Let's Get Serious About CCS

By Ryan Fitzpatrick and Melissa Carey | Published: 08/05/15

TAKEAWAYS

Washington has failed to give carbon capture and storage (CCS) the attention it deserves, especially since this technology has the capacity to resolve some of the nation's greatest environmental and economic challenges. Commercial development of CCS offers a chance to:

1. Decarbonize fossil fuels that will remain in global use for decades.
2. Ensure a reliable electric grid in the face of tightening environmental standards.
3. Lead fossil-reliant communities to a thriving future amidst rapidly changing energy markets.

Instead of letting CCS technology languish and fall short of its potential, the federal government must do more to help the private sector develop and commercialize this potentially game-changing technology.

CCS: not broken, just neglected

What if there were a way to substantially cut carbon emissions worldwide by improving an existing technology that can be used on coal- and gas-fired power plants, as well as oil refineries, steel mills, and other major industrial facilities? What if this technology helped ensure the diverse, cleaner energy mix analysts argue the world needs to maintain economic growth and address climate change?

This technology actually exists. It's called CCS.

The perception in Washington, however, is that CCS has collapsed under its own weight of cost over-runs and project cancellations. But a yearlong study by Third Way has found that while CCS is desperately needed, its development has been undermined by a combination of market and policy failures. Targeted policy reforms and re-focused funding can build on current CCS project

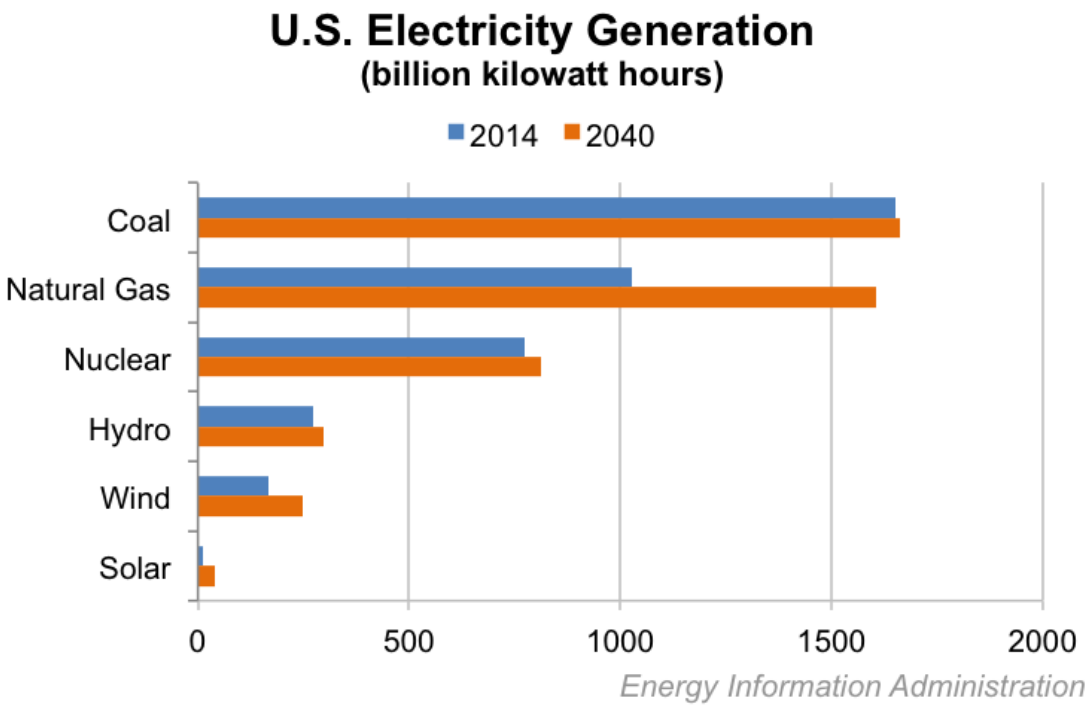
successes and help jumpstart private sector CCS development in the United States.[1] This would preserve a role for American innovation and American fossil fuels in a global market that is facing simultaneous pressure to grow and decarbonize.

