalized in June 2010; next 5-year review underway	Initial designations were made in June 2013; additional designations for major emitters required by July 2, 2016 per consent decree	Sulfur dioxide; nitrogen oxides; carbon monoxide; ozone; particulate matter; and lead
	PM2.5 annual NAAQS was finalized in December 2012	Final designations announced December 18, 2014; SIPs due in April 2018 with attainment required by 2020	
	8-Hour Ozone NAAQS was finalized in October 2015	Designations for updated standard will be made in late 2017; attainment dates vary by severity of problem	
Cross State Air Pollution Rule (CSAPR)	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 pushing back 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; remanded by U.S. Supreme Court in July 2015 for failing to consider costs; in December 2015, D.C. Circuit rejects request to vacate rule, leaving it in place while EPA develops cost assessment	Compliance required by April 16, 2015; rule allows for a 1-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	Effective October 19, 2015; utilities must file intent to close legacy ash ponds by December 17, 2015; structural safety inspections due October 2016	Coal combustion residuals (ash)
Steam Electric Effluent Guidelines (ELGs)	EPA issued final rule on September 30, 2015	Pretreatment requirements by November 2018; Best Available Technology requirements phased in over 5-year NPDES permitting cycle	Toxins and wastewater 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 intake
Regional Haze Rule	Regional Haze Rule issued in July 1999	States must install the Best Available Retrofit Technology (BART) controls on eligible units by 2018; thereafter, states must demonstrate "reasonable progress" toward natural conditions by 2064	Sulfur oxides, nitrogen oxides, and particulate matter

4.3. State and Regional Policies

State and regional environmental policies regulating power plants can also result in an effective CO_2 price. Currently, 29 states have renewable portfolio standards and 26 have efficiency standards. Twenty states plus the District of Columbia have set greenhouse gas emissions targets as low as 80 percent below 1990 levels by 2050.[11][12] In addition, there are two regional and state cap-and-trade programs in the United States today: the Northeast's RGGI and California's Cap-and-Trade Program under the state's Global Warming Solutions Act (Assembly Bill 32).

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 seven years of successful CO_2 allowance auctions, with Auction 30 in December 2015 resulting in a clearing price of $7.50 per ton.[13] RGGI is designed to reduce electricity sector CO_2 emissions to at least 45 percent below 2005 levels by 2020.[14]

RGGI is also a potential avenue for Clean Power Plan compliance for these states.

While the RGGI targets are largely consistent with (and slightly more stringent than) the states' Clean Power Plan targets, a recent Pace Energy and Climate Center analysis showed that the availability and use of cost containment reserves—which limit increases in the allowances prices by automatically loosening CO_2 limits—could keep the RGGI states from meeting their federal targets. Without use of the cost containment reserve instrument, allowance prices are likely to increase.

California's AB 32 Cap-and-Trade-Program

With the goal of reducing the state's emissions to 1990 levels by 2020, California's Global Warming Solutions Act (AB 32) created the world's second largest carbon market, after the European Union's Emissions Trading System.

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[11] NC Clean Energy Technology Center. *Database of State Incentives for Renewables & Efficiency (DSIRE).* DSIRE Detailed Summary Maps: Renewable Portfolio Standards and Energy Efficiency Resource Standards. Accessed: Jan 19, 2016. Available at: http://www.dsireusa.org/resources/detailed-summary-maps/.

[12] Center for Climate and Energy Solutions. "Greenhouse Gas Emissions Targets." *U.S. Climate Policy Maps.* Accessed Jan 19, 2015. Available at: http://www.c2es.org/us-states-regions/policy-maps/emissions-targets.

[13] Regional Greenhouse Gas Initiative (RGGI). RGGI Auction 23 results available at: http://rggi.org/market/co2_auctions/results/Auction-23.

[14] 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.

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.[15] The second joint auction was held on February 18, 2015, and cleared at $11.08. This auction, which was the first to include transportation fuels, sold 73.6 million allowances, as compared to only 23 million allowances in the prior November 2014 auction.[16] In 2015, Ontario and Manitoba announced that they would soon join California and Québec in a unified cap-and-trade system.[17]

While the current cap-and-trade program in California only runs through 2020, the passage of Senate Bill 350 in 2015 increased the states renewable portfolio standard goals to 50 percent by 2030 and doubled building efficiency standards.[18] Also in 2015, Governor Jerry Brown set new goal of 40 percent below 1990 levels of statewide greenhouse gas emissions by 2030, by executive order. The legislature will still need to approve the legal framework for expansion of the cap-and-trade system in this timeframe.

Historical RGGI and California auction prices are presented in Figure 4 below.

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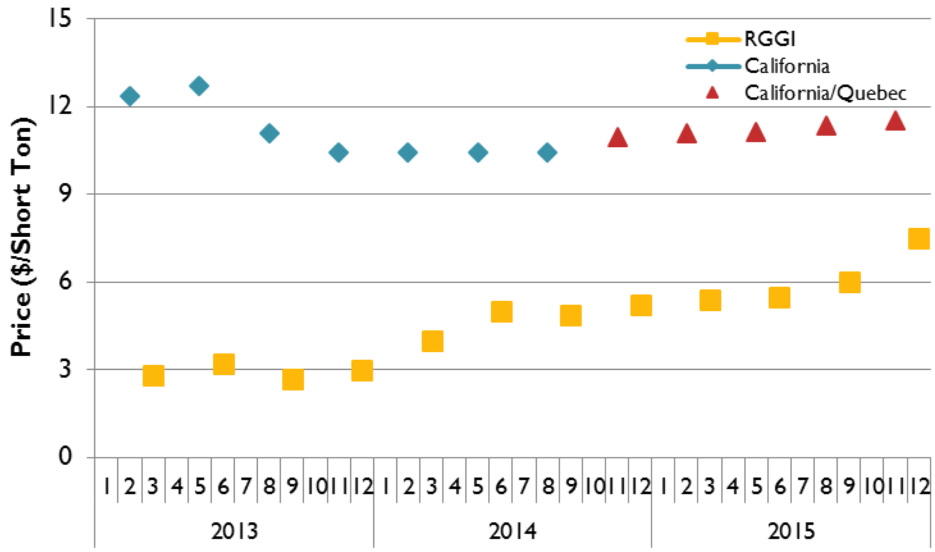
[15] California Air Resources Board. 2015. California Cap and Trade Program Summary of Auction Results. Updated 1/12/2015. Available at: http://www.arb.ca.gov/cc/capandtrade/auction/results_summary.pdf.

[16] 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.

[17] Hamilton, T. 2015. "Ontario agrees to linked cap-and-trade deal with Quebec, Manitoba." *The Star*. December 7. Available at: http://www.thestar.com/news/canada/2015/12/07/manitoba-sign-paris-deal-to-join-ontario-quebec-in-carbon-cap-and-trade-system.html.

[18] Environmental Defense Fund. 2015. "California Makes Clean Energy History with Passage of SB 350." Blog published September 14 at: http://blogs.edf.org/energyexchange/2015/09/14/california-makes-clean-energy-history-with-passage-of-sb-350/.

Figure 4: Auction results from RGGI and California cap-and-trade programs



Source: RGGI Auction Results available at: https://www.rggi.org/market/co2_auctions/results. California Air Resources Board Summary Results available at: http://www.arb.ca.gov/cc/capandtrade/auction/results_summary.pdf.

4.4. 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;[19] updated values were released in 2013.[20] The 2013 Economic Report of the President acknowledges that these values will continue to be updated as scientific understanding improves.[21]

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 1 for more explanation of the "social cost of carbon" methodology). These

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[19] 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.

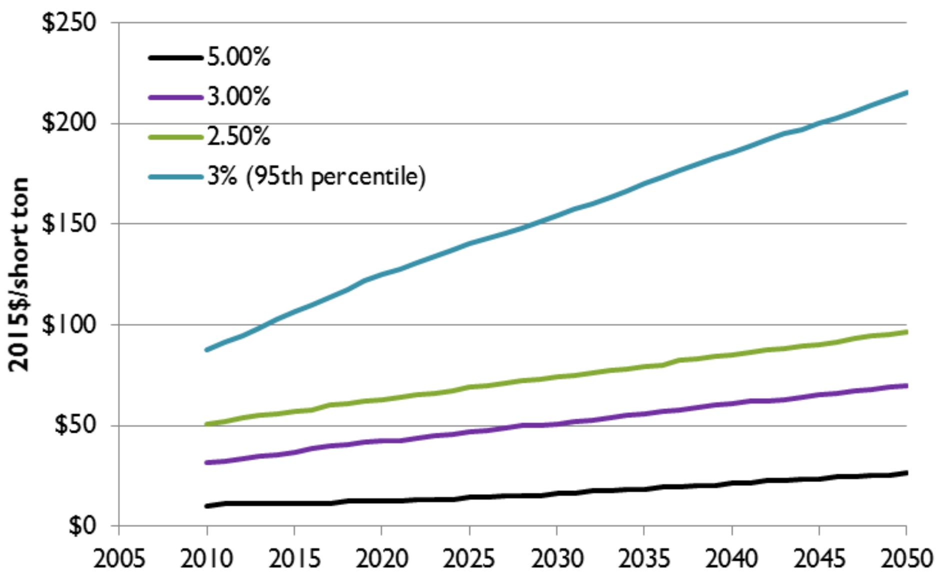
[20] Interagency Working Group on the Social Cost of Carbon. 2013. *Technical Support Document – Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis – Under Executive Order 12866*. Available at: https://www.whitehouse.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf. Reported values have been converted to 2015 dollars per short ton.

[21] 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.

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.[22] While subject to significant uncertainty, this multi-agency effort represents an initial attempt at incorporating the benefits associated with CO_2 abatement into federal policy. These values are presented in Figure 5.

The average social cost of CO_2 at a 3 percent discount rate—$36 in 2015—is often called the "central value" by EPA and is commonly used in federal rulemakings to represent the value of CO_2 emissions avoided by the policy under consideration. 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 and may therefore impact on the effective price of CO_2.

Figure 5: Range of federal social cost of CO_2 estimates, by discount rate



Source: Synapse Energy Economics, Inc. 2016.

