Meeting Global Carbon Reduction Goals

A Technology Driven Climate Paradigm

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Executive Summary

Policymakers concerned about Climate Change have expressed frustration regarding continued growth in global anthropogenic greenhouse gas (GHG) emissions, despite calls for dramatic reductions. Equally clear is the world's continued reliance on fossil fuels. Both the U.S. and the world rely on "fossil" fuels for about 84% of their energy. In the U.S., 39% of electric power in 2013 was produced from coal, and another 28% was from natural gas. The federal executive branch has chosen to move forward with GHG regulations, with or without Congressional action.

President Obama, in his June 25, 2013 Remarks on Climate Change at Georgetown University, stated: *"…this challenge does not pause for partisan gridlock. – Forty-three years, ago Congress passed a law called the Clean Air Act of 1970 (CAA). – So today, --, I'm directing the Environmental Protection Agency to put an end to the limitless dumping of carbon pollution from our power plants, and complete new pollution standards for both new and existing power plants…."*

EPA has responded and developed a series of new rules under the CAA. But the cited provisions within the CAA date back to its 1970 amendments, and perhaps because during that era the main climate concern related to planetary cooling, not warming, the CAA is poorly suited to addressing GHG emissions from large stationary sources, like power plants, factories, refineries, etc. The administration's goal, which lacks legislative support, is to reduce U.S. GHG emissions in 2050 by 83%, compared to U.S. emissions in 2005.

In January 2014, EPA proposed CO2 limits for new fossil fueled electric power plants, and in June 2014, EPA proposed guidelines for states to follow in setting standards for CO2 emissions from existing fossil fueled power plants. Even though these rules are only at the proposal stage, states and others have already filed legal challenges. History suggests that there will likely be a period of at least 5 -10 years, while these CO2 standards for new and existing power plants are being finalized and litigated, during which the ultimate emissions requirements will remain uncertain. This period of protracted uncertainty will contribute to an absence of private sector interest and underinvestment in further advancing Carbon Capture and Storage (CCS) technologies.

The Five-to-Ten years of legal uncertainty and inhibition of investment in the development of technological solutions cannot wait if reasonable commercial CCS technology is to be available for deployment in the next decade.

Various reports by the IPCC have concluded that, given projections for continued and expanded Global use of fossil fuels, and given significant GHG emissions from industrial processes like cement manufacture, strategies to achieve large global reductions in GHG emissions are only practical with an effective and affordable CCS technology option. Most of the IPCC models were unable to project a set of mitigation measures to reach aggressive GHG goals without the use of CCS technology, and those that could incurred more than a doubling in the cost of mitigation without affordable CCS.

The Five-to-Ten years of legal uncertainty will surely inhibit investment in the development of technological solutions. Neither the American economy, those people genuinely concerned about climate change or the energy industry can risk waiting 5 to 10 years before developing needed technologies. In particular, America cannot wait if reasonable commercial CCS technology is to be available for deployment in the next decade.

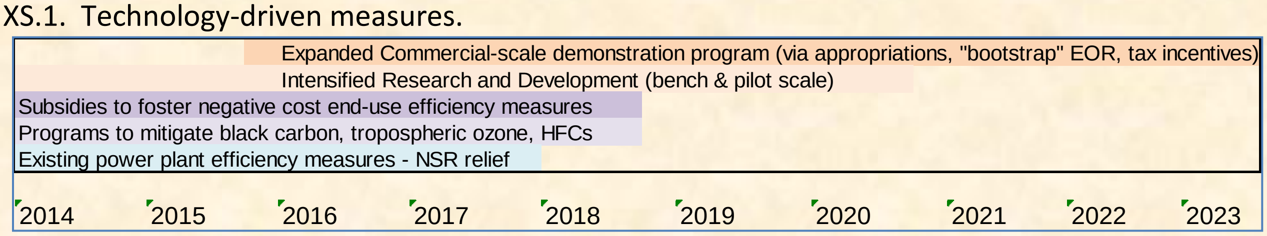
An alternative approach for the successful and economically viable meeting of climate change policy goals is needed. A technology Driven Climate Paradigm drawing on past analogous efforts to the current situation include NSPS revisions adopted in the late 1970's as well as the acid rain program implemented in the 1980's and 1990's. The relevant pollutants were sulfur dioxide (SO_2) and nitrogen oxides (NO_x) emitted from power plants. Key technologies for controlling these pollutants were just emerging from R&D efforts. The strategy that worked in those cases was to develop the needed technologies via a collaborative effort between the private sector and public sector, and after a number of commercial scale demonstration projects were successful, to adopt regulations leading to widespread technology deployment both domestically and internationally.

This paper offers a menu of alternatives to address the larger issue of climate change and the narrower issue of CCS technology development. These options, expanded in the Introduction and further detailed in the overall paper, include the following:

- Near-term measures for inexpensive reduction of GHGs. These include reduction of non-CO2 GHGs like black carbon and tropospheric ozone to reduce global warming in 2050 by half, while reducing global premature mortality from indoor air pollution by millions of lives per year; cost-saving end use efficiency measures; and cost-saving power plant efficiency measures.[144]
- Substantial increases in federal funds for RD&D for CCS technology.
- Creative approaches to raising funds needed accelerate and expand CCS technology RD&D.

A general depiction of how these programs might be applied over time is provided in Figure XS.1.

Figure XS.1. Technology-driven measures.



Conclusions

It is broadly believed that large reductions in anthropogenic GHG emissions are needed to achieve posited GHG concentration goals and cannot be achieved without viable CCS technologies. Current CCS technologies are not commercially up to the challenge. EPA has pursued a regulatory path to force the use of current technology, or sharply reduce coal use in the U.S. There is a reasonable likelihood that this strategy will be rejected by the courts as inconsistent with legal authority under the CAA. In any case, equipment vendors and others have concluded that these rules will discourage, not encourage CCS technology development. So regardless of the U.S. outcome, without U.S. leadership in CCS technology development the global outcome of this regulatory approach is inconsistent with achieving climate goals.

There are potentially attractive alternatives to the EPA regulatory approach. These include near-term emission reduction opportunities on non-CO2 GHGs that could provide almost immediate reductions in temperature increases – something that CO2 cuts cannot accomplish – and "negative" cost options to increase power plant efficiency and to reduce electricity use. Other options are oriented around approaches to foster faster development of CCS technology, and include a range of approaches to develop the needed funds for the public sector's share of these CCS development costs.

1. Introduction and overview

Policymakers concerned about Climate Change have expressed frustration regarding continued growth in global anthropogenic greenhouse gas (GHG) emissions, despite calls for dramatic reductions. The Fifth Assessment Report, by the United Nations Intergovernmental Panel on Climate Change (IPCC), shows global emissions increasing from 27 billion tonnes in 1970, to 38 billion tonnes in 1990, to 49 billion tonnes in 2010. Leaders of rapidly expanding economies that are heavily reliant on coal have failed to embrace policies that they see as harmful to their energy needs and economic interests. Indeed, the U.S. Congress has refused to enact a broad climate mitigation program for the U.S., although one bill passed the House of Representatives in 2009.

The principal long term anthropogenic GHG is carbon dioxide (CO2), produced by combustion of carbon-based fuels including coal, oil, and natural gas. Both the U.S. and the world rely on these three "fossil" fuels for about 84% of their energy. In the U.S., 39% of electric power in 2013 was produced from coal, and another 28% was from natural gas.