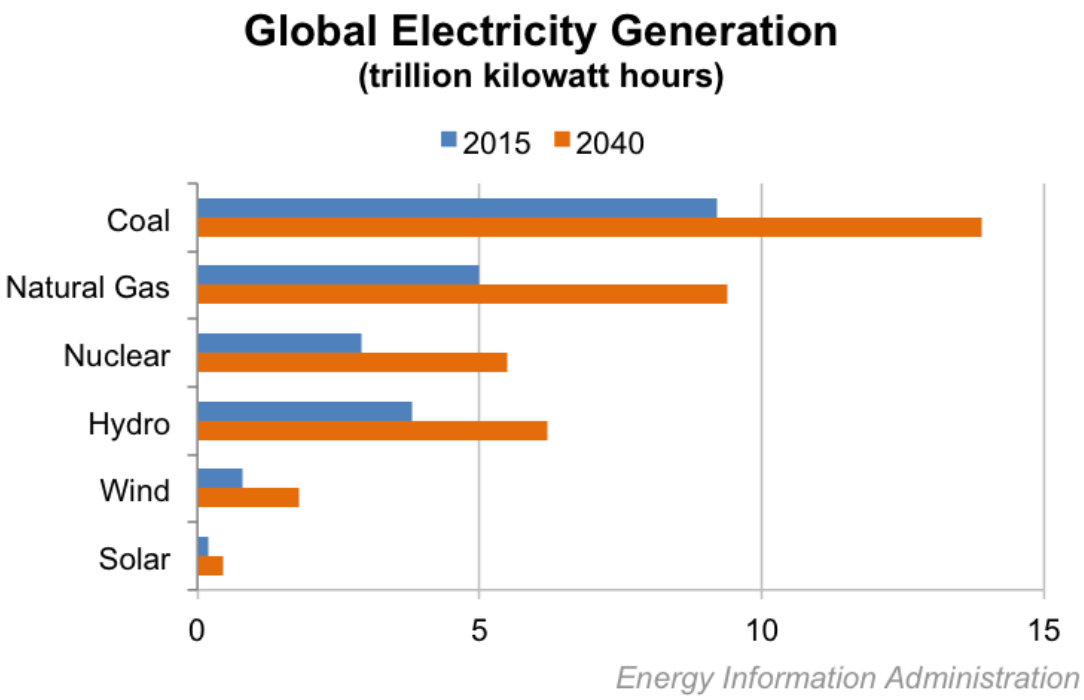
Another "Inconvenient Truth" about Climate Change

Virtually every day, it seems, we read another headline about the rapid rise of renewables at home and abroad: double-digit growth, enhanced projections about the role of solar and wind in our energy future, and advances in battery technology seem to indicate that the fossil fuel era is drawing to a close.

Stanford Professor Mark Jacobson,[2] wind advocate Steve Sawyer,[3] the Sierra Club and many more have described a world powered entirely by renewables in the next few decades. We'd love that to be true. We are vocal supporters of renewable energy and are thrilled to see record growth in the United States and globally over the past decade.

But the reality is much more complicated than headlines suggest. As the charts below make clear, fossil fuels are still keeping the lights on, both at home and abroad—and they are projected to continue to do so for a long time to come.





So here's the unfortunate truth that policymakers must address: we're very unlikely to see a renewables-only world in our lifetime. Dave Roberts, the columnist who coined the term "climate hawk" and is an outspoken climate advocate, describes mitigation plans that rely too heavily on renewables as little more than "thought exercises."[4] DotEarth columnist Andrew Revkin says that reports suggesting a 100% renewable future have a lot of "that darned fine print." Of a recent Intergovernmental Panel on Climate Change (IPCC) report, Revkin takes issue with language suggesting that existing renewable technology can largely resolve climate concerns, saying, "you'd have to dig deep and long in the background chapters to learn that 'many of these technologies exist today' hides huge gaps, particularly at the scale that would be needed to blunt emissions of greenhouse gases."[5]

These more realistic assessments echo the findings of some of the most respected authorities on climate and energy. Even after the Clean Power Plan is fully implemented in 2030, the U.S. Environmental Protection Agency (EPA) believes that coal and natural gas will still rule the grid, respectively accounting for 28% and 32% of America's electricity generation.[6] The U.S. Energy Information Administration (EIA) also expects coal and gas to continue providing over half of U.S. electricity, and projects an increasingly troubling reliance on fossil fuels worldwide. EIA forecasts suggest that by 2040, global energy demand will grow by 56%, and fossil fuels will supply 80% of that demand.[7] As Maria van der Hoeven, Executive Director of the International Energy Agency (IEA) concluded, "With coal and other fossil fuels remaining dominant in the fuel mix, there is no climate friendly scenario in the long run without CCS."[8] U.S. Energy Secretary Ernest Moniz has made similar statements and specifically highlighted the need for CCS on cleaner-burning natural gas, saying "Eventually, if we're going to get really low carbon emissions, natural gas, just like coal,

would need to have carbon capture to be part of that."[9]