22 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. They 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].

4.5. 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. 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 reduction in emissions from 2005 levels by 2020, and an 83 percent reduction by 2050.[23] Further analysis of these proposals is provided in Synapse's *2012 Carbon Dioxide Price Forecast*.[24]

We expect that federal cap-and-trade legislation will eventually be enacted but that it is unlikely to happen in the near term. The Clean Power Plan represents an effective price of greenhouse gas emissions, but is not expected to meet long-term science-based goals of reducing total U.S. greenhouse gas emissions to approximately 80 percent below 2005 levels by 2050.[25] A more comprehensive, economy-wide approach will be needed to meet these goals at the lowest possible cost to consumers.

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

With EPA's Clean Power Plan finalized in October, states have just begun the process of modeling compliance options, drafting state implementation plans, and analyzing the potential costs associated with achieving compliance. In addition to EPA's estimates of the costs of compliance using ICF's Integrated Planning Model (IPM) model, many other researchers have estimated the cost of the Clean Power Plan at state, regional, and national levels, as summarized in Figure 6.[26]

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[23] U.S. Energy Information Administration (EIA). 2010. "Energy Market and Economic Impacts of the American Power Act of 2010." Available at http://www.eia.gov/oiaf/servicerpt/kgl/index.html.

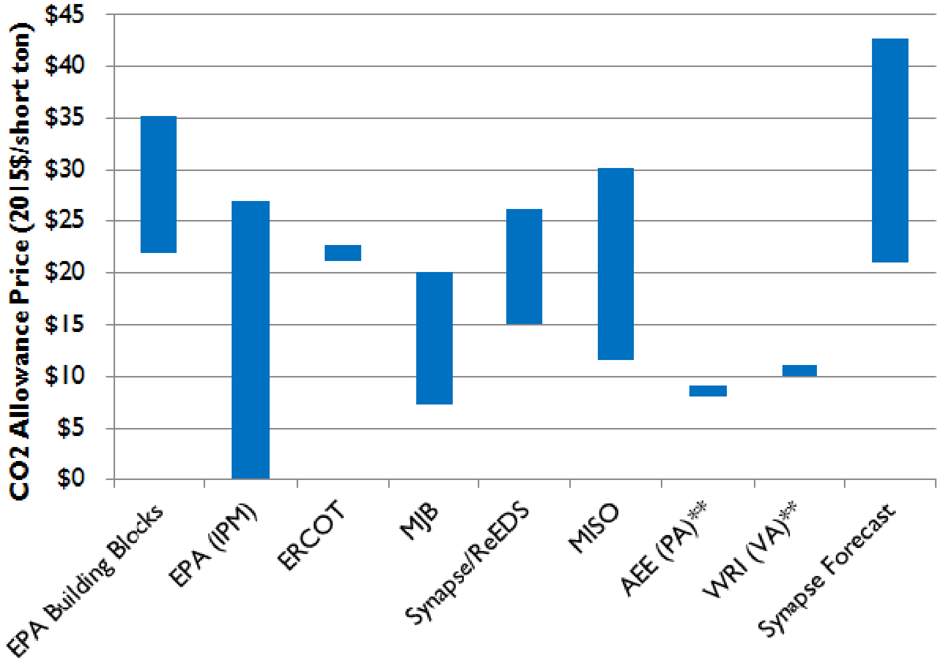
EIA. 2009. "Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009." Available at http://www.eia.doe.gov/oiaf/servicerpt/hr2454/index.html.

[24] Wilson et al. 2012.

[25] World Resource Institute. 2013. "Can the U.S. Get There From Here?: Using Existing Federal Laws and State Action to Reduce Greenhouse Gas Emissions." Report available at: http://www.wri.org/publication/can-us-get-there-here.

[26] Three studies, MISO, AEE, and WRI, assumed an exogenous price. This should be interpreted differently than the more analytically determined prices from the other studies.

Figure 6: Summary of Clean Power Plan study CO_2 price estimates for 2030 (2015 dollars/short ton)



Source: Synapse Energy Economics, Inc. 2016.

Synapse's nationwide allowance price falls within the range of other publicly available findings. Studies' CO_2 prices associated with compliance depend on a number of factors, including assumptions about cooperation, fuel prices, renewable and energy efficiency costs, and retirements.

5.1. EPA's IPM Results

In the final Clean Power Plan rule, EPA provides a range of estimates of the modeled cost of compliance with the final rule based on the two main target options. Compared to a non-compliant base case, EPA estimates annual Clean Power Plan costs growing steadily to $8.4 billion nationwide in 2030 under a rate-based approach to compliance, and to $5.1 billion under a mass-based approach to compliance.[27] These costs are incremental to the base case, and represent a combination of electric generating production cost savings plus the costs of demand side resources and measurement and verification of results. To put these costs in perspective to the CO_2 prices forecasted in this report, EPA found that the

[27] U.S. EPA. 2015. *Regulatory Impact Analysis for the Clean Power Plan Final Rule*. Table ES-5. Revised: October 23. Available at: http://www.epa.gov/sites/production/files/2015-08/documents/cpp-final-rule-ria.pdf. *Note: EPA's cost estimates are in 2011 dollars.*

range of CO_2 prices necessary for Clean Power Plan compliance ranged from $0 per short ton—in states without much work to do to comply— to $26/short ton in coal heavy states.[28]

This analysis is separate from EPA's "building block" analysis in the final rule. Here it estimated the cost of emissions reductions from the three building blocks: operational improvements at existing coal plants, shifting generation from coal power plants to gas power plants, and increasing generation from renewable energy. They found these measures to cost $23 per ton, $23 per ton, and $37 per ton, respectively, with a weighted average of $30 per ton.[29]

5.2. ERCOT's Texas Results

Electric Reliability Council of Texas (ERCOT) analyzed three different paths to compliance for the state of Texas: an energy efficiency scenario with a modest level of savings (7 percent cumulative savings by 2030), a simple CO_2 price optimization, and a combination of increased coal retirements from the Regional Haze rule and a CO_2 price optimization.[30] The two scenarios explicitly incorporating a CO_2 price found that the price would rise from $1/short ton in 2022 to $22.50/short ton in 2030, or from $0/short ton in 2022 to $21.50/short ton in 2030 as a result of additional retirements in the Regional Haze case. In the energy efficiency scenario, the cost of energy rises 11 percent above a non-compliant base case, while it rises 20 to 44 percent above the base case in the CO_2 scenarios. This implies a shadow price of CO_2 in the energy efficiency case much lower than that observed in the cases explicitly modeling a CO_2 price.

5.3. MISO's Midwest Results

MISO used the PLEXOS production cost model to update its draft analysis for the final rule. This analysis found that—without building any new capacity—mass-based compliance could be achieved at a cost of $5 billion for the full MISO system, while rate-based compliance cost $17 billion. New natural gas power

[28] U.S. EPA. "Analysis of the Clean Power Plan." Last accessed January 28, 2016. Available at: http://www.epa.gov/airmarkets/analysis-clean-power-plan.

[29] Final Rulemaking, Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, Federal Register/ Vol. 80, NO. 205. October 23, 2015 Page 64749. Available at: https://www.gpo.gov/fdsys/pkg/FR-2015-10-23/pdf/2015-22842.pdf.

[30] Electric Reliability Council of Texas. 2015. *ERCOT Analysis of the Impacts of the Clean Power Plan: Final Rule Update*. Available at: http://www.ercot.com/content/news/presentations/2015/ERCOT_Analysis_of_the_Impacts_of_the_Clean_Power_Plan-Final_.pdf.

plants, renewable energy facilities, or energy efficiency would reduce this cost. These capacity additions reduced the marginal CO_2 price in 2030 from $30 per short ton to $11 per short ton.[31]

5.4. M.J. Bradley Analysis

M.J. Bradley & Associates (MJB) used the same model EPA used in their analysis of the Clean Power Plan, IPM, to analyze compliance costs under a much broader range of sensitivities, assuming varying levels of energy efficiency and interstate trading under mass-based and rate-based policies.[32] MJB found that coal declined to supply 23 to 28 percent of total generation under Clean Power Plan cases. Natural gas supplied 25 to 32 percent. As the level of energy efficiency increased, MJB found steady reductions in allowance prices.

This analysis considered compliance plans on "existing units only," as well as "existing plus new" scenarios that incorporated EPA's New Source Complement. Emissions under an existing unit only approach were 94 million tons higher— suggesting these plans are more susceptible to leakage.

5.5. Energy Ventures Analysis updated analysis for NMA

For the final rule, Energy Ventures Analysis (EVA) updated its 2014 analysis of the Clean Power Plan performed for the National Mining Association.[33] EVA used the AURORA dispatch model to calculate the lowest cost compliance pathway, assuming no interstate trading (similar to the EPA modeling). While EVA did not present the resulting allowance prices from their analysis, wholesale electricity prices rose 10 percent in 2022 and 21 percent by 2030. This contributed to a total wholesale electricity spending increase of $15 billion in 2022, and $32 billion in 2030. These values are substantially higher than EPA's ($8.4 billion total costs in 2030), and do not include incremental capital spending.

5.6. NERA Consulting Report on Final Rule

NERA used its energy and economy model, NewERA, to analyze the impacts of the Clean Power Plan under two mass-based scenarios: one with no trading and one with regional trading.[34] While NERA did

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[31] Midcontinent Independent System Operator (MISO). 2016. "Results for MISO's Near-Term Analysis of EPA's Final Clean Power Plan." Last accessed January 20th 2016. Available at: https://www.misoenergy.org/Library/Repository/Meeting%20Material/Stakeholder/PAC/2016/20160120/20160120%20PAC%20Item%2002aii%20CPP%20Final%20Rule%20Analysis%20Near%20Term%20Results.pdf.

[32] M.J. Bradley & Associates. 2016. "Modeling Analysis of EPA's Clean Power Plan." Available at: http://www.mjbradley.com/reports/modeling-analysis-epas-clean-power-plan.