Fossil fuel emissions associated with electric power generation can be reduced either by not burning these fuels (e.g., improved power generation efficiency, switching to non-fossil generation, reducing electricity use), or by capturing, storing or utilizing the CO2 otherwise emitted. Modest reductions in emissions can be achieved by increasing generation efficiency, and the nation generates 33% of its power in 2013 from non-fossil sources (nuclear, hydro, renewable energy); but a major reduction in GHG emissions from large facilities like power plants would require the application of carbon capture and storage (CCS).

Various reports by the IPCC have concluded that, given projections for continued use of fossil fuels, and given significant GHG emissions from industrial processes like cement manufacture, strategies to achieve large global reductions in GHG emissions are only practical with an effective and affordable CCS technology option. The IPCC reports that most of their models were unable to project a set of mitigation measures to reach aggressive GHG goals without the use of CCS technology, and those that could incurred more than a doubling in the cost of mitigation compared to a scenario that included affordable CCS. Leading advocates for climate change mitigation have stated the issue clearly beginning with Prime Minister Tony Blair's statement in 2008 that CCS "is literally of the essence" in combating climate change, and most recently with IEA Executive Director Maria van der Hoeven's statement in 2014 that "there simply is no climate-friendly scenario in the long run without CCS."

However, there is broad recognition that current CCS technology is not ready for commercial application on power plants. That is the reason that the Department of Energy (DOE) spends hundreds of millions of dollars annually on CCS research and development (R&D). No power plant in the world employs a commercial scale CCS system, although two, government supported, demonstration projects are nearing their completion of construction. Various reports for and by the U.S. government have identified the major barriers to commercialization of this technology. A DOE technology roadmap projects cost reductions of 40% by about 2040. These are heroic efforts, given the resources made available to researchers. But the scope of the effort is terribly out of sync with the scope of the challenge and the magnitude of the consequences of failure to provide more timely solutions.

EPA's regulatory approach

The Administration's goal is to reduce GHG emissions in 2050 by 83%, compared to U.S. emissions in 2005. The Clean Air Act (CAA) is EPA's primary statutory authority for addressing climate change. Because most of the provisions in the CAA date back to its 1970 amendments, and perhaps because during that era the main climate concern was related to planetary cooling, not warming, the CAA is poorly suited to addressing GHG emissions from stationary sources, like factories and power plants. The Act has been applied successfully to certain elements of the GHG mosaic, such as certain chlorofluorocarbons (CFCs) that impact stratospheric ozone, and mobile source emissions of CO2; but EPA has only recently attempted to address stationary source emissions.

Following the Supreme Court's *Massachusetts v. EPA* decision in 2007, which determined that CO2 could be considered to fit within the CAA definition of "air pollutant," EPA embarked on a series of rulemakings that were necessary before the Agency could begin to address GHG emissions from stationary sources. These rules acquired arcane nicknames that described their general function (e.g., the Endangerment Finding, the Triggering Rule, theTailoring Rule). By 2011, EPA had established the legal groundwork it considered necessary to enable it to issue guidance that directed permitting authorities (primarily state environmental officials) to include in the construction permits for large <u>new</u> stationary sources, like power plants, a requirement to use the "best available control technology" (BACT) for reducing GHGs. BACT was evaluated on a case-by-case basis, using criteria based on the statutory authority and derivative EPA guidance. To date, CCS technology has not been considered to meet those criteria and BACT has tended to reflect application of highly efficient energy conversion technology.[1]

In 2012 EPA proposed a New Source Performance Standard (NSPS) to limit CO2 emissions from new fossil fueled power plants. The agency proposed a single standard to apply to both coal and natural gas power plants, and basically said that the appropriate technology for a new fossil fueled power plant was an efficient natural gas combined cycle (NGCC) system. In 2012, EPA was unwilling to assert that CCS was an adequately demonstrated technology that met the CAA's criteria for setting an NSPS. However, in September 2013,[2] EPA withdrew the 2012 proposal and issued a new one in which the agency asserted that "partial" CCS was adequately demonstrated and met the statutory criteria for an NSPS for new coal fueled generating units, but not for new gas fueled generating units. Industry stakeholders promptly filed comments on the rule challenging most of EPA's technical findings regarding CCS technology, and assuring a period of uncertainty if the rule is promulgated as proposed, while litigation moves through the court system. A final rule is not expected before 2015, and the last major rule in this area, the "Tailoring Rule" required four years after issuance of the final rule to reach the ultimate

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[1] Note that CCS is being installed and will be used on a commercial scale, federally supported, demonstration project now under construction.

[2] The language posted by EPA on its website in September did not become an official proposed rule until published in the <u>Federal Register</u> on January 8, 2014.

decision by the Supreme Court. Hence, it could be 2019 before these matters are settled, if the courts agree with EPA's approach, longer if they do not.

In June 2014, EPA proposed guidelines for states to follow in setting standards for CO2 emissions from existing fossil fueled power plants. These guidelines were issued under a little-used provision of the CAA – Section 111(d). The proposed rule departed from prior agency rulemaking approaches under Section 111(d), suggesting that this rule will also be litigated. In contrast to the proposal for new power plants, EPA concluded in the proposal for existing power plants that CCS was not an appropriate technology on which to base the emission limit. Instead, the limit was based primarily on measures that would reduce the use of coal fueled power plants.

In short, there will likely be a period of at least 5 years,[3] while these CO2 standards for new and existing power plants are being finalized and litigated, during which the ultimate emission requirements will remain uncertain. Major equipment vendors have stated that this type of protracted uncertainty and the regulatory price advantage created by the regulations for natural gas fueled power plants will lead to an absence of private sector interest in further advancing CCS technology.

An alternative approach

It seems reasonable to consider what other approaches might be successful in meeting climate policy goals. Past efforts analogous to the current situation include NSPS revisions adopted in the late 1970's and the acid rain program implemented in the 1980's and 1990's. The relevant pollutants were sulfur dioxide (SO2) and nitrogen oxides (NOx) emitted from power plants. Key technologies for controlling these pollutants (flue gas desulfurization systems and selective catalytic reduction systems) were just emerging from R&D efforts. The strategy chosen was to develop the needed technologies via a collaborative effort between the private sector and public sector, and after a number of commercial scale projects were successful, adopt regulations leading to widespread technology deployment.

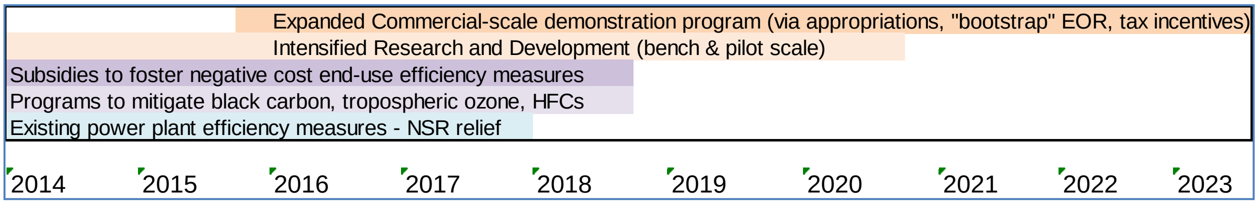
This paper offers a menu of alternatives to address the larger issue of climate change and the narrower issue of CCS technology development. These options include the following:

- Near-term measures for inexpensive reduction of GHGs. These include reduction of non-CO2 GHGs like black carbon and tropospheric ozone to reduce global warming in 2050 by half, while reducing global premature mortality from indoor air pollution by millions of lives per year; cost-saving end use efficiency measures; and cost-saving power plant efficiency measures.
- Substantial increases in federal funds for RD&D for CCS technology.
- Creative approaches to raising funds needed accelerate and expand CCS technology RD&D.