Of course, energy projections can (and often do) turn out to be incorrect. Predicting the speed of innovation and deployment for technologies like wind and solar is tricky, and none of the aforementioned organizations is infallible.[10] If the EIA, EPA, and IEA are wrong and renewables displace the overwhelming majority of the world's coal and natural gas within the next few decades, we'll be well on our way to meeting our carbon reduction goals. Excellent news.

But, what if the EIA, EPA, and IEA projections are right?

By the time we find out, it'll be far too late to ask for a do-over. On this basis alone, it makes sense to ensure that CCS is ready to assist in cutting emissions from fossil fuel consumption around the world—because it's the only technology that can do the job

Cutting carbon…and costs

According to the International Panel on Climate Change (IPCC) and International Energy Agency (IEA), CCS offers the most effective means of drastically reducing emissions from fossil fuel-fired power plants—*and the only means* of making deep cuts in some of the world's most carbon-intensive industries such as cement and steel production.[11] Access to CCS technology will also be critical in keeping mitigation costs from skyrocketing. The IPCC has found that without CCS, reaching the aggressive mitigation goals suggested by the scientific community will be 138% more expensive than if CCS were used. To put this into perspective, having limited penetration of renewables on the grid would also increase mitigation costs, though by just 6%.[12]

Ensuring reliability while decarbonizing the grid

President Obama's Clean Power Plan has sparked a heated debate about the challenges of maintaining grid reliability while simultaneously cutting emissions from the power sector. Recent analysis suggests that utilities and grid operators have options for complying with the Clean Power Plan that won't affect their ability to provide dependable service to customers.[13] But even if this turns out to be accurate, what about future requirements to further decarbonize the grid? The Clean Power Plan is just one piece of President Obama's strategy to cut U.S. emissions roughly 27% below 2005 levels by 2025.[14] But the IPCC finds that, by 2050, developed countries like the U.S. will need to have made much more aggressive cuts (at least 80% below 1990 levels) in order to avoid the worst impacts of climate change.[15] Even after the Clean Power Plan is implemented, the power sector will still be one of the greatest contributors to U.S. emissions.[16] Because of this, it stands to reason that electricity production will be a top target for subsequent cuts. So what will happen if utilities and grid operators already have exhausted the low-hanging fruit of decarbonization options?

At issue is the fuel shift that utilities are anticipated to make—away from coal and toward lower-carbon power sources like renewables and natural gas—in order to meet emissions requirements. Utilities are largely unable to predict or control how much electricity will be generated by wind or solar installations at any given point, like they can with a coal plant. Retiring coal plants and replacing them with renewables therefore adds variability. Significantly expanding renewable use without degrading reliability creates significant technical and financial challenges for grid operators.[17]

There are also limitations to the amount of coal generation that can be shifted to natural gas without creating reliability concerns. In many cases, a utility can cheaply store enough coal onsite to fuel a power plant for weeks or even months, allowing it to adapt to unexpected surges in demand or emergency fuel supply interruptions like what occurred during the polar vortex of 2014.[18] Increasing reliance on natural gas, however, may require utilities and regional grid operators to invest heavily in transmission and storage infrastructure in order to maintain a similar level of reliability—a challenge that the nation's largest grid operator, PJM, is already anticipating in its Mid-Atlantic and Midwest service territory.[19]

If CCS technology were more readily available today for power plants, utilities and grid operators would have the option to keep coal in their portfolios while still meeting regulations on greenhouse gas emissions—no matter how aggressive they become in the future. That's because CCS can enable the power sector to produce reliable, long-term base load power with near zero emissions and enhance overall grid performance while renewables ramp up.