[33] Energy Ventures Analysis. 2015. "EPA's Clean Power Plan: An Economic Analysis." Available at: http://nma.org/attachments/article/2368/11.13.15%20NMA_EPAs%20Clean%20Power%20Plan%20%20An%20Economic%20Impact%20Analysis.pdf.

[34] National Economic Research Associates. 2015. "Energy and Consumer Impacts of the EPA's Clean Power Plan." Available at: http://www.americaspower.org/nera/.

not report allowance prices from these case. The case with no trading had a cumulative impact of $241 billion dollars, in present value terms. With trading, the cost was reduced to $220 billion, an 8 percent decrease.

5.7. AEE's Pennsylvania Results

Advanced Energy Economy (AEE) conducted an analysis of Clean Power Plan compliance approaches for the Commonwealth of Pennsylvania. In this analysis Pennsylvania achieved compliance using an assumed allowance trading price of $8/short ton, with a sensitivity at $4/short ton, based on historical prices in RGGI and California markets.[35]

5.8. WRI's Virginia Results

World Resources Institute did a similar analysis for the state of Virginia and in which Clean Power Plan compliance was achieved using an assumed $10/short ton allowance price.[36]

5.9. Synapse's U.S. States Results

For this report, 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 Clean Power Plan compliance. The first assumed full trading amongst all states, and the second separated out the three major electrical interconnects. In the latter, these separate groups must comply independently and are not allowed to trade with others. Closely related Synapse analyses were recently published as *The RGGI Opportunity*[37] and *Cutting Electric Bills with the Clean Power Plan.*[38]

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 2015 Annual Energy Outlook. Synapse's Clean Power Plan scenarios included state caps on CO_2 emissions consistent

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[35] Advanced Energy Economy. 2015. "Model Shows Clean Power Plan Could Produce Savings for Pennsylvania Ratepayers." Available at: https://www.aee.net/articles/model-shows-clean-power-plan-could-produce-savings-for-pennsylvania-ratepayers.

[36] World Resources Institute. 2015. "How Virginia Can Meet its Clean Power Plan Targets." Available at: http://www.wri.org/sites/default/files/wri15_fact_sheet_VA_Clean_Power_1.pdf.

[37] Stanton, E.A, P. Knight, A. Allison, T. Comings, A. Horowitz, W. Ong, N. Santen, K. Takahashi. 2016. "The RGGI Opportunity." Synapse Energy Economics. Available at: http://www.synapse-energy.com/sites/default/files/The-RGGI-Opportunity.pdf.

[38] Knight, P., A. Allison, W. Ong, N. Santen, E. Stanton. 2016. "Cutting Electric Bills with the Clean Power Plan." Synapse Energy Economics. Available at: http://www.synapse-energy.com/sites/default/files/cutting-electric-bills-cpp.pdf.

with EPA's mass-based targets for existing sources with a new source complement.[39] After 2030, we assume the cap remains flat at 2030 levels. We believe this to be a very conservative assumption—continued global pressure to meet science-based emissions goals of 80 percent below 2005 levels will require even further reductions. This analysis was conducted using an in-house Synapse version of the ReEDS model, modified to include the latest known power plant additions and retirements, renewable portfolio standards, state energy efficiency standards and technology cost assumptions.[40] This analysis is based on AEO 2015 natural gas prices, which rise from $5.30 per million BTU in 2022 to $5.93 per million BTU in 2030. Importantly, this analysis used baseline levels of energy efficiency consistent with existing state standards. Further energy efficiency would reduce compliance costs. ReEDS assigns CO_2 prices by year and trading area as a shadow price necessary to achieve Clean Power Plan compliance.

The resulting allowance prices should be applicable for reasonably large groups of states that allow for trading of allowances or emissions rate credits (ERCs) among the group. For individual states that take an isolate approach to Clean Power Plan compliance, the relevant CO2 price could be significantly higher. Alternatively, if a state relatively low-cost compliance chooses to avoid trading, it could achieve a very low cost of CO_2. That state would, however, miss the benefits of selling allowances for that over-compliance.

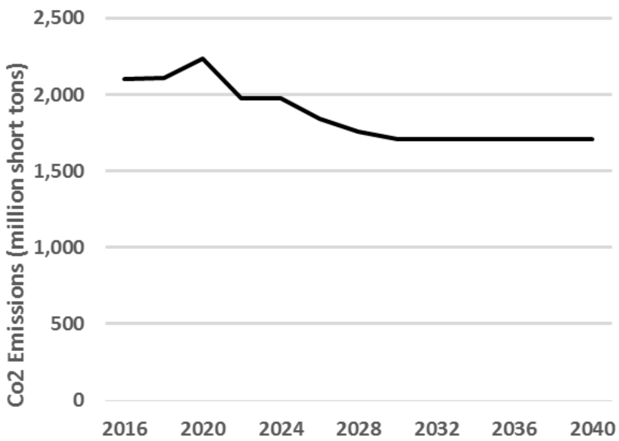
Figure 8 reports aggregate national emissions for both scenarios. Emissions slowly rise towards 2020 as gas prices increase from recent lows, leading to increased utilization of coal resources. As shown in Figure 8, when nationwide trading is permitted allowance prices typically range from $15 to $25/short ton (in 2014 dollars) throughout the 2022-2032 Clean Power Plan compliance timeframe. [41] In the regional trading scenario, prices are highest in the East, ranging from $21 to $28 per short ton in the Clean Power Plan compliance timeframe. The West sees lower costs due to both excellent renewable resource options and substantial complementary policies, such as California's recently announced 50 percent renewable portfolio standard.

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

[40] Stanton, E.A et al. 2016. "The RGGI Opportunity."

[41] The West has a zero carbon allowance price between 2022 and 2025, largely driven by the RPS in California exceeding the Clean Power Plan requirements. These numbers would change if California were to not participate in trading.

Figure 7: National CO_2 emissions under all scenarios (million short tons)



Source: Synapse Energy Economics, Inc. 2016

Figure 8: CO_2 allowance prices with nationwide trading area ($/short ton)

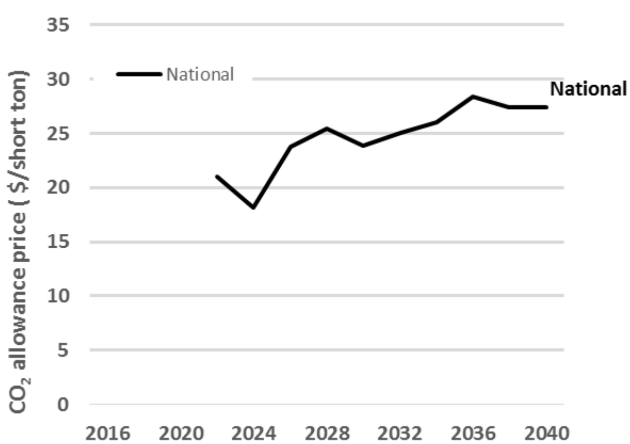
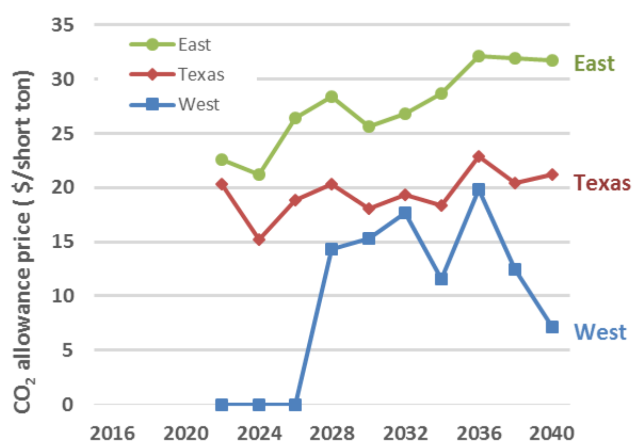


Figure 9: CO_2 allowance prices with no trading between interconnects ($/short ton)



Source: Synapse Energy Economics, Inc. 2016.

6. CO_2 Price Forecasts in Utility IRPs

Many electric utilities include projections of the expected costs associated with reductions to 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. We have not updated this analysis since the release of our 2015 CO2 Price Forecast in May 2015. The release of the final Clean Power Plan has led some utilities to reconsider their analysis, and IRPs incorporating compliance with the Clean Power Plan are just beginning to emerge. We believe the set of utility forecasts presented here provides a reasonable reflection of the current expectation for compliance costs associated with policies of moderate stringency in the 2020-2030 timeframe, largely consistent with the Clean Power Plan.