A general depiction of how these programs might be applied over time is provided in Figure 1.1.

[3] This could easily stretch to 10 years if the outcome of litigation is vacatur of the regulations and EPA must begin anew.

Figure 1.1. Technology-driven measures.



Near-term climate change mitigation

CO2 is a long-life GHG; emissions can remain in the atmosphere more than 100 years. As a result, reducing future emissions of CO2 will require decades to have a significant impact on atmospheric concentrations and secondary global warming impacts. Other GHGs have much shorter atmospheric lifetimes with greater near term warming impact. The opportunity for a near-term reduction in global temperature increases centers around reduction of these non-CO2 GHGs. Unlike CO2 emission reductions, which are unlikely to have a meaningful impact on atmospheric temperatures before 2100,[4,5] reductions in BC and TO could reduce temperature increases predicted for 2050 by 0.5 ^{o}C, or about one half. Warming in the Arctic over the next 30 years would be reduced by about two-thirds, thereby reducing risks of changing weather patterns. Moreover, controlling these emissions is supportable on other merits: eliminating 2.4 million premature deaths per year (primarily from indoor air pollution); and reducing global crop losses (corn, rice, soybean, wheat) by 50 million tonnes per year (about 2%).[6] Reports on black carbon have been published by the United Nations Environment Programme (UNEP),[7] EPA,[8] and others.[9] An assessment of methane reduction strategies, which would impact tropospheric ozone, has been published by German researchers.[10] A climate strategy including BC and TO mitigation would effectively reduce warming while additional research is conducted to produce cheaper technologies to address longer term mitigation of CO2. Hence, the effort would provide a near-term climate benefit, while allowing technology cost reductions that would make longer-term climate goals economically practicable.

The EPA Regulatory Impact Analysis (RIA) published in support of the agency's Section 111(d) proposed rule suggests that, by 2030, aggressive measures to reduce electricity demand (i.e.,

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[4] The IEA has concluded that the climate commitments proposed at the 2009 Copenhagen Climate Conference, if they were implemented, would lead to a long term (year 2300) global temperature increase of 3.5 ^{o}C, far more than the announced policy goal of 2 ^{o}C. World Energy Outlook 2010, International Energy Agency, OECD, 2010, p.384.

[5] Temperature differences in 2050, based on a "Copenhagen" emission scenario versus a business as usual case, can be gleaned from comparing the IPCC's 650ppm scenario to its 1000ppm scenario. The difference is less than 0.1 ^{o}C. Climate Change 2001: The Scientific Basis, IPCC 3rd Assessment Report, Figure 26.

[6] Op.Cit., Integrated Assessment of Black Carbon and Tropospheric Ozone.

[7] Integrated Assessment of Black Carbon and Tropospheric Ozone, UNEP & WMO, June 2011.

[8] Report to Congress on Black Carbon, USEPA, March 2012.

[9] An Analysis of Black Carbon Mitigation as a Response to Climate Change, Baron, Montgomery, & Tuladhar, 2009.

[10] An Analysis of Methane Mitigation as a Response to Climate Change, Kemfert & Schill, 2009. The proposed mitigation strategy focuses on emissions from livestock, rice cultivation, solid waste management, coal mine methane control, and natural gas production & use.

end-use efficiency measures like low-energy lighting, more energy efficient appliances, and installation of building insulation) will be almost cost free. Based upon the RIA, it seems reasonable that many of the lower cost end-use efficiency measures could be deployed immediately if provided a modest financial incentive. Quantification of an appropriate deployment target and funding level is beyond the scope of this paper.

A recent report to the Secretary of Energy by the National Coal Council[11] provided documentation that deployment of available measures to improve the efficiency of existing coal-fired power plants has been and continues to be deterred by EPA regulations. These regulations characterize such efficiency improvements as "major modifications" that, if implemented, would invoke costly procedural and control technology requirements. Hence, it appears that a portion of the heat rate (or efficiency) improvement proposed to be implemented under EPA's Section 111(d) regulations could be accomplished by simply eliminating the existing regulatory barrier.

Increasing funding for CCS

An effective CCS development program must promote lower cost technologies for a range of different types of power plants and industrial processes, and for a range of different CO2 storage or reuse applications. The DOE/NETL strategy for coping with such an impressive array of possible technological solutions is to conduct broad initial evaluations at bench and small-pilot scale, where research costs are relatively small, and take only the most promising solutions to evaluation at a large-pilot scale or commercial demonstration scale, where costs are much higher. However, the entire DOE FY14 budget for coal and CCS technology development was $392 million, and the Administration's proposal for FY15 was $302 million. Compare these amounts to the capital cost of the Kemper County IGCC/CCS demonstration project: over $5 billion. Or, compare the CCS budget to other energy programs. The Congressional Research Service reports that FY2013 appropriations for energy efficiency and renewable energy technology development totaled $3.9 billion,[12] and production tax incentives for wind energy alone were an equivalent amount.[13] These figures seem even more out of balance when one considers that in 2013 the U.S. consumed over 10 times as much fossil energy as renewable energy.[14]

Consider a hypothetical RD&D program consisting of research activity expanded slightly over FY14's $392 million to accelerate the pace of development – perhaps a total of $500 million per year. Add to that a demonstration program aimed at building 10 commercial scale power plants with CCS costing $5 billion each, over a 15 year period (a total of $50 billion over 15 years). Assuming a government share of 50-75% for the demonstration units (an increase over current funding policies that reflects the relatively high risk of accelerating CCS technology development) suggests a federal contribution of $1.7 to 2.5 billion per year. Total federal

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[11] Expedited CCS Development: Challenges & Opportunities, National Coal Council, March 18, 2011.

[12] Renewable Energy And Energy Efficiency Incentives: A Summary of Federal Programs (Appx A), Congressional Research Service, R40913, October 18, 2013.

[13] Reliable & Resilient – The Value of Our Existing Coal Fleet, National Coal Council, May 2014.

[14] Monthly Energy Review – July 2014, Tables 1.1 and 10.1, USDOE/EIA, July 2014. For 2013, EIA reports that fossil energy consumption was 82% of the U.S. total; non-hydro renewable energy was 7%.

budget: $2.2 – 3.0 billion per year, for more than a decade – a five or six-fold increase over FY14.

Once the scope and timing of the RD&D program are established, the most challenging aspect of a successful program is identifying sources of funds to conduct research and to build the relatively expensive commercial scale demonstration projects that fit that scope and timetable. Several generically different options for generating funds are discussed below.

Traditional appropriations

Appropriations for coal and CCS technology development have averaged less than $400 million per year over the past decade. A budget proposal such as that posited above (a five or six-fold increase) would likely be opposed by those who favor other energy forms such as renewable energy and demand-side efficiency measures, those who want to reduce federal spending in general or direct increases to other areas, and those who oppose demonstration projects because they view large demonstrations as a private sector responsibility. However, increased funding of CCS technologies might be supported because CCS is considered necessary to achieving global climate change goals, could preserve a portfolio of base load electric power options, and could provide a long-term payoff in the reduced cost of future electric power.