A path forward for fossil industries and the communities depending on them

Fighting climate change might not be a top priority for fossil fuels industries. But these companies are certainly paying close attention to climate policy efforts in the U.S., E.U., China, and elsewhere. These attempts to decarbonize could have a massive impact on the size of fossil fuel markets—and profits. As Wyoming State House Speaker Tom Lubnau (R) put it upon returning from a recent trip to China, "It doesn't matter what you think, if there's anthropogenic—fill in the blank: climate change, global warming **…** Our markets change, and if we want to continue utilizing coal we have to respond to the market."[20]

Access to CCS technology could enable these industries to compete in markets with increasingly stringent emissions requirements and reduce the risk of losses from "stranded assets." Given their relatively high CO2 emissions, coal-fired power plants are the first electricity sources impacted as emissions limits are ratcheted downward. Such is the case with the Clean Power Plan, which is expected to exacerbate challenges the coal industry already faces in competing with natural gas.

Some voices from America's coal country see CCS and related technologies as a way to stabilize the industry and the local economies that rely on it. Wyoming Governor Matt Mead, for instance, has worked with the state's conservative legislature to fund a facility that will test ways of utilizing captured CO2 and turning it into marketable products—helping to offset some of the costs of carbon capture. Though a climate skeptic himself, Governor Mead has explained that global markets for coal are beginning to change in response to climate concerns and that Wyoming, which relies on coal for 6% of its jobs and 14% of its GDP, must adapt to keep up.[21]

Coal isn't the only fossil fuel industry that will need access to CCS technology—especially if energy markets in certain parts of the world continue their trend toward decarbonization. Natural gas power plants and processing facilities will be likely targets of emissions reductions plans too. For example, California has found that in order to meet its 2050 emissions goals, electricity production from natural gas power plants will have to be significantly curtailed if they are not equipped with CCS.[22] Today, California's power plants consume 10% of the natural gas used for electric generation in the U.S., purchasing roughly $4.5 billion worth of gas each year.[23] Losing a large piece of the market in just this one state would have a sizeable impact on the natural gas industry. But the pain might not stop there. Since California's emissions reduction targets are in line with the cuts that scientists are recommending on a global scale, it is possible that natural gas plants in other states and countries seeking to achieve this same level of reduction will need CCS too.

California's decarbonization efforts could also create demand for CCS from petroleum refineries—the state's second largest stationary source of emissions, after power plants.[24] And there is always the chance that EPA will expand federal regulations on greenhouse gas emissions to include refineries, as it agreed to in the same legal settlement that precipitated the Clean Power Plan.[25]

In any of these cases, commercial availability of CCS technology could mean the difference between profit and loss for companies in several fossil industries—as well as the employees, investors, and communities that depend on them. As some forward-looking members of these industries have acknowledged, it's in their best interest to have CCS technology as accessible and affordable as possible for when they eventually need to use it.

Picking Up the Pace of CCS Development

Even with all of the reasons to move ahead on CCS, it is important to be clear about where things stand today: carbon capture and storage is a first-generation, nascent technology that hasn't received serious attention or investment in nearly a decade. Today's CCS systems—the few that exist at commercial scale—are large, complicated, heavily engineered, and at a learning-by-doing stage of development. CCS is technically feasible and in operation but it isn't elegant, and it certainly isn't cheap.

Most new and complex technologies require a certain degree of public investment, in partnership with the private sector, in order to get off the ground. CCS is no exception to this rule. And in light of the public benefits it can provide, this technology is certainly worthy of more public backing than it currently receives.

To be effective, federal investment in CCS must be sizeable and consistent, and it must address the distinct needs of CCS projects at all stages of development—from R&D to construction and through operation. To get CCS into the market at scale, three steps must be taken:

- Shift Research and Development into High Gear
- Support Construction of the Next Wave of Demonstration Plants
- Help CCS Plants Reach Long-Term Profitability

Shift Research and Development Into High Gear

Even after the Clean Power Plan is fully implemented, fossil fuels will still account for at least 60% of U.S. electricity generation.[26] Yet we are spending only 4% of our energy research budget on the technology most badly needed to address this massive source of emissions in the long-term.[27] The Department of Energy has done a commendable job of stretching its limited fossil energy technology budget to reduce the environmental impacts of using coal, natural gas, and other carbon-heavy fuels—including research and development for CCS. But these resources do not come close to meeting the needs of such a significant source of carbon emissions in the U.S. and global economies.

The federal government should support more research and development in reducing or eliminating emissions from the very fossil fuels that are expected to generate more than half of the electricity in the U.S. for at least the next several decades. Though basic technologies for capturing, transporting, and sequestering carbon dioxide were developed decades ago, expanding federal research and development would help to improve integrated CCS system performance and lower costs.