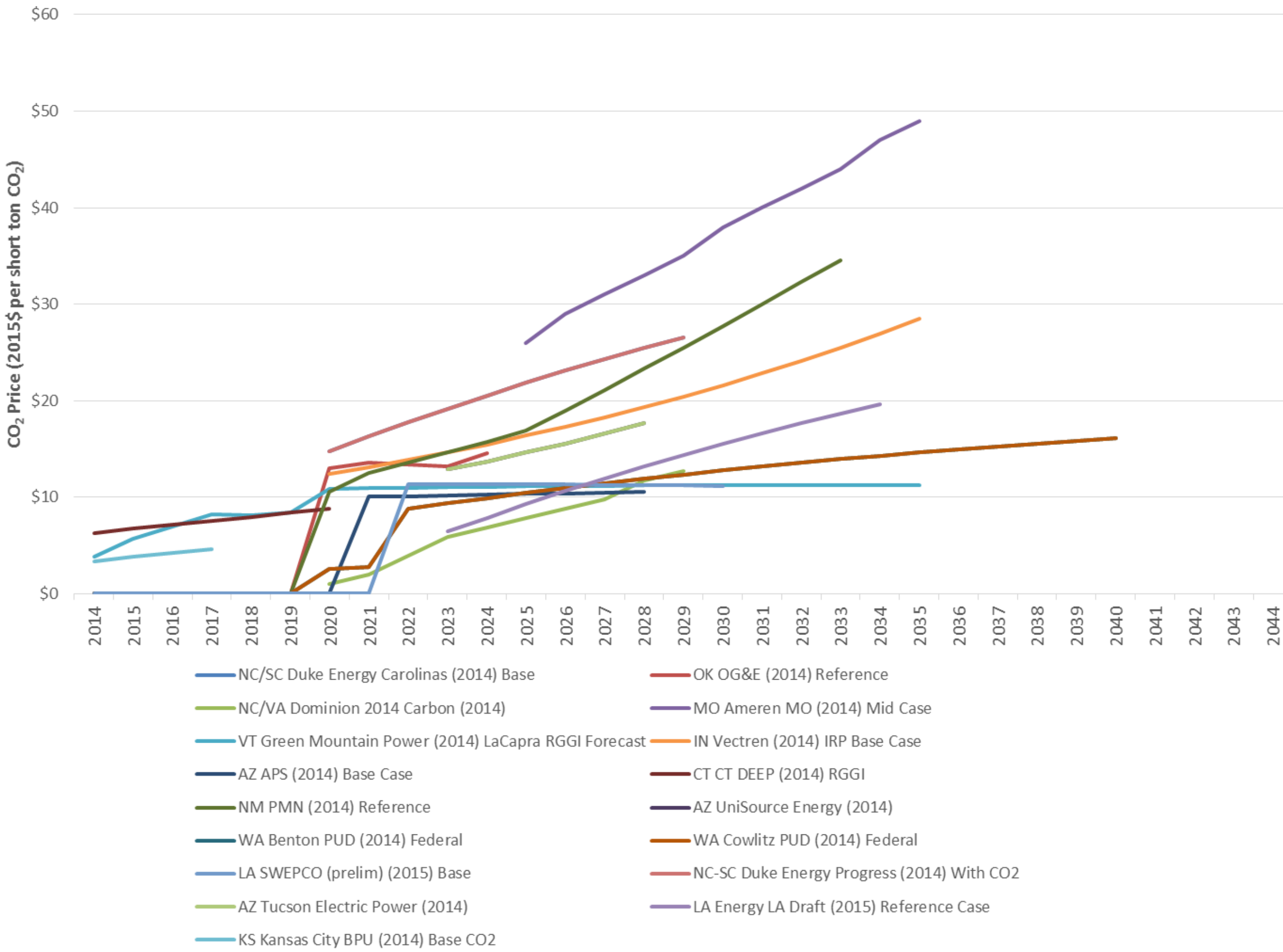
History has shown a steady increase in the number of utility planning processes that include a CO_2 price:

- None of the 15 IRPs published from 2003-2007 reviewed by Synapse included a CO_2 price forecast.
- Of the 56 IRPs from 2008-2011 reviewed, 23 included a CO_2 price forecast. This jump in the inclusion of CO_2 price projections in IRPs from 2008 onwards coincided with the introduction of the Waxman-Markey cap-and-trade bill in Congress. As a result of this bill, the inclusion of CO_2 pricing sensitivities in IRPs became paramount to prudent planning. A majority of the IRPs in our 2015 review reflect an understanding that including a price to reflect future environmental regulations is necessary to prudent planning.
- Of the 115 IRPs released in 2012-2015 and reviewed by Synapse (referred to below as the "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.
- Moreover, of the 24 IRPs in the Synapse review that were released in 2014-2015, 20 included a CO_2 price in at least one scenario. Of these, 19 includes a CO_2 price in their reference case scenario.

Figure 10 below displays non-zero reference case CO_2 price forecasts from 24 utility IRPs over the period of 2014-2044.[42] Although we refer above to 61 non-zero CO_2 price reference case forecasts in the current sample, 15 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 in Figure 10. 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.

[42] We also provide a figure showing 46 forecasts produced since 2012 in Appendix A.

Figure 10: 2014 and 2015 utility non-zero and non-confidential reference case forecasts



Source: Synapse Energy Economics, Inc. 2016.

APPENDIX A: SYNAPSE FORECASTS COMPARED TO UTILITY FORECASTS AND PAST SYNAPSE FORECASTS

Figure 11: Utility non-zero and non-confidential reference case forecasts from 2012-2015

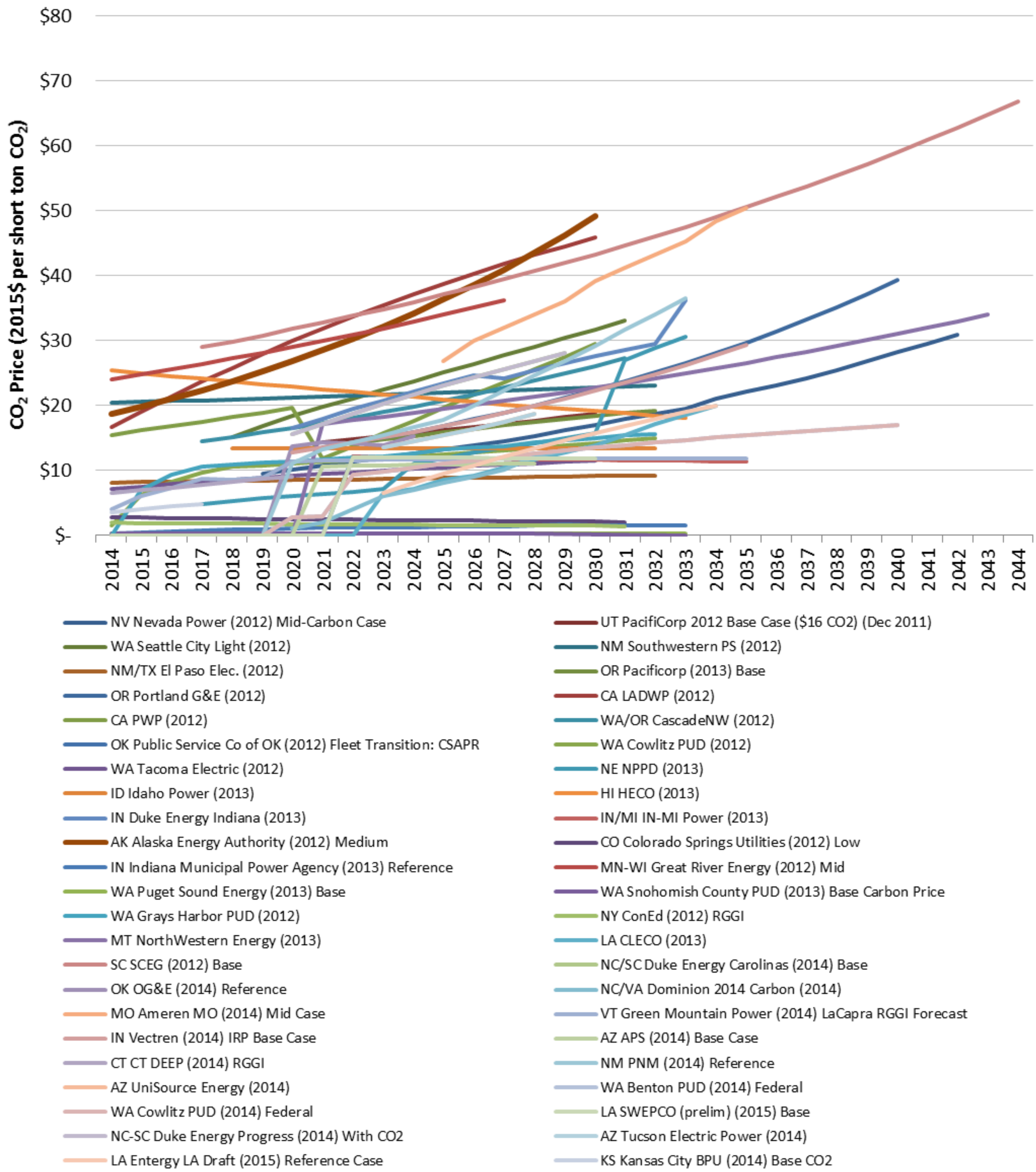
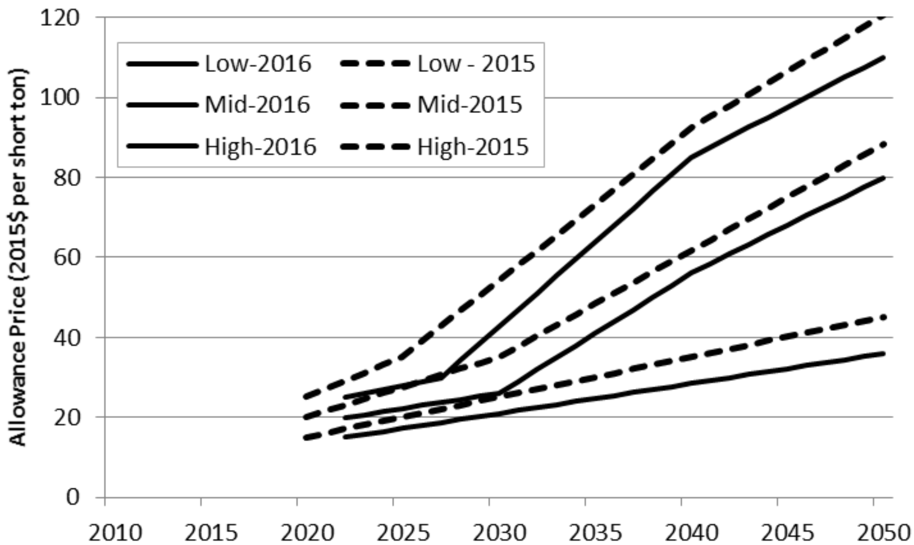


Figure 12 compares Synapse's 2016 and 2015 CO_2 price forecasts. These forecasts do not differ substantially. Two key differences are a tighter range of prices in 2020 resulting from greater policy certainty, and higher 2015 forecasts for the Mid and High cases, resulting from the indicated stringency of the Clean Power Plan. The 2015 forecast was the first Synapse forecast to extend to 2050.

Figure 12: Comparison of 2013 and 2015 Synapse CO_2 price forecasts



Source: Synapse Energy Economics, Inc. 2016.