Targeted financial and tax incentives

Several approaches have been used to provide CCS projects, or coal-fueled power plants using CCS, with tax or financial incentives. These include:

- Internal Revenue Code (IRC) Section 48A investment tax credits. Tax credits of up to 30% of the qualified investment were provided for certain types of advanced coal-fueled power projects using CCS. The credits were limited by the total amount of credit authorized by Congress.[15]
- IRC Section 45Q production tax credits for captured CO2. A credit of $10/tonne CO2 or $20/tonne CO2 from qualified facilities and permanently stored via EOR or geologic storage was provided for a total of 75 million metric tonnes of CO2.[16]
- EPAct 2005 Section 1307 loan guarantees. Section 1703 of Title XVII of the Energy Policy Act of 2005 authorized USDOE to provide loan guarantees to certain eligible projects, including advanced coal projects, that avoid, reduce, or sequester anthropogenic GHG emissions. Loan guarantees are attractive to project developers with shallow pockets and higher-than-normal risk technologies.

Although inadequate by themselves to offset the increased cost of CCS, expansion of programs like these existing programs might be helpful in combination with other assistance programs.

EOR bootstrap

Several technical reports[17,18,19] and at least two bills introduced in Congress[20,21] have proposed a concept that would provide funds for CCS subsidies from the additional taxes generated by

[15] Internal Revenue Bulletin: 2009-16, April 20, 2009, Notice 2009-24.
[16] Internal Revenue Bulletin: 2009-44, November 2, 2009, Notice 2009-83.
[17] An Early Deployment Strategy for Carbon Capture, Utilization, and Storage (CCUS) Technologies, L.D. Carter, for United States Carbon Sequestration Council, June 2012.

deployment of CCS systems as part of enhanced oil recovery (EOR) expansion.[22] The basic proposition is that captured CO2 would enable increased domestic oil production via EOR. The EOR activity would generate federal revenues in the form of royalties on oil produced from federal lands, and from income taxes from the profitable sale of produced oil. Unlike almost any other approach to fostering new technology, various analyses have concluded that the overall operation would be "revenue positive" for the government – i.e., provide more tax income than tax outlays.

NCEP-type fee & directed trust fund

A 2004 report by the National Commission on Energy Policy (NCEP) concluded that aggressive goals for reducing emissions of GHGs could not be met with currently available technologies due to their high cost. NCEP recommended a climate policy that recycled fees from early climate regulation to conduct research on less costly mitigation technologies.[23]

Such a fee, aimed primarily at developing less costly mitigation technology, would be quite different from a "carbon tax" or "Cap &Trade" approach aimed at deterring use of fossil fuels. For example, EPA estimated that the marginal cost of H.R. 2454 (a "cap &trade" bill passed by the House of Representatives in 2009) began at $13/tonne CO2 in 2015, and rose to $70/tonne in 2050 (in 2005 dollars).[24]

In contrast, a $1 per tonne CO2 fee on crude oil, natural gas, and coal consumption in the U.S. would generate $6 billion per year in revenues. Half of this could be directed toward CCS RD&D (which would be applicable to coal and gas power plants, and large industrial facilities such as refineries and cement plants). The remainder could be divided between incentives for demand-side energy efficiency to reduce electricity demand, and mitigating non-CO2 GHG emissions that can materially reduce global temperatures by 2050 (see discussion of tropospheric ozone and black carbon in subsection 9.8).

The increased cost of energy due to a $1/tonne CO2 fee would be 0.4%, 1.4%, and 4.8% for crude oil, natural gas at distribution hubs, and coal at the mine. The relative price impact on delivered fuels would be less.

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[18] The Value of Enhanced Oil Recovery, L.D. Carter, Presentation to The CO2 Carbon Management Workshop, Houston, TX, December 2011.

[19] Carbon Dioxide Enhanced Oil Recovery: A Critical Domestic Energy, Economic, and Environmental Opportunity, National Enhanced Oil Recovery Initiative, February 2012.

[20] S. 2152 (Heitkamp), Section 203, introduced March 25, 2014.

[21] S. 2288 (Rockefeller), introduced May 5, 2014.

[22] Enhanced Oil Recovery is a technique that injects CO2 into partially depleted oil reservoirs to allow extraction of additional crude oil. The U.S. leads the world in use of this technology. Current EOR projects generally use "natural" CO2 produced from underground deposits, but these sources of CO2 are limited.

[23] Ending the Energy Stalemate, National Commission on Energy Policy, December 2004.

[24] EPA Analysis of the American Clean Energy and Security Act of 2009 – H.R. 2454 in the 111th Congress, USEPA, June 23, 2009.

Regulatory incentives

The NCEP principle was employed in climate change mitigation bills introduced in 2007-2009, in the context of "bonus allowances."[25] Under these allowance-based "cap & trade" bills, power plant owners reducing emissions via CCS technology would be provided more than one allowance for each tonne of CO2 captured and stored (hence the term "bonus") for up to 60 GW of such facilities. Rather than provide direct financial subsidies, the bonus allowance approach provided a regulatory allowance, which had monetary value. This type of regulatory incentive has never been used in a traditional pollution control regulation, but it might be possible to do so in a rule defined as broadly as EPA has interpreted its statutory authority under CAA Section 111(d), i.e., as part of a "system" of emission reduction.

Another regulatory incentive approach would be to enact legislation requiring a national "clean energy portfolio," similar to state renewable energy portfolios. To minimize cost, the design of the program (eligibility) could be tailored to ensure that it encouraged advanced technologies, rather than subsidizing additional deployment of already commercialized clean energy approaches. The goal of such a program would be technology advancement, rather than direct achievement of climate mitigation goals, but the technologies deployed would clearly contribute emission reductions.

Recent legislative proposals

Table 9.1 presents a selection of bills recently proposed in Congress that take various approaches to some of the concepts identified in this section. Several additional bills have been introduced aimed at limiting or revoking EPA's authority to regulate GHG emissions from the electric power sector.

2. The role of CCS in mitigation global climate change

2.1. What the experts say

The most recent reports by the Intergovernmental Panel on Climate Change (IPCC) conclude that a 2°C increase in global temperatures is needed to avoid substantial environmental damages from climate change,[26] and a 450 ppm CO2-eq "ceiling" on atmospheric concentrations will be necessary to constrain temperature increases to 2°C. That implies about a 50% reduction in GHG emissions by 2050, relative to 2005, and 90% by 2100.[27] Emission reductions in developed nations are likely to be greater than these global averages; the posited goal for the U.S. is an 83% reduction by 2050.[28] Given that the world currently relies on CO2-

[25] See, for example, H.R. 2454 (2009), passed by the House of Representatives, but not by the Senate.
[26] Working Group II, Summary for Policymakers, Fifth Assessment Report, p.13, IPCC, 2014.
[27] Working Group III, Summary for Policymakers, Fifth Assessment Report, p.11, IPCC, 2014.
[28] President Obama supports a goal to reduce U.S. GHGs by 83% in 2050, relative to emissions in 2005. U.S. Climate Action Report – 2010, Fifth national Communication of the USA Under the United Nations Framework Convention on Climate Change, June 2010.

emitting fossil fuels for about 84% of its energy,[29] it is difficult to conceive of an approach to reaching those reduction targets without a technology like CCS that controls CO2 emissions from the combustion of fossil fuels.