Steps to Take:

- Increase funding for CCS research and development within DOE's Fossil Energy program budget to at least $500 million annually for the next ten years.[28] This should be done without undermining the Department's other efforts to reduce energy-related emissions.
- Reorganize existing programs to allow greatly needed support for large-scale pilot projects in cooperation with the private sector. This would help DOE identify the most promising technologies before moving them forward to larger "demonstration" scale.
- Restore at least $2 million in annual funding for research on CO2 utilization applications that would reduce emissions and have market potential. Advances in utilization technology could

help to offset CCS operating costs and provide local economic development benefits.

Support Construction of the Next Wave of Demonstration Plants

Once the various pieces of a CCS system are proven in the lab and at the pilot-scale, the next step is to integrate them together in a large-scale demonstration plant. These "first of a kind" projects are a critical step in improving CCS technologies and driving down the cost of future plants. But in a competitive market, the expense of these initial projects is still too great for the private sector to take on alone. A brief surge of direct federal investment nearly a decade ago is responsible for the handful of large-scale CCS projects underway in the U.S. today.[29] Unless policymakers follow-up with additional rounds of this type of funding, future projects are unlikely and the momentum we have built toward CCS commercialization will be lost.

Steps to Take:

- Create a National Utility Reinvestment Fund, managed by private sector representatives, to issue grants for large-scale CCS demonstration projects. Funding could be supplied by a small fee, collected by utilities, on the electricity delivered to retail consumers that was generated from fossil fuel combustion.[30]
- Make CCS projects eligible for master limited partnerships (MLPs), a tax treatment that has driven $400 billion of investment to oil and gas infrastructure projects over the past 30 years.[31]
- Offer a refundable investment tax credit (ITC) for coal and natural gas plants that capture and store (or use) at least 75% of their total CO2 emissions.[32]

Help CCS Plants Reach Long-Term Profitability

Even if R&D and large-scale demonstration efforts succeed in drastically lowering the cost of building a CCS plant, most facilities will still need some form of public support in order to operate profitably. This isn't so much a flaw in CCS technology as much as a failure of the electricity market itself. Running a CCS system on a power plant requires a significant amount of energy and increases operating costs. But because U.S. policy does not make polluters pay for the CO2 they emit, utilities that take on the added cost of sequestering their CO2 put themselves at a competitive disadvantage to those who simply release their pollution into the atmosphere for free. To make up for this market flaw, a federal tax credit was created to reward CCS operators for each ton of CO2 that they sequester. The value of this credit, however, has not been adequate to offset the costs of CCS.

Steps to Take:

- Provide a higher value tax credit for carbon storage or utilization in order to incentivize additional private investment. Making the credit refundable is also key, as it could further encourage additional participation from project developers.

Conclusion

Like it or not, the odds are that the world will remain heavily reliant on fossil fuels for electricity and industrial processes for many decades to come. This is awful for the climate. That is why so many countries around the world are beginning to put policies in place to restrain carbon emissions. There is the slim possibility that such policies, and improvements in technology, might be enough to lead us to an almost entirely renewable energy-powered planet.

But what if that doesn't happen? Or what if your job, your company, or your state relies on fossil fuels for economic growth?

That is why we must invest in developing and commercially advancing carbon capture and storage, the only technology that can address fossil fuel and industrial emissions at large-scale. This is a technology that already exists but has been starved of critical funding that can improve performance, lower cost, and get it more broadly to market. If CCS is further developed and deployed more widely at commercial scale, it can clean up the fossil fuels that the world will continue to burn, help ensure a reliably functioning electric grid, and provide an economic lifeline for fossil fuel-dependent communities. At worst, this is an insurance policy that turns out not to be needed. But, we believe much more likely, it will turn out to be the critical technology that keeps the lights on, keeps our factories running, and keeps us on track to win the fight against climate change—but only if the right federal investments are made today.

Endnotes

1 CCS is now a reality in the power sector with the Boundary Dam CCS Project in operation in Canada and two more projects in the United States expected to come on line in 2016 (Kemper Country Energy Facility and NRG/Petra Nova CCS Project). According to the Global CCS Institute, there are currently 22 large-scale CCS projects in operation or construction around the world. See "Large Scale CCS Projects," Global CCS Institute, Accessed August 5, 2015. Available at: http://www.globalccsinstitute.com/projects/large-scale-ccs-projects.