APPENDIX B: COMPLEMENTARY POLICIES FOR GREENHOUSE GAS REDUCTIONS

- *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. Phase I of the reinstated CSAPR has already begun; the more stringent requirements of Phase II begin January 1, 2017.
- *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. In July 2015, the U.S. Supreme Court remanded the MATS rule to the D.C. Circuit Court of Appeals, finding that EPA had failed to properly account for costs in determining whether it should regulate mercury. In December 2015, the D.C. Circuit Court rejected a request from coal interests to vacate the rule, leaving it in place while the EPA drafts its cost assessment per the Supreme Court's ruling. Many utilities have already undertaken the capital improvements at their coal plants to comply with the standard. In fact, in early 2014, EIA found that approximately 70 percent of U.S. coal-fired power plants already comply with MATS.[43]

- *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. It requires existing ash ponds at operating coal plants to either install liners and ground water monitoring or permanently retire, and also 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

[43] See EIA website. Accessed December 17, 2015. Available at: http://www.eia.gov/todayinenergy/detail.cfm?id=15611.

online. This is significant because 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 September 30, 2015, EPA released its final steam-electric ELGs to reduce or eliminate the release of toxins into U.S. waterways.[44] The rule sets the first federal limits on the levels of toxic metals in wastewater that can be discharged from power plants. New requirements for pretreatment must be in place by November 2018 and best available technology requirements will be implemented in 2018 through 2023 through the five-year National Pollutant Discharge Elimination System permit cycle.[45]

- *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.[46]

- *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, with a goal of achieving natural conditions by 2064. The initial round of SIPs 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 and no later than 2018.

[44] See U.S. EPA website. Accessed December 17, 2015. Available at: http://www.epa.gov/eg/steam-electric-power-generating-effluent-guidelines-2015-final-rule.

[45] See U.S. EPA website. "Final Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Industry Factsheet." Accessed December 17, 2015. Available at: http://www.epa.gov/sites/production/files/2015-10/documents/steam-electric-final-rule-factsheet_10-01-2015.pdf.

[46] See U.S. EPA website. Accessed December 17, 2015. Available at: http://water.epa.gov/lawsregs/lawsguidance/cwa/316b/index.cfm.

JIF Exhibit 5

Fisher, J.I. Environmental Regulations in Integrated Resource Planning, EUCI 2015. Atlanta Georgia

Environmental Regulations in Integrated Resource Planning

Utility Integrated Resource Planning

EUCI, Atlanta

May 14, 2015

Jeremy Fisher, PhD
Synapse Energy Economics
Cambridge, Massachusetts

Synapse Energy Economics

- Founded in 1996. Based in Cambridge, Massachusetts
- Leader for public interest and government clients in providing rigorous analysis of the electric power sector
- Staff of 30 includes experts in energy and environmental economics and environmental compliance

- Our work covers almost every state, each year.
- Policy development and assessment, system planning, litigation and enforcement, & forensic modeling.
- Clients include NARUC, NASUCA, EPA, DOE, State agencies, consumer advocates and environmental advocates.

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Jeremy Fisher, PhD

- Work on Resource Planning for vertically integrated utilities
- Expert witness in 18 environmental compliance litigated cases in a dozen states.
- Conduct policy analysis for public agencies and public interest groups.
- Consult for EPA on rulemaking activities; trained EPA HQ on electric system planning.
- Developed EPA's Avoided Emissions and Generation Tool (AVERT)

  - B.S. Geology/Geography, University of Maryland, College Park
  - M.Sc. Geology, Brown University
  - PhD. Geology, Brown University

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Agenda

- Electric Sector Environmental Regulations
  - Status Update
- Accounting for Environmental Regulations in Planning
  - Impacts of Regulations in Planning
  - General Principles
  - Assigning Costs
  - Assessing Risk and Impact
  - Option Value
- How IRPs have Incorporated Regulations: 2008-2015
- Case Studies
  - PacifiCorp Naughton 1 & 2 Disallowance
  - PNM San Juan Stakeholder Process
  - IP&L Harding Street 7
- Best Practices

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Electric Sector Environmental Regulations

Regulatory Update

Rule	Current Status as of Release	Next Deadline(s)	Pollutants Covered
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	Summer 2015: EPA must finalize standards for existing power plants	
		Summer 2016: States must submit state compliance plans to EPA	
National Ambient Air Quality Standards (NAAQS)	1-Hour SO_2 NAAQS finalized in June 2010	Initial designations based on monitoring data were made in June 2013; additional designations required by consent decree by July 2, 2016 with remaining designations by end of 2017	SO_2; NOx; carbon monoxide; ozone; particulate matter; and lead
	$PM_{2.5}$ annual NAAQS 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 1 began January 1, 2015 and Phase II begins January 1, 2017	Nitrogen oxides and sulfur dioxide

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Regulatory Update

Rule	Current Status as of Release	Next Deadline(s)	Pollutants Covered
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. “Reasonable progress” goals spinning up.	Sulfur oxides, nitrogen oxides, and particulate matter

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Accounting for Environmental Regulations in Planning

Impacts of Regulations in Planning

New Unit Selection

- Restrictions on unit types (e.g. NSPS for CO_2 bars new coal)
- Availability of permits (ozone, water)
- Preferred selection towards low-impact resources

Existing Units

- Capital expenditures
- Fixed operations and maintenance (O&M)
- Variable O&M
- Heat rate
- Capacity
- Operational limits
- Fuel sources

System

- Dispatch cost & loading order
- Wholesale energy prices
- Overall system cost

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General Principles

1. A key purpose of system planning is to determine near-term actions.
   - Acquisitions, builds, sales, contracts, funding levels
2. In least-cost planning, existing units compete with new units and EE/RE programs.
3. Existing and new units may be subject to existing, proposed, and expected environmental regulations.
   - Existing regulations are (likely) the rule of law.
   - Existing, proposed and expected environmental regulations impose costs and restrictions

…therefore…

4. The economic viability of existing units should be tested rigorously in the face of environmental regulations.
5. The purpose of examining proposed and expected regulations is to examine if different choices would be made in the near term in light of future risks – including retirement, new builds, EE/RE investments, etc…

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Assigning Costs & Impacts

Existing Regulations

- Engineering costs and estimates
- Known allowance costs for tradable emissions
- Permit conditions for restrictions

Proposed Regulations

- Proxy costs for capital
- Proxy allowance cost
- Proxy restrictions or caps
- Lenient and strict interpretations of final rule

Pending Regulations

- Estimated impact: general proxy cost
- Best guess on timing and magnitude

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Assessing Probability of Impact

- Requires subjective probability of regulation
  - Is there significant momentum behind the regulation?
  - Is there a court order or consent decree requiring the regulation?
  - What is the current estimated date of finalization / implementation?
  - Will the rule really be held up in court?

- Probability and impact are separate items, and should not be confounded or combined in assumptions.
  - i.e. a modeled CO_2 price should not be the allowance cost times the probability of occurrence, it should simply be the allowance cost. Probability comes later.

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Assessing Probability of Impact

A “reference” case is the expected, or mean, outcome.

Assuming that there is no impact of a regulation in the reference case implies:

(a) There is absolute certainty that the regulation will not come to fruition;

(b) There is an equal probability that the regulation will be beneficial as harmful.

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Option Value

- Given significant uncertainty on future environmental regulations, how do we make resource decisions today?

Hypothetical Scenario:

- Need to decide this year if we install an expensive flue gas desulfurization (FGD) by 2018 for SO_2 NAAQS compliance.
- New ozone standard implies potential need to install selective catalytic reduction (SCR) in 2022.
- Installing both an FGD **and** SCR is non-economic.
- Once I install the FGD, the cost is sunk.
- Avoid a piecemeal solution

What should we do? Option value.

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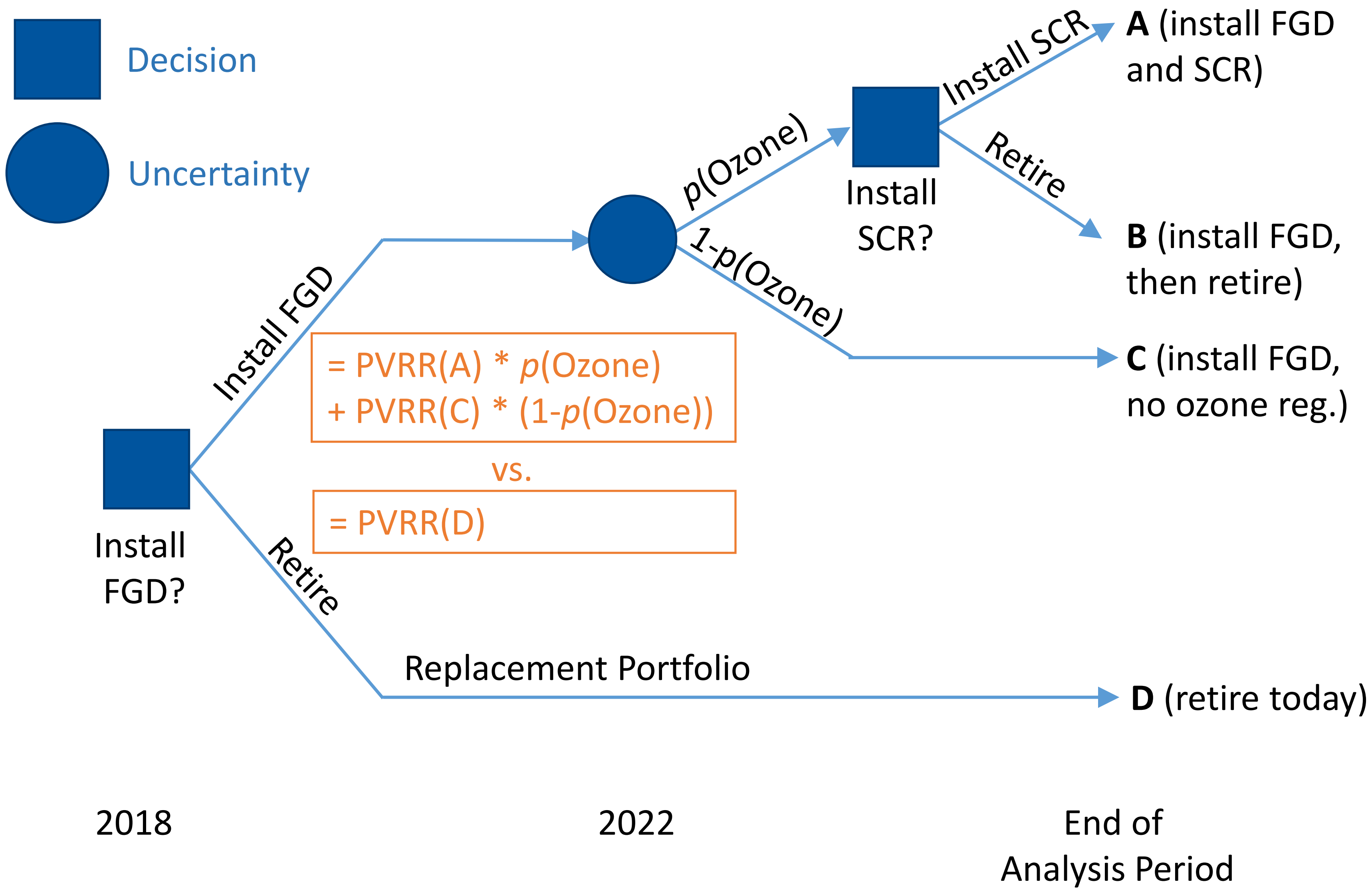
Option Value



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Option Value

Install FGD today?