Tony Blair, former Prime Minister of the UK, recognized six years ago that the explosion of coal use in Asia would shape the future of climate change when he stated: "The vast majority of new power stations in China and India **will be** coal-fired; not 'may be coal-fired'; **will be**. So developing carbon capture and storage technology is not optional, it is literally of the essence."[30]

Maria van der Hoeven, Executive Director of the IEA, stated in 2013, "As long as fossil fuels and carbon-intensive industries play dominant roles in our economies, there simply is no climate-friendly scenario in the long run without CCS. But despite tangible technological progress, CCS has been developing far too slowly and urgent action is now needed." "The deployment of CCS absolutely needs to start happening beginning 2020. If it doesn't, and if as a consequence we don't have CCS available before 2030-2035, this will have serious financial consequences. If we want to decarbonise the power sector without CCS, it will cost an extra USD 1 trillion by 2035, and yet another USD 2 trillion by 2050."[31]

2.2. What the models say

In 2008, the International Energy Agency concluded that affordable CCS technology could reduce the marginal cost of meeting GCC targets in 2050 from $394 per ton to $200 per ton of CO2, a reduction of almost half. The IEA valued the contribution of this single technology at $1.3 trillion per year.[32]

Recent modeling reported by the Intergovernmental Panel on Climate Change (IPCC) in its Fifth Assessment Report (AR5) was even more pessimistic. The report found that most of the models used to project the cost of mitigating climate change to achieve a maximum 2 ^{0}C global temperature increase (or 450 ppm CO2-eq) could not achieve the targeted goal without inclusion of CCS in the solution portfolio. For those models that could reach the target, doing so without CCS increased the cost, on average, by 138%.[33]

The critical need for affordable CCS technology is due to the fact that the world relies on fossil energy for the major share of its commercial energy. According to the USDOE/EIA, that share was 84% from 2005-2010, and is projected to decline only slightly to 79% in 2035-2040.[34] The International Energy Agency projects a somewhat lower fraction of 75% in 2035.[35] Global coal use is projected by EIA to increase by 47% between 2010 and 2035.

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[29] International Energy Outlook – 2013, USDOE/EIA, July 2013.
[30] Statement by Tony Blair, as quoted in Business Green, June 27, 2008.
[31] Maria van der Hoeven, Executive Director, International Energy Agency, Presentation to Carbon Sequestration Leadership Forum, Washington, DC, November 7, 2013.
[32] Energy Technology Perspectives – 2008, OECD/International Energy Agency, 2008, p. 85.
[33] AR5 Workgroup 3 Summary for Policymakers, Table SPM.2, 2014, http://report.mitigation2014.org/spm/ipcc_wg3_ar5_summary-for-policymakers_approved.pdf .
[34] World total energy consumption, Reference Case, International Energy Outlook 2013, USDOE/EIA, July 2013.
[35] 2013 World Energy Outlook, International Energy Agency, November 2013.

Some have questioned the need for CCS, pointing to the fact that natural gas power plants (without CCS) emit about half the CO_2 as coal-fired power plants (without CCS) and could be substituted for coal-fired power plants. There are several problems with this solution including:

- In 2013, the U.S. consumed 18 quadrillion Btu's of coal, and 27 quadrillion Btu's of natural gas. There simply is not enough natural gas to replace so much coal.
- The 50% reduction in CO_2 is not enough to meet climate change mitigation goals.
- This solution fails badly in China and India, countries with plentiful coal but scarce natural gas resources, and these nations are driving GHG emission trends.
- Natural gas may have additional GHG liabilities associated with methane leakage, particularly during production.[36]
- The price of natural gas has historically been highly volatile and difficult to predict more than a year or two into the future. Heavy reliance on natural gas for electricity could have significant impacts on the price of electricity, and degrade U.S. competitiveness in international markets for manufactured goods.

CCS is sometimes thought of as an emissions technology limited to coal-fueled power plants, but this view is incorrect. CCS-equipped coal-fueled power plants are an important component of an overall climate change mitigation program, but CCS will also need to be applied to natural gas-fueled power plants if the U.S. is to meet announced GHG reduction goals.[37] Industrial applications of CCS are also important. For example, the International Energy Agency's projection of technologies needed to reach a 450 ppm CO_2 concentration ceiling drew 10% of the global reduction in emissions from CCS applied to power generation and 9% from CCS applied to industrial activity and fuel transformation.[38]

3. Challenges to CCS technology

The National Coal Council, an advisory committee to the U.S. Secretary of Energy established pursuant to the Federal Advisory Committee Act, has outlined challenges to CCS technology in recent reports to the DOE Secretary. For example, in a March 2011 report,[39] the NCC organized these challenges into the following categories: technical, financial, and regulatory. Technical challenges included the dearth of commercial-scale demonstrations of CCS technology; the need for more tools to analyze, design, and monitor CO_2 storage sites; and the high cost of CCS projects. Regulatory challenges include a lengthy permitting process and long-term financial liability provisions in EPA's underground injection control (UIC) regulations.

A more recent NCC report[40] reiterated many of these concerns in the context of retrofitting CCS to existing coal-fueled power plants. The report also noted that the average coal unit in the

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[36] See, for example, Natural Gas & Climate Change, E. Larson, Climate Central, May 2013.
[37] President Obama supports a goal to reduce U.S. GHGs by 83% in 2050, relative to emissions in 2005. U.S. Climate Action Report – 2010, Fifth national Communication of the USA Under the United Nations Framework Convention on Climate Change, June 2010.
[38] Op. cit., Energy Technology Perspectives, Figure ES-2.
[39] Expedited CCS Development: Challenges & Opportunities, National Coal Council, March 18, 2011.
[40] Reliable & Resilient – The Value of Our Existing Coal Fleet, National Coal Council, May 2014.

U.S. is 39 years old. Many of these plants are already too old to consider retrofitting a high capital cost technology, and the anticipated pace for marked cost reductions is not encouraging for the remainder.

Specific challenges to CCS will be discussed in the context of EPA's proposed NSPS rule, in Section 6.1 of this paper.

4. General background on GHG regulations under the CAA

4.1. EPA's actions establishing its authority to regulate CO2

A series of court decisions and EPA regulations prepared the legal foundation for EPA's regulation of GHGs from stationary sources under the CAA's new source review program. These are depicted as a time line in Figure 4.1, and include:

- The 2007 the Supreme Court decision that Title II of the Clean Air Act (CAA), which addresses mobile source emissions, provided legal authority for EPA to regulate greenhouse gas (GHG) emissions from new motor vehicles if the Agency judged that those emissions "contribute to climate change."[41]
- EPA's 2008 Advanced Notice of Proposed Rulemaking seeking input on whether mobile source GHG regulations triggered authority to regulate stationary sources and on how to deal with the applicability thresholds in the CAA, when regulating new facilities emitting GHGs.[42] Those thresholds were considered reasonable for traditional air pollutants like SO2 and NOx, but seemed impractically low for GHGs like CO2.[43]
- EPA's 2009 "Endangerment Finding," responding to the 2007 Supreme Court decision with EPA's conclusion that GHGs endanger human health and welfare via climate change – meeting the Court's precondition for regulating GHGs from motor vehicles.[44]
- EPA's promulgation of the "Triggering Rule," in 2010. This rule contained a finding that regulating GHGs for motor vehicles would set in motion a requirement for regulation of GHGs from new stationary sources, on the date that the motor vehicle rules took effect.[45]
- EPA's 2010 promulgation of the "Tailoring Rule, " which changed the thresholds for applicability of new source permitting requirements from 100 or 250 TPY, to 75,000 or 100,000 TPY for GHGs.[46]