2 Bjorn Carey, "Stanford engineers develop state-by-state plan to convert U.S. to 100% clean, renewable energy by 2050," Stanford News Service, June 8, 2015, Accessed July 7, 2015. Available at: http://news.stanford.edu/pr/2015/pr-50states-renewable-energy-060815.html.

3 Steve Sawyer, "A Renewable Energy Future," The Huffington Post, September 10, 2014, Accessed July 7, 2015. Available at: http://www.huffingtonpost.com/stevesawyer/a-renewable-energy-future_b_5725712.html.

4 David Roberts, "We Can Solve Climate Change, But It Won't Be Cheap or Easy," Grist, January 26, 2015, Accessed July 7, 2015. Available at: http://grist.org/climate-energy/we-can-solve-climate-change-but-it-wont-be-cheap-or-easy/. See also David Roberts, "Here's What it Would Take for The U.S. to Run on 100% Renewable Energy," Vox, June 9, 20215. Accessed August 4, 2015. Available at: http://www.vox.com/2015/6/9/8748081/us-100-percent-renewable-energy.

5 Andrew Revkin, "A Climate Hawk Separates Energy Thought Experiments from Road Maps," *The New York Times*, January 27, 2015, Accessed July 13, 2015. Available at: http://dotearth.blogs.nytimes.com/2015/01/27/a-climate-hawk-separates-energy-thought-experiments-from-road-maps/.

6 United States, Environmental Protection Agency, "FACT SHEET: Clean Power Plan Benefits," Accessed July 13, 2015. Available at: http://www2.epa.gov/carbon-pollution-standards/fact-sheet-clean-power-plan-benefits.

7 United States, Department of Energy, Energy Information Administration, "Analysis of the Impacts of the Clean Power Plan," May 2015, Accessed July 13, 2015. Available at: http://www.eia.gov/analysis/requests/powerplants/cleanplan/pdf/powerplant.pdf; See also United States, Department of Energy, Energy Information Administration, "EIA Projects World Energy Consumption Will Increase 56% by 2040," Today in Energy, July 25, 2013. Accessed July 7, 2015. Available at: http://www.eia.gov/todayinenergy/detail.cfm?id=12251.

8 "Technology Roadmap: Carbon Capture and Storage," International Energy Agency, 2013, Accessed July 8, 2015. Available at: http://www.iea.org/publications/freepublications/publication/TechnologyRoadmapCarbonCaptureandStorage.pdf.

9 Amy Harder, "Moniz: Natural Gas Will Need Carbon-Capture 'Eventually'," *National Journal*, August 1, 2013, Accessed August 5, 2015. Available at: http://www.nationaljournal.com/energy/moniz-natural-gas-will-need-carbon-capture-eventually-20130801.

10 Michael Grunwald, "Why are the Government's Energy Forecasts So Bad?" *Politico*, June 2015, Accessed July 13, 2015. Available at: http://www.politico.com/agenda/story/2015/06/why-are-the-federal-governments-energy-forecasts-so-bad-000111; See also Manuel Quiñones, "'Global Renaissance of Coal' Seen Undermining Mitigation," Greenwire (subscription) , July 8, 2015, Accessed July 13, 2015. Available at: http://www.eenews.net/greenwire/2015/07/08/stories/1060021452.

11 "Technology Roadmap: Carbon Capture and Storage," International Energy Agency, p. 8; See also "Global Action to Advance Carbon Capture and Storage," International Energy Agency, 2013, Accessed July 8 2015. Available at: https://www.iea.org/publications/freepublications/publication/CCS_Annex.pdf; See also IPCC, 2014: Summary for Policymakers. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, p. 16. Accessed July 8, 2015. Available at: http://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_summary-for-policymakers.pdf.

12 IPCC, 2014: Climate Change 2014: Mitigation of Climate Change. *Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von

Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, Accessed July 8, 2015. Available at: http://mitigation2014.org/report/publication/.