Install FGD

= PVRR(A) * *p*(Ozone)
+ PVRR(C) * (1-*p*(Ozone))

Retire

= PVRR(D)

A (install FGD and SCR)

C (install FGD, no ozone reg.)

D (retire today)

I should install the FGD for today's regulation if the cost of the retiring and replacing the energy exceeds the cost of maintaining the unit

Maintaining the unit accepts the risk that the ozone standard will require the installation of SCR.

Install FGD today if:
PVRR(A) * *p*(Ozone)
+ PVRR(C) * *p*(Ozone)
<<
PVRR(D)

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How IRPs have Incorporated Regulations: 2008-2015

Review of Utility IRPs – 2008-2015

- Synapse collects public IRPs.
  - Currently 203 in database from 165 utilities.
  - From small coops to large IOUs
  - Not all states require or produce IRPs
- Mined IRPs for utilities that served >8,500 GWh in 2013. (*n* = 66)
- Queries:
  - Included a CO_2 price?
  - Included a CO_2 price in base case?
  - Assessed cost of pending regulations?
  - Retire / retrofit evaluation?
    - Optimal retirement?
    - Optimal replacement?

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Utilities in our Survey

State	Utility	State	Utility
AR	Arkansas Electric Cooperative Corporation	LA	Entergy Louisiana
AR	Entergy Arkansas Inc.	MN	Minnesota Power
AZ	Arizona Public Service	MN	Northern States
AZ	Salt River Project	MO	Ameren MO
AZ	Tucson Electric Power	MS	Entergy
CA	Los Angeles Department of Water & Power	MT	NorthWestern Energy
CA	Sacramento Municipal Utility District	NC	Duke Energy Carolinas
DE	Delmarva Power & Light Company	NE	Omaha Public Power District
FL	Florida Power and Light	NM	Public Service Company of New Mexico
FL	Progress Energy Florida	NV	NV Energy North
FL	Duke Energy Florida	NY	Consolidated Edison
GA	Georgia Power	OK	Oklahoma Gas & Electric
IN	Duke Energy IN	OR	PacifiCorp
IN	Indiana-Michigan	OR	Portland General Electric
IN	Indianapolis Power and Light	SC	Progress Carolinas
IN	Northern Indiana Public Service Company	SC	South Carolina Electric & Gas
KS	Kansas City Power & Light	TN	Tennessee Valley Authority
KY	KU/LG&E	VA	Dominion
LA	CLECO	WA	Puget Sound Energy
LA	Entergy New Orleans	WA	Seattle City Light

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CO_2 Risk Assessed

Did the IRP take into account the risk of a future CO_2 price?

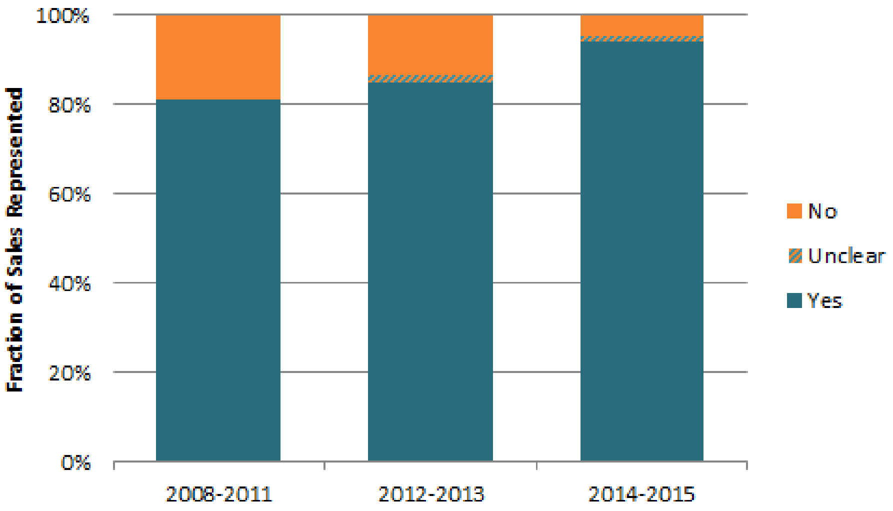
In 2008, American Clean Energy and Security Act was all but settled, failed to clear Senate.

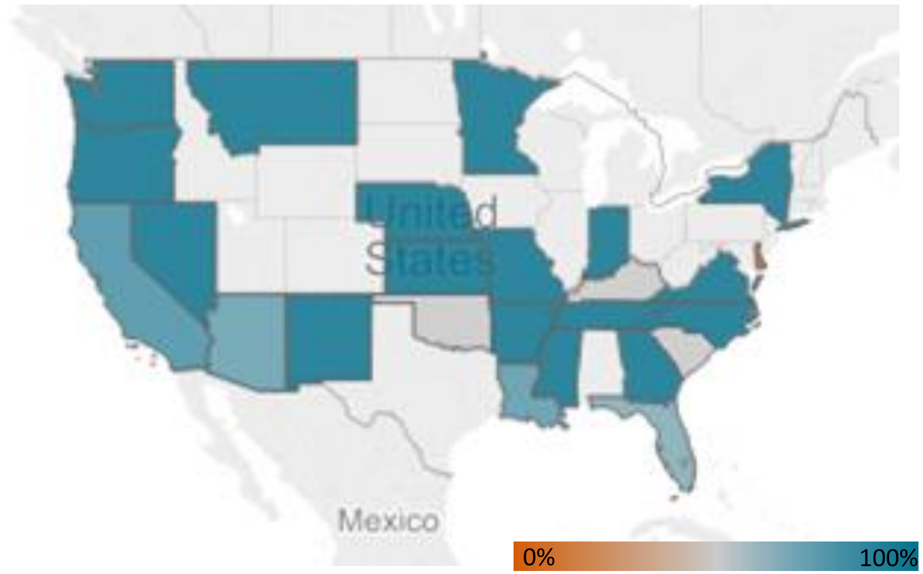
Public sentiment building for some form of action through 2012.

By 2013, announcement of future EPA ruling.

Results shown as fraction of total sales represented in survey.

- *i.e. bigger utilities more represented.*





CO_2 Risk in Reference Case

Did the IRP assume that CO_2 prices would be in place anytime during the analysis period?

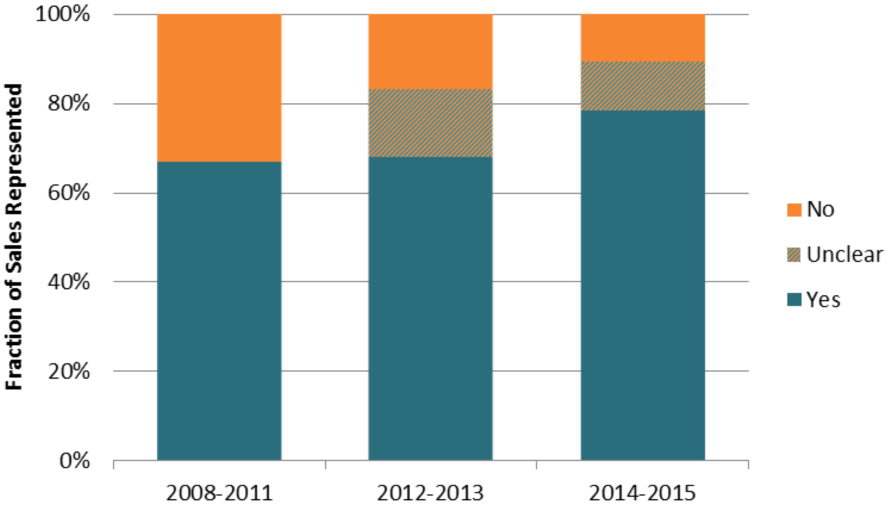
Choice to exclude a CO_2 price in the reference case is very specific to some states and utilities.

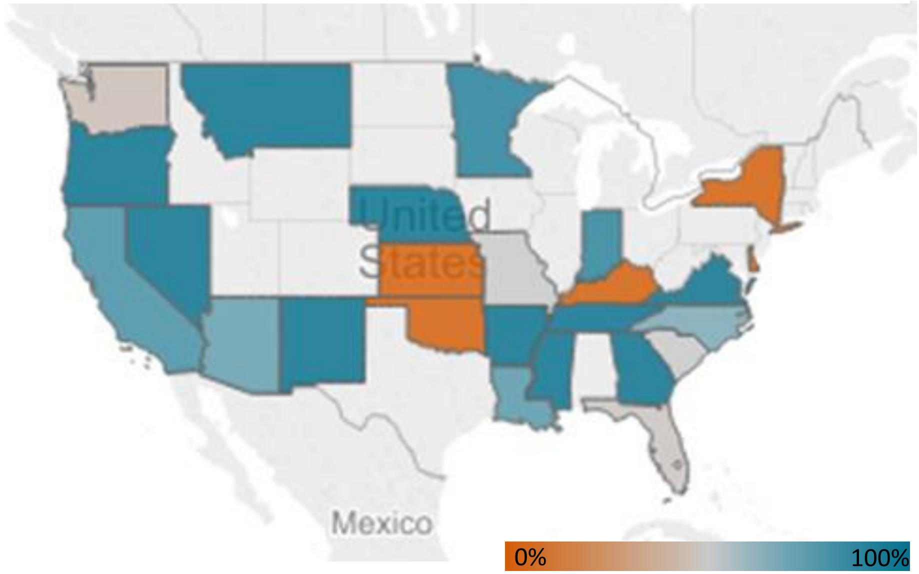
Some states are inconsistent across utilities.