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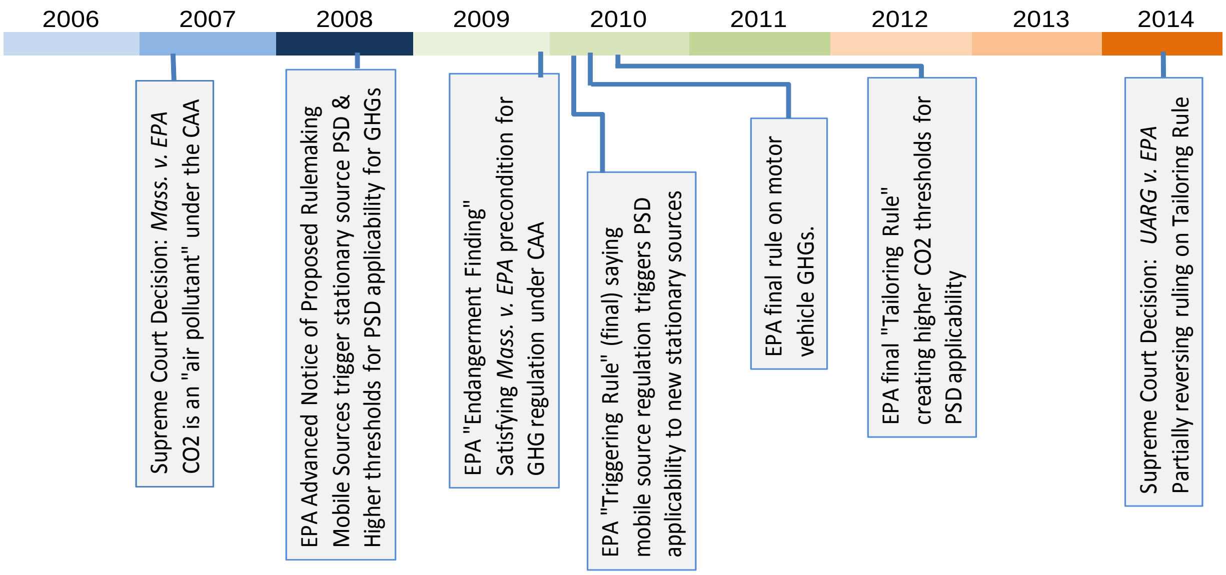
[41] *Massachusetts v. EPA*, 549U.S.497, 528, 2007.
[42] 73FR44420, 2008. Certain identified source categories had a threshold limit of 100 TPY; other unnamed categories had a higher threshold of 250 TPY.
[43] For example, a 500 MW coal-fueled power plant might have the potential to emit (after application of pollution controls) 500 to 2000 tons per year of particulate matter, sulfur dioxide, or nitrogen oxides, versus about 4 million tons per year of carbon dioxide.
[44] 74FR66523, 2009.
[45] 75FR17004, 2010.
[46] 75FR31514, 2010.

- The June 23, 2014 Supreme Court decision (*UARG v. EPA*), partially reversing a decision by an appellant court approving EPA's redefinition of new source permitting applicability thresholds.[47] The practical result for new power plants is that they must obtain permits for CO_2 emissions, and those permits must require use of the best available control technology.

Figure 4.1. Timeline for major GHG court decisions and rules.



4.2. EPA's settlement agreement on power plant regulation under CAA Section 111

On a separate track, eleven states, the District of Columbia, New York City, and several environmental groups had petitioned[48] the DC Circuit Court of Appeals, challenging EPA's omission of CO_2 emission limits in 2006 New Source Performance Standards (NSPS) for electric utilities and industrial boilers.[49] Following the *Massachusetts* decision, the DC Circuit remanded the 2006 NSPS rule to EPA. In December 2010, EPA and the litigants entered into a settlement agreement in which, among other things, EPA committed to issuing a notice of proposed rulemaking for standards of performance for new and modified power plants (under CAA Section 111(b)), and for guidelines for existing power plants (under CAA Section 111(d)) by July 26, 2011; and to promulgate final standards and guidelines by May 26, 2012.[50] These dates were changed in subsequent modifications to the Settlement Agreement. EPA ultimately

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[47] "EPA lacked authority to "tailor" the Act's unambiguous numerical thresholds of 100 or 250 tons per year ….", *Utility Air Regulatory Group v. EPA, et al.*, No. 12-1146, U.S. Supreme Court, June 23, 2014.

[48] *State of New York, et al. v. EPA*, Case No. 06-1322.

[49] 71FR0866, 2006.

[50] EPA Press Release, December 23, 2010, http://yosemite.epa.gov/opa/admpress.nsf/6424ac1caa800aab85257359003f5337/d2f038e9daed78de8525780200568bec!OpenDocument .

published a proposed rule for new sources in April 2012.[51] In that proposal, EPA determined that the "best system for emission reduction" (BSER -- the statutory criterion used by EPA in setting a performance standard) would be a natural gas fueled combined cycle (NGCC) generating unit achieving an emission rate of 1,000 pounds of CO2 per megawatt-hour (#CO2/MWh, gross generation). Note that this BSER and emission limit applied both to natural gas units and to coal units, so EPA was essentially saying that the best technology for coal was to not burn coal. EPA did not make a determination that CCS technology was adequately demonstrated, but it is likely that if EPA had judged the technology to meet the statutory criteria for use as a basis for BSER, then the agency would have made such an affirmative finding.

A year and a half later, in September 2013, EPA released a regulatory package proposing to withdraw the 2012 proposed rule, and to replace it with a different rule. This regulatory package was formally published in January 2014.[52] The new rule declared "partial CCS" to fit the statutory criteria for BSER for coal-fueled power plants, and proposed an emission limit of 1,100 #CO2/MWh (gross generation) for new coal-fueled power plants. A limit of 1,000 #CO2/MWh (gross) was proposed for large new NGCC systems, based on the use of an efficient power plant design, but without the need for CCS.

On June 18, 2014, EPA proposed regulations pursuant to authority in CAA Section 111(d), establishing a framework under which states would be required to reduce CO2 emissions from <u>existing</u> power plants.[53] The proposal included identification of state-wide emission rate targets (expressed in pounds CO2 emitted per megawatt-hour of power generation) for 2020-2029 and more restrictive targets for after 2029. Targets differed by state and were based on EPA's estimate of reductions achievable at reasonable cost using heat rate improvements at coal units, non-hydro renewable energy, end-use energy efficiency measures, and certain other approaches.

Section 111(d)(1) of the CAA states that,

> *(1) The Administrator shall prescribe regulations which shall establish a procedure similar to that provided by section 7410 of this title under which each State shall submit to the Administrator a plan which (A) establishes standards of performance* ***for any existing source for any air pollutant (i) for which air quality criteria have not been issued or which is not included on a list published under section 7408(a) of this title or emitted from a source category which is regulated under section 7412 of this title*** *but (ii) to which a standard of performance under this section would apply if such existing source were a new source….* [Emphasis added]

[51] 77FR22392, 2012.
[52] 79FR1430, 2014.
[53] 79FR34830, 2014.

Because EPA regulates hazardous emissions from power plants under Section 7412, some have argued that the exclusions in Section 111(d)(1) mean that EPA lacks legal authority to regulate existing power plants under Section 111(d). Normally, resolution of such an issue could require courts to wait until EPA took "final action" on the rule, but a dozen state attorneys general have petitioned the D.C. Circuit Court of Appeals to review the matter now, based on the "final action" of the Settlement Agreements leading up to the proposed rule.[54]

5. EPA's regulatory approaches for CO2 emissions from power plants

5.1. Regulatory background

GHG emissions from large stationary sources are being addressed under three separate provisions in the CAA:

- The first is Part C of Title I of the CAA (Prevention of Significant Deterioration of Air Quality) and particularly Section 165, which establishes the authority to require preconstruction permits from entities proposing to construct a major new source that would emit regulated air pollutants.
- The second is an <u>operating</u> permit program set forth in Title V of the CAA, and generally referenced as "Title V permits."
- The third is Section 111 of the CAA, which provides EPA with the authority to establish new source performance standards (NSPS) under Section 111(b) and to issue regulations establishing a framework under which state environmental agencies establish performance standards (under Section 111(d)) for existing sources in a category subject to an EPA-issued NSPS.