13 "Compliance with EPA's Clean Power Plan Unlikely to Materially Affect Electric Grid Reliability, According to Report by Brattle Economists," News and Knowledge, The Brattle Group, February 12, 2015, Accessed August 4, 2015. Available at: http://www.brattle.com/news-and-knowledge/news/790; See also "Clean Power Plan Study: Midwestern Electric Grid Is Well Positioned to Maintain Reliability and Lower Carbon Emissions to Meet EPA Regulations", News and Events, Analysis Group, June 8, 2015, Accessed August 4, 2015. Available at: http://www.analysisgroup.com/news-and-events/news/clean-power-plan-study--midwestern-electric-grid-is-well-positioned-to-maintain-reliability-and-lower-carbon-emissions-to-meet-epa-regulations/; See also Robert Walton, "Another Study, this Time from SPP, Boosts Case for Regional Clean Power Plan Compliance," Utility Dive, July 29, 2015, Accessed August 4, 2015. Available at: http://www.utilitydive.com/news/another-study-this-time-from-spp-boosts-case-for-regional-clean-power-pla/403050/; See also "PJM Interconnection Economic Analysis of the EPA Clean Power Plan Proposal," PJM, March 2, 2015, Accessed August 4, 2015. Available at: http://www.pjm.com/~/media/4CDA71CBEC864593BC11E7F81241E019.ashx; See also Peter Behr and Rod Kuckro, "Obama Rule Adds 'Safety Valve' for Grid Emergencies," EnergyWire (subscription), August 4, 2015, Accessed August 5, 2015. Available at: http://www.eenews.net/energywire/2015/08/04/stories/1060022947.

14 Brad Plumer, "The Clean Power Plan is a Big Deal. But it's Only One Piece of Obama's Climate Agenda," Vox, August 3, 2015, Access August 4, 2015. Available at: http://www.vox.com/2015/8/3/9090453/obama-climate-plan-full; See also United States, Executive Office of the President, Office of the Press Secretary, "Fact Sheet: U.S. Reports its 2025 Emissions Target to the UNFCCC," March 31, 2015, Accessed August 4, 2015. Available at: https://www.whitehouse.gov/the-press-office/2015/03/31/fact-sheet-us-reports-its-2025-emissions-target-unfccc.

15 IPCC 2007: Climate Change 2007: Mitigation of Climate Change. *Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, Accessed August 4, 2015. Available at: https://www.ipcc.ch/publications_and_data/ar4/wg3/en/ch13-ens13-3-3-3.html.

16 Based on Third Way analysis using historical and projected emissions in the U.S. Climate Action Report finding that, if the Clean Power Plan reduces emissions from the power sector by 30% below 2005 levels, in 2030 emissions from the power and transportation sector would remain the largest sources of US greenhouse gas emissions, taking into account no additional policy measures to reduce transportation sector emissions. United States, Department of State, "United States Climate Action Report 2014," Report, p. 139, January 1, 2014, Accessed August 4, 2015. Available at: http://www.state.gov/documents/organization/219038.pdf.

17 David Roberts, "Why Wind and Solar Power are Such a Challenge for Energy Grids," Vox, June 19, 2015, Accessed July 7, 2015. Available at: http://www.vox.com/2015/6/19/8808545/wind-solar-grid-integration.

18 Rod Kuckro, "Northeast Blizzard Evokes Polar Vortex -- and Region's Gas Pipeline Shortages," EnergyWire (subscription), January 27, 2015, Accessed July 13, 2015. Available at: http://www.eenews.net/energywire/stories/1060012323.

19 United States, Department of Energy, Office of Energy Policy and Systems Analysis, "Natural Gas Infrastructure Implications of Increased Demand from the Electric Power Sector," pp. 1 & 10, February 2015, Accessed July 8, 2015. Available at: http://energy.gov/sites/prod/files/2015/02/f19/DOE%20Report%20Natural%20Gas%20Infrastructure%20V_02-02.pdf; See also "Divided FERC Approves PJM's Capacity Performance Proposal," Gibson Dunn, June 15, 2015, Accessed July 8, 2015. Available at: http://www.gibsondunn.com/publications/pages/Divided-FERC-Approves-PJMs-Capacity-Performance-Proposal.aspx.

20 Dustin Bleizeffer, "Wyoming Lawmakers Talk Carbon Cooperation in China Summit," WyoFile, June 9, 2014, Accessed July 7, 2015. Available at: http://www.wyofile.com/blog/wyoming-lawmakers-talk-carbon-cooperation-china-summit-wyoming-coal-tour-in-china/.