- *Louisiana: Entergy & SWEPCO, not Cleco*

Some utilities make different choices in different states.

- *Progress Carolinas (2012) included a CO_2 price*
- *Progress Florida (2012) did not.*





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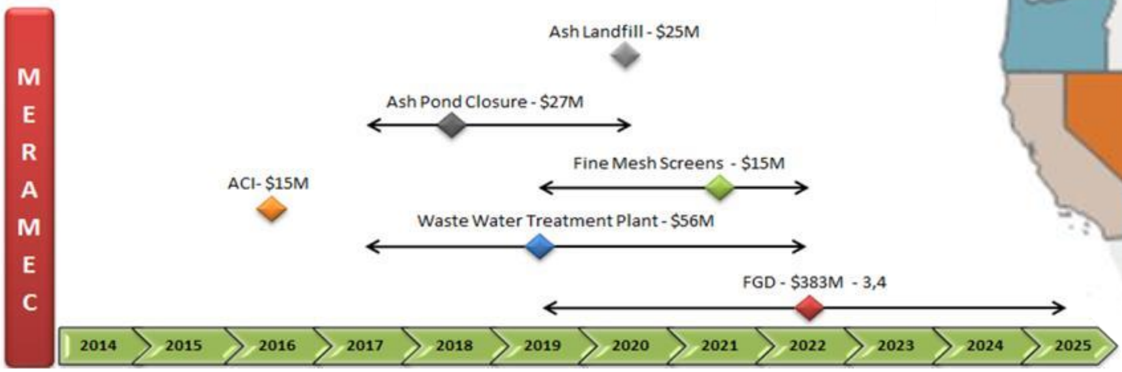
Pending Regulations Quantified

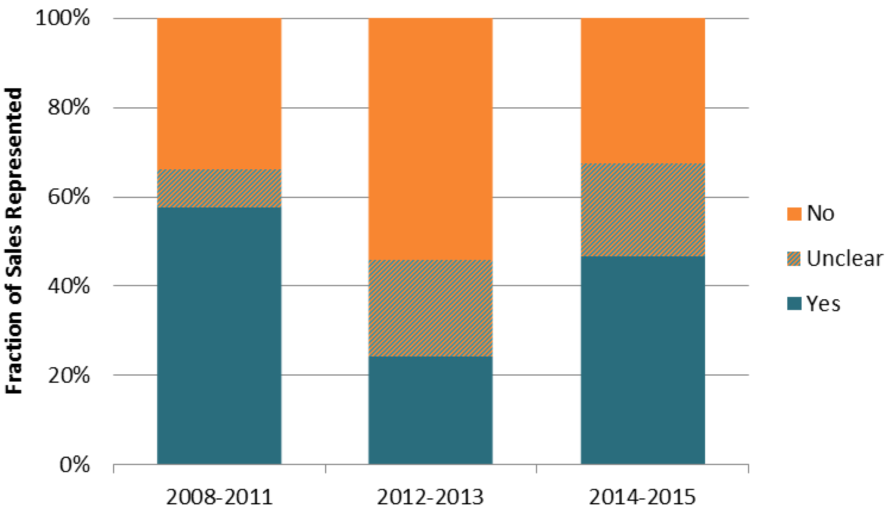
Did the IRP describe and assess the impact of pending regulations on their existing fleet?

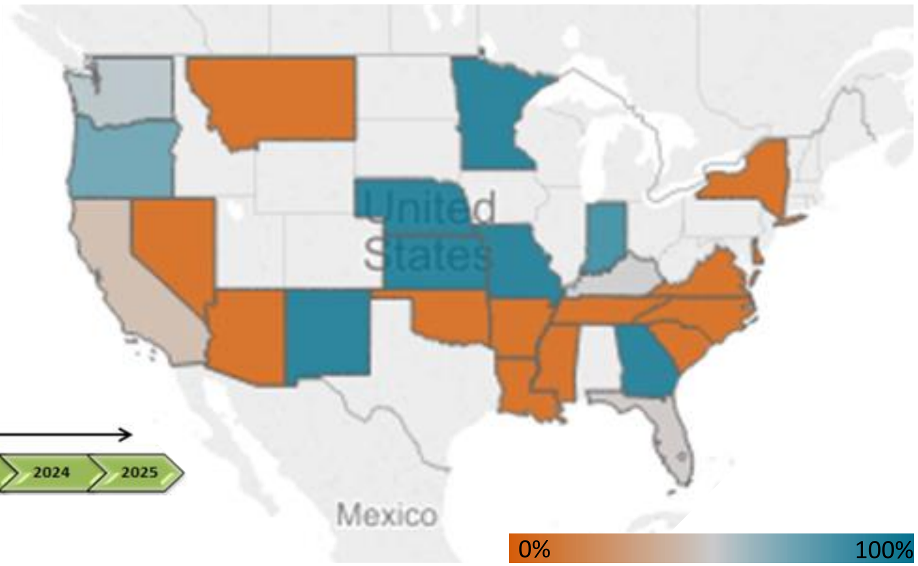
Review of potential costs for CSAPR, coal ash, effluent, 316(b), and impending NAAQS.

Incorporate costs into modeling.

Ameren Missouri Example







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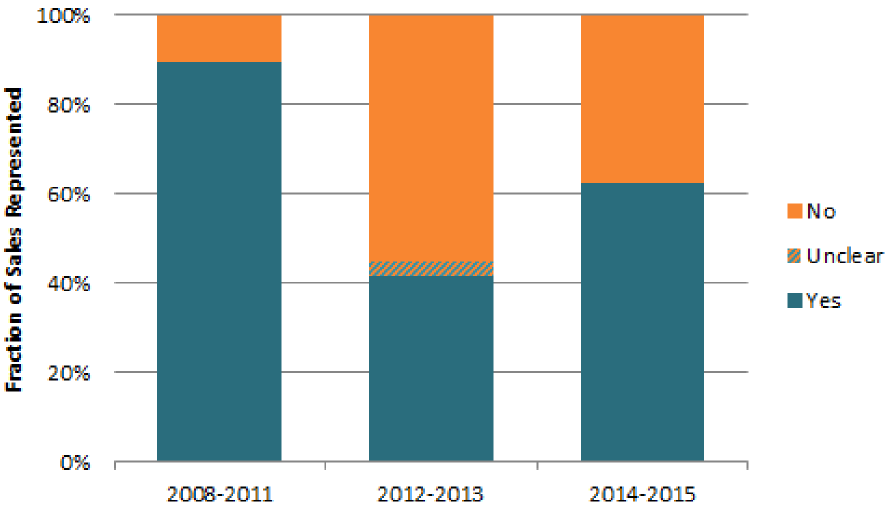
Retire / Retrofit Analysis

Did the IRP assess if existing units should receive continued investment or be retired?

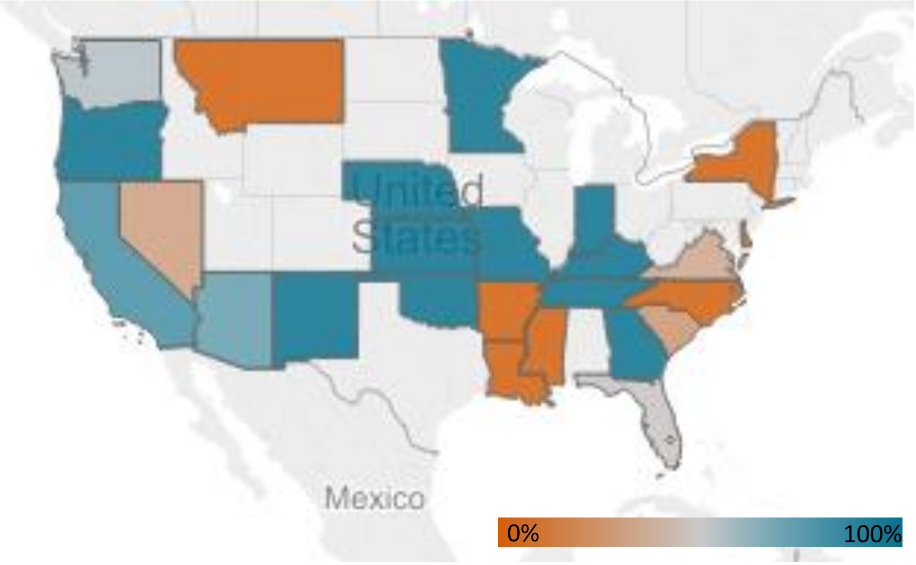


2008-2011

- Surprisingly high fraction likely driven by significant uncertainty and talk of "train wreck."
- Included nearly every surveyed utility with significant coal infrastructure.

2012-2013 & 2014-2015

- Some large utilities simply start structuring fixed "environmental compliance plans," with no explicit retrofit/retirement analysis.
- Rise from 2012-2015 may be artifact of IRP cycles.
- Quality of analyses generally poorer than 2008-2011 assessments.