5.2. New source review regulations

Section 165 requires that major new sources must obtain a permit prior to commencement of construction. The permit must, among other things, ensure protection of ambient air quality standards, and ensure "the proposed facility is subject to the best available control technology [BACT] for each pollutant subject to regulation under this chapter emitted from, or which results from, such facility."[55] Section 169 defines BACT:

> *The term ''best available control technology'' means an emission limitation based on the **maximum degree of reduction** of each pollutant subject to regulation under this chapter emitted from or which results from any major emitting facility, which the permitting authority, on a case-by-case basis, taking into account energy,*

[54] *State of West Virginia, et al., v. USEPA*, Petition for Review, U.S. Court of Appeals for the District of Columbia Circuit, August 1, 2014.

[55] CAA Section 165(a). 42USC§§7475(a) Note that these rules are referenced both as "new source review" regulations and "prevention of significant deterioration" (PSD) regulations.

> *environmental, and economic impacts and other costs, determines is **achievable** for such facility through application of production processes and available methods, systems, and techniques, including fuel cleaning, clean fuels, or treatment or innovative fuel combustion techniques for control of each such pollutant. In no event shall application of ''best available control technology'' result in emissions of any pollutants which will exceed the emissions allowed by any applicable standard established pursuant to section 111 or 112 of this title.*
> [Emphasis added.]

Note the requirement that BACT be at least as stringent as a Section 111 (NSPS) standard for that source category.

Because there is no air quality standard for GHGs, the essential requirement for GHG permitting from power plants is application of BACT to the proposed new source. EPA issued guidance for new source review permitting for GHGs in November 2010, and reissued the guidance with minor changes in March 2011.[56] Guidance was appropriate because the new source review and permitting programs are generally implemented by state environmental agencies, consistent with EPA regulations.

5.3. Title V operating permits

The second area of the CAA that addresses GHG emissions is Title V (also cited as "Subchapter V"), which prescribes requirements for operating permits (in contrast to construction permits). An operating permit includes a recitation of all air pollution limits, monitoring requirements, and reporting requirements applicable to the particular emission source. GHG emission limits in Title V permits are currently limited to requirements established under new source review permits (via BACT limits), but will expand to include limits established under Section 111(b) and 111(d) when those rules are ultimately promulgated.

5.4. Section 111 performance standards

The third section of the CAA addressing GHG emissions from stationary sources is Section 111, which authorizes EPA to adopt "New Source Performance Standards" (NSPS). Provisions specific to new sources are in Section 111(b) and a separate process for establishing performance standards for existing sources is set forth in Section 111(d). The key provision for both Section 111(b) and Section 111(d) standards is:

> *The term ''standard of performance'' means a standard for emissions of air pollutants which reflects the **degree of emission limitation achievable** through the application of the **best system of emission reduction** which (taking into account the cost of achieving such reduction and any nonair quality health and environmental impact and energy requirements) the Administrator determines has been **adequately demonstrated**.*
> [Emphasis added.]

[56] PSD and Title V Permitting Guidance For GHGs, USEPA, March 2011.

There are clearly similarities between the BACT criteria under new source review and the criteria for setting a standard of performance under NSPS: both limitations are to reflect maximum achievable emission reductions, with consideration given to cost, environmental impacts, and energy requirements. Additionally, Section 111 performance standards must be based on technology that has been adequately demonstrated.

Section 111(d) directs EPA to establish a procedure under which a state submits to EPA "a plan which establishes standards of performance for any existing source for any air pollutant … to which a standard of performance would apply if such existing source were a new source…." This program is limited to pollutants and source categories not regulated under other EPA programs.[57] Standards adopted are to take into account, among other factors, the remaining useful life of the existing sources. In other words, once EPA has set standards for new sources in a particular category (like power plants) under Section 111(b), and assuming the applicability provisions of Section 111(d) are met, states are to adopt standards for existing sources in that category.

EPA has not promulgated any GHG limits under the authority provided in Section 111, but NSPS limits for CO2 emissions from new power plants were proposed in April 2012, and reproposed in January 2014. The standards eventually promulgated will apply to any fossil fueled power plant that commences construction after the date the rules were proposed, i.e., after January 8, 2014. Guidelines for the development of state-issued standards for CO2 emissions from existing fossil fueled power plants were proposed by EPA in June 2014.

It is important to recognize that the first two programs discussed above are: (1) case-by-case determinations of technology requirements based on statutory criteria in Section 165 of the CAA; and (2) are currently operational and have been applied to CO2 emissions from major sources that sought to commence construction after January 2, 2011. In contrast, CO2 regulations under the NSPS program: (1) apply a single emission limit to all new coal-fueled units nationwide (not varying by facility circumstances); and (2) have been proposed, but not promulgated. Past standards set by states under Section 111(d) have generally been uniform (a single emission rate for all units in a source category), but the statutory language does not mandate such uniformity.

Another interesting aspect of the new source review and NSPS limits applicable to CO2 is the statutory provision that a BACT determination may not be less stringent than an applicable NSPS, and the regulatory requirement that NSPS limits apply to units commencing construction after the proposal date of the rule eventually promulgated. EPA has reviewed and not opposed permits for a number of power plants granted permits to construct by state permitting authorities since 2010, and all of these permits considered and rejected the use of CCS technology for the particular units. However, EPA has made it clear in the proposed CO2 NSPS that its position on CCS has changed, and that EPA now considers CCS feasible and affordable for application at new coal-fueled power plants. Even though the NSPS rule is only a proposal,

[57] As noted in Section 4.2, twelve state attorneys general have already filed a challenge to the Section 111(d) process because EPA regulates power plants under one of the exclusionary regulatory sections.

it seems highly probable that it has had a chilling effect on any entity considering the construction of a new coal-fueled power plant that would not use CCS. There are several reasons supporting this conclusion. First, the state permitting authority may also believe that application of CCS technology is appropriate, and if so the proposed design (without CCS) would be rejected out of hand. Second, even if the state permitting authority determined that BACT did not require use of CCS, the unit would have to apply CCS should the NSPS be promulgated as proposed. Third, both the state permitting authority and the permit applicant could reasonably expect EPA to veto a permit not as stringent as the proposed NSPS. And fourth, the applicant would have difficulty obtaining external financing, given that lenders would not be willing to risk billions of dollars of capital on a facility that might not be allowed to operate and generate the revenues needed to repay the lender. The point is that the proposed CO2 NSPS regulation very likely has already had the effect of stopping the commencement of construction of any domestic coal-fueled power plant not designed to use CCS, even though it is not a final rule.

6. Overview of proposed NSPS rule

EPA published a notice of proposed rulemaking for GHG emissions from electric utility generating units in the January 8, 2014, Federal Register.[58] Affected units included new fossil fuel-fired electric utility generating units (EGUs) above certain sizes. All affected coal-fueled units were subject to a single limit: 1,100 #CO2/MWh (gross). Large NGCC units were subject to a limit of 1,000 #CO2/MWh, and smaller NGCC units were subject to a limit of 1,100 #CO2/MWh.