21 Robert Godby, Roger Coupal, David Taylor, Tim Considine, "The Impact of the Coal Economy on Wyoming," Report, Center for Energy Economics and Public Policy, Department of Economics and Finance, University of Wyoming, February 2015, p. 4, Accessed July 8, 2015. Available at: http://www.uwyo.edu/cee/_files/docs/wia_coal_full-report.pdf; See also Benjamin Storrow, "Gov. Matt Mead Seeks to Recast Debate on Climate Change," *Casper Star Tribune,* May 15, 2014, Accessed July 8, 2015. Available at: http://trib.com/business/energy/gov-matt-mead-seeks-to-recast-debate-on-climate-change/article_e1bfa185-80dd-56a2-9506-7c85cdd94678.html.

22 Amber Mahone, et al. "California PATHWAYS: GHG Scenario Results," Presentation, Energy and Environmental

Economics, Inc. p.43, April 6, 2015, Accessed August 4, 2015. Available at: https://ethree.com/documents/E3_PATHWAYS_GHG_Scenarios_Updated_April2015.pdf.

23 United States, Department of Energy, Energy Information Administration, "Natural Gas Consumption by End Use" June 30, 2015, Accessed July 8, 2015. Available at: http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm; See also United States, Department of Energy, Energy Information Administration, "Natural Gas Consumption by End Use" June 30, 2015, Accessed July 8, 2015. Available at: http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_SCA_a.htm; See also United States, Department of Energy, Energy Information Administration, "Natural Gas Prices" June 30, 2015, Accessed July 8, 2015. Available at: http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_SCA_a.htm.

24 United States, Environmental Protection Agency, "2013 Greenhouse Gas Emissions from Large Facilities," Facility Level Information on GreenHouse gases Tool, August 18, 2014, Accessed July 13, 2015. Available at: http://ghgdata.epa.gov/ghgp/main.do.

25 Elizabeth McGowan, "EPA Puts Greenhouse Gas Rules for Oil Refineries on Backburner," Inside Climate News, March 8, 2012, Accessed July 13, 2015. Available at: http://insideclimatenews.org/news/20120308/epa-greenhouse-gas-emissions-rules-oil-refineries-power-plants-tailoring-rule-2012-elections-obama-climate-change.

26 United States, Environmental Protection Agency, "Regulatory Impact Analysis: Clean Power Plan Final Rule."

27 United States, Department of Energy, Office of Chief Financial Officer, "FY 2016 Congressional Budget Request" Vol. 3, pp. 1 & 566, February 2015, Accessed July 8, 2015. Available at: http://energy.gov/sites/prod/files/2015/02/f19/FY2016BudgetVolume3_7.pdf.

28 The budget for CCS research and development within DOE was $400 million in FY15. See United States, Department of Energy, Office of Chief Financial Officer, "FY 2016 Congressional Budget Request" Vol. 3, pp. 1 & 566, February 2015, Accessed July 8, 2015. Available at: http://energy.gov/sites/prod/files/2015/02/f19/FY2016BudgetVolume3_7.pdf.

29 "Fossil Forward: Revitalizing CCS. Bringing Scale and Speed to CCS Deployment," Report, National Coal Council, p. 31, January 2015, Accessed August 4, 2015. Available at: http://www.nationalcoalcouncil.org/newsletter/Bridging_the_CCS_Chasm.pdf.

30 Similar to proposals put forward in previous congresses. See: United States, Congress, House, "H.R.1689 - Carbon Capture and Storage Early Deployment Act," 111th Congress, 1st Session, March 24, 2009, Date accessed August 4, 2015. Available at: https://www.congress.gov/bill/111th-congress/house-bill/1689/text?q=%7B%22search%22%3A%5B%22carbon%22%5D%7D&resultIndex=1; See also United States, Congress, Senate, "S.3589 - Carbon Capture and Sequestration Deployment Act of 2010," 111th Congress, 2nd Session, July 14, 2010, Accessed August 4, 2015. Available at: https://www.congress.gov/bill/111th-congress/senate-bill/3589/text?q=%7B%22search%22%3A%5B%22carbon%22%5D%7D&resultIndex=4.

31 The Joint Committee on Taxation issued a 10-year score of $1.3 billion to S. 577, Sen. Coons' bill to extend MLP eligibility to a wide array of clean energy technologies. The CCS portion of the bill on its own scored at $3 million.

32 This is in line with a provision in the White House's FY2016 budget proposal. The refundable nature of this ITC would make it far more useful to project sponsors than the existing 48A tax credit for clean coal investment, which is not refundable. Several CCS projects have received 48A credits but do not have sufficient tax obligation to make use of them—nor have they been able to take advantage of tax equity markets.