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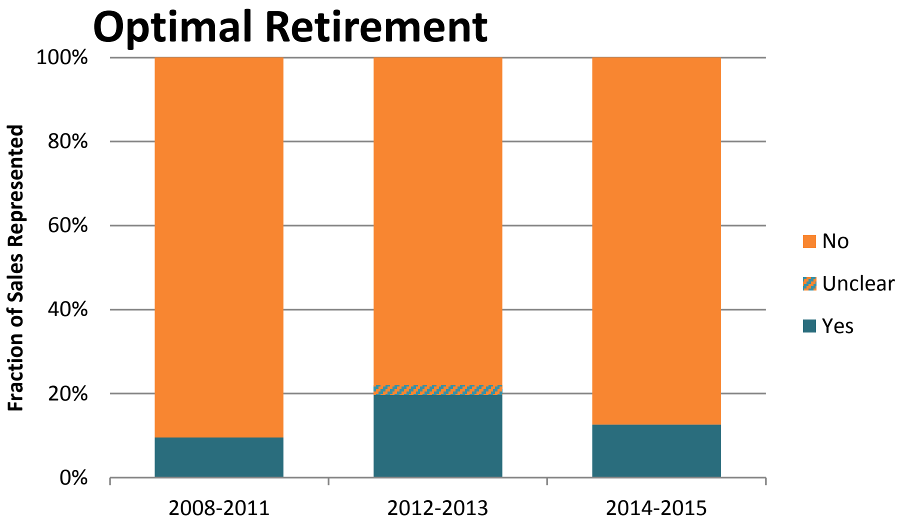
Optimal Retirement and Replacement

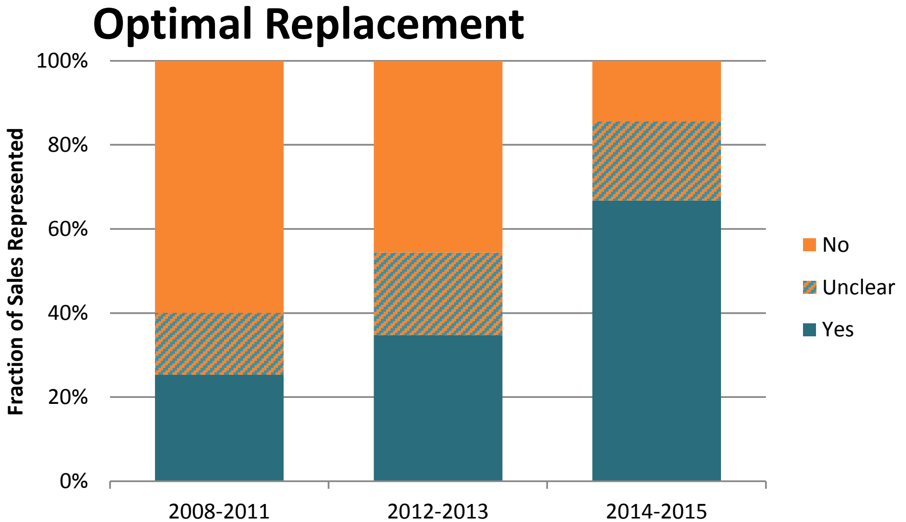
If a retire/retrofit analysis was conducted, did it allow units to be retired optimally?

Alternative is forcing specific units (or plants) for retirement at a specific date. This mechanism may obscure cost-effective retirement solutions.



If a retire/retrofit analysis was conducted, did it allow replacement energy and capacity to be chosen optimally?

Alternative is forcing a specific replacement option (i.e. 1:1 NGCC for coal unit retirements)



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Case Studies

Cases in which intervener / stakeholder engagement has changed the environmental compliance decision matrix used by a utility.

PacifiCorp Naughton 1 & 2 Disallowance

- March 2012: PacifiCorp filed Oregon rate case requesting a 3.5% rate increase, substantially driven by 2009 FGD investments at Naughton 1 & 2 ($300 million).
- Regional Haze rule not yet finalized in Wyoming, even as rate case was filed.
- Investment analysis in simple spreadsheet. Analysis was inconsistent with known risks for CO2, mercury, deeper regional haze requirements, or coal ash regulations.
- Proper analysis, even without risks, would have shown preferred retirement.
- December 2012: Oregon PUC ordered 10% disallowance ($17 million) on all retrofits for poor analysis.
- Wyoming PSC ordered CPCN process for all retrofits > $25 million. Improved analysis of Naughton 3 revealed that next investment was non-economic, and PacifiCorp moved to convert the unit instead.

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PNM San Juan Retire/Replace Analysis

Part 1:

- In 2011, EPA Federal Implementation Plan (FIP) for Regional Haze requires SCRs on all four San Juan units.
- Analysis indicates that SCRs are non-economic (i.e. retirement preferred).
- Through 2012, PNM convenes stakeholder process to determine next steps for San Juan. Environmental groups recommend SNCR on 1 & 4, and retiring 2 & 3. PNM agrees.

Part 2:

- December 2013, PNM files rate case w/ retirement of 2 & 3 and acquisition of 1 & 4. After intense analyses, all but one environmental group settle.
- Remaining group finds flawed model: all four units should be retired.
- Other groups drop out of stipulation, co-owner drops additional share. ALJ recommends against Stipulation. Fate of plant now up in the air.

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IP&L Harding Street 7

- August 2012, Indianapolis Power & Light files "environmental compliance" CPCN ($500 million), including FGD at Harding Street 7.
  - No modeling. Spreadsheet only, non-optimal analysis.
- Environmental interveners demonstrate that analysis has numerous errors, and is not a reasonable assessment.
- IP&L conducts 11th hour modeling for rebuttal. Assessment demonstrates marginal benefit for HS7, no CO_2 risk.
- Final IURC order in August 2013 approves retrofits, but dings Company $10 million for last minute analysis and flaws, and states that IP&L is on the hook for stranded investments if CO_2 regulations render HS7 non-economic.
- August 2014: IP&L announces that HS7 will convert to gas and not install FGD.

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Best Practices

Best Practices

1. **Describe** current, proposed and pending environmental regulations
2. Detail potential **range of impacts** on individual generating units
3. Identify **costs and/or restrictions** imposed by regulation
   - Support with engineering studies, when possible; proxy costs if not
   - Includes capital costs, operating costs, capacity reductions, generating limits
4. **Estimate probability** of specific regulatory outcomes
5. Create **Reference Case** as most likely set of outcomes
6. Run **capacity expansion model** with Reference Case and range of risks.

Okay
- Reference/strict/lenient environmental compliance
- Optimal retire decisions

Better
- Reference/strict/lenient environmental compliance
- Optimal retire decisions
- Stress test individual units against replace options

Best
- Explicit value option decision tree
- Optimal retire decision, replace portfolio

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Best Practices

1. Understanding the impacts of environmental compliance risk on today's decisions does not imply acting on proposed or pending regulations.
   - Deferring action until final requirements are in place is always preferable to piecemeal, premature action.
2. Capital costs should always be re-evaluated prior to commitment, even without an IRP.
   - Changing circumstances demand review even during construction.
3. Retirement decisions are forward looking and should not take into account sunk costs.
   - Exclude remaining plant balance – and blood, sweat and tears.
   - Include opportunities to avoid fixed capital and O&M in final years of operation.
4. State and utility political (or legal) preferences should not be substituted for prudent, risk-aware analysis.

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Questions?

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JIF Exhibit 6

Response to Staff 14-2

STF-14-2

Question:

Regarding the Asset Valuation analysis for the Mitchell unit, and concerning the following two files, OUTPUT_Mitchell.xlsx and TS Attach E - Detailed Asset Valuation B2016 Mitchell 3.xlsm.

a) Explain the process (explain step-by-step) used to develop the Output file.

b) In the Detailed asset Valuation spreadsheet, explain the process (explain step-by-step) to develop the Unit Inputs Tab and explain each row.

c) In the Detailed asset Valuation spreadsheet, explain the process (explain step-by-step) to develop the Cost Inputs Tab. Provide all workpapers, electronically that were used to develop each row. Also, explain the formula calculating Fuel pasted in cell I10, and the formula calculating Transmission Replacement Cost pasted in cell J11.

d) In the Detailed asset Valuation spreadsheet (Tab = Asset Valuation Calc), explain what is included in row 13, System Avoided Energy Cost for the CC comparison unit. It appears that it is based on data from the GenValData tab, which uses the rows labeled Margin. It seems that the Margin value for the Generic CC was calculated using fuel cost as a component. Please explain why row 20, Fuel is also incorporated into the net benefit calculation, as it appears to be double counting Fuel, or is Fuel another variable? Please explain.

e) Please confirm that in the Output files, VOM is included in the Cost variable, and that Cost is subtracted from Mkt Rev to calculate Margin.

f) In the Detailed asset Valuation spreadsheet, explain what is included in row 26, System Avoided Energy Cost for the Mitchell 3 unit. It appears that it is based on data from the GenValData tab, which sums the rows labeled Margin and VOM. Why isn't the analysis inconsistent in that VOM is included in the Mitchell 3 System Avoided Energy Cost row, but VOM is not included in the same row for the comparison CC unit (row 13)?

g) Please provide the analysis and workpapers, electronically with all formulas intact, that led to the development of the Mkt Rev, Cost, and Margin rows found in the Output files. Please provide this electronically with all formulas intact for each of the 9 fuel/CO2 cases, and provide the analysis separately for the comparison unit as well as the evaluation unit. For this question, please provide this same information for the McIntosh, Hammond, and Bowen analyses.

h) See the GenValData tab in the file TS Attach E - Detailed Asset Valuation B2016 Mitchell 3.xlsm, why don't all years that have Margin values also have VOM values, or vice-a-versa. For example, see 2029 and 2034 for the Mitchell MG10 case.

Response:

The requested information was previously provided to Commission Staff.

JIF Exhibit 7

Response to Staff 1-1

STF-1-1

Question:

Please provide the input databases/files and output reports/files (electronically for purposes of loading into any model, particularly Strategist) that were used for all modeling conducted in support of any aspect of the IRP, with an index indicating the scenario addressed in each input and output file. Also, supply the supporting documents/workpapers that were used to compute the inputs associated with the databases. These workpapers should be supplied electronically with all formulas attached and no pasted in data assumptions should exist.

Response:

The requested information was provided to Commission Staff on January 29, 2016, in accordance with the Commission's final order in the 2013 IRP in Docket No. 36498.

Contact: Alison Chiock