The coal limit was “based on partial implementation of carbon capture and storage (CCS) as the BSER.” The gas limits were “based on modern, efficient NGCC technology as the BSER.”[59] EPA’s assumptions and analysis led to its conclusion that “few, if any, solid fossil fuel-fired EGUs will be built in the foreseeable future; and … electricity generators are expected to choose new generation technologies (primarily NGCC) that would meet the proposed standards. Therefore, … EPA projects that this proposed rule will result in negligible CO2 emission changes, quantified benefits, and costs by 2022.”[60] Although the preamble to the proposed rule cited extensive concerns regarding the adverse impacts of global climate change, EPA did not explain in the preamble to the proposal why it was proposing a regulation which, in EPA’s judgment, would not reduce GHG emissions. Two possible reasons are discussed in Section 6.2, below, but it is unclear if either meshes well with EPA’s legal authority under Section 111(b).

6.1. Criticisms of the proposed rule

[58] Standards of Performance for GHG Emissions from new Stationary Sources: Electric Utility Generating Units; Proposed Rule, USEPA, 79FR1430, January 8, 2014.
[59] Ibid., p.1433.
[60] Ibid. Note also that the EPA Regulatory Impact Analysis projected that this lack of impacts and/or benefits extended to 2030 and beyond.

A sampling of public comments on the proposed rule indicates that most of industry's concerns focused on the CO_2 limit proposed for coal-fueled EGUs.[61] The following discussion provides an overview of those comments organized by three themes: the legal basis for the proposed rule, EPA's determination of BSER, and peripheral issues associated with CCS technology. This review of the proposed rule addresses major issues raised in the public comment process, particularly those associated with CCS, but does not attempt to include all issues or all perspectives on issues presented.

6.1.1. The legal basis for the rule

Three overarching legal arguments concerning the proposed rule appeared in multiple comment packages:

- An NSPS-specific "endangerment finding" is a necessary prerequisite to the rule (EPA relied upon its 2009 endangerment finding associated with the motor vehicle GHG regulation). Indeed, EPA appears to recognize some vulnerability on this issue because, in addition to stating that such a finding is unnecessary, it "coproposed" to make exactly that finding. Those raising this issue included the Utility Air Regulatory Group (UARG),[62] American Electric Power (AEP),[63] and Peabody Energy.[64]
- EPA's reliance on CCS demonstration projects receiving federal subsidies was in violation of the 2005 Energy Policy Act (EPAct05). Section 402(i) of EPAct05[65] states: "No technology, or level of emission reduction, solely by reason of the use of the technology, or the achievement of the emission reduction, by 1 or more facilities receiving assistance under this Act, shall be considered to be . . . adequately demonstrated for purposes of section 111 of the Clean Air Act." Similar language appears in Section 1307(b) of EPAct05, governing certain tax credits: "No use of technology (or level of emission reduction solely by reason of the use of the technology), and no achievement of any emission reduction by the demonstration of any technology or performance level, by or at one or more facilities with respect to which a credit is allowed under this section, shall be considered to indicate that the technology or performance level is . . . adequately demonstrated for purposes of section 111 of the Clean Air Act."[66] This issue was cited in a petition by the State of Nebraska seeking declaratory and injunctive relief by a U.S. District Court, and seeking a court order for EPA to withdraw the rule.[67] Subsequently, EPA published an explanation augmenting its arguments regarding this

[61] Over 11,000 comments are available via www.regulations.gov, at Docket Number: EPA-HQ-OAR-2013-0495. Individual comments are assigned a specific document number that consists of the Docket Number and a 4 or 5 digit unique identifier. For example, Duke Energy's comments are identified in the docketing system as "EPA-HQ-OAR-2013-0495-9426."
[62] EPA-HQ-OAR-2013-0495-10938.
[63] EPA-HQ-OAR-2013-0495-238.
[64] EPA-HQ-OAR-2013-0495-10951.
[65] 42 U.S.C. 7411
[66] Ibid.
[67] *State of Nebraska v. USEPA*, Case No. 4:14-cv-3006, filed January 15, 2014, U.S. District Court for the District of Nebraska.

issue and sought public comment.[68] EPA received positive comments on its arguments from a group of environmental organizations,[69] and negative comments from UARG,[70] the National Mining Association (NMA),[71] AEP,[72] the National Association of Manufacturers (NAM),[73] and Peabody Energy.[74]

- EPA's general approach to BSER was contrary to case law and agency precedent. Previous NSPS, such as the 1979 NSPS effectively requiring use of flue gas desulfurization (FGD) systems and the 1998 NSPS effectively requiring use of selective catalytic reduction (SCR), were based on widely deployed technologies, with months or years of monitored performance data. The current proposal, while accepting efficient designs already in use on 95% of recently commissioned NGCC power plants as BSER for gas-fueled EGUs,[75] bases the limit for coal-fueled units on technology which has never been installed at commercial scale on a power plant. Specific criticisms offered by commenters included EPA's introduction of a new four-factor approach for determining BSER, inconsistent (in the judgment of commenters) with statutory criteria and case law focused on "best adequately demonstrated" technology; EPA's presumption that the standard need not be achievable for all areas of the country; and basing cost considerations on national impacts rather than impacts at a unit-specific level.[76] Additional detail on these and other legal objections to the proposed rule can be found in comments submitted by UARG,[77] AEP,[78] and Southern Company.[79]

Commenters also questioned the legitimacy of a rule that acknowledged that it would provide no reduction in regulated emissions,[80] and that (for coal systems) would require emissions capture but not disposal or storage.[81] EPA required reporting of storage, but not storage itself, under 40CFR98, Subpart RR,[82] (separate from the proposed NSPS) and additionally under

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[68] Standards of Performance for GHG Emissions From New Stationary Sources: Electric Utility Generating Units – Notice of Data Availability (NODA), USEPA, 79FR10750, February 26, 2014. EPA also published a 33 page technical support document providing more detailed arguments.
[69] These included Natural Resources Defense Council (NRDC), Environmental Defense Fund (EDF), and Western Resource Advocates, EPA-HQ-OAR-2013-0495-10108.
[70] EPA-HQ-OAR-2013-0495-10938.
[71] EPA-HQ-OAR-2013-0495-9319.
[72] EPA-HQ-OAR-2013-0495-10618.
[73] EPA-HQ-OAR-2013-0495-10503.
[74] EPA-HQ-OAR-2013-0495-10951.
[75] "… we reviewed the emissions rate of natural gas-fired (non-CHP) combined cycle facilities used in the power sector that commenced operation between 2006 and 2010…. [N]early 95% of these facilities meet the proposed standards ….," EPA preamble to proposed NSPS, 79FR1436, 2014.
[76] 79FR1462-1467, 2014.
[77] EPA-HQ-OAR-2013-0495-10938.
[78] EPA-HQ-OAR-2013-0495-10618.
[79] EPA-HQ-OAR-2013-0495-10095.
[80] EPA-HQ-OAR-2013-0495-10036.
[81] EPA-HQ-OAR-2013-0495-8030.
[82] 79FR1505, 79FR1514, 2014.

40CFR98, Subpart PP.[83] EPA stated its belief that the storage "requirement" could be incorporated into the facility's operating permit.[84]

6.1.2. The best system of emission reduction (BSER)

For the current proposed NSPS, EPA introduced a new approach to determining the BSER, based on four factors:[85]

- Whether an emission reduction is technically feasible
- Whether its cost is "reasonable"
- The amount of emission reductions generated
- Whether the system promotes technology deployment and further development.

EPA applied these factors and concluded that "partial CCS" was BSER for new coal-fueled EGUs. However, in addition to objecting to the legitimacy of this four-factor approach, commenters identified issues associated with each of these four factors. Regarding feasibility, for example, commenters quoted testimony before the House Science Committee: (1) by Robert Hilton, Vice President, Alstom Power: *"Alstom does not currently deem its technologies for carbon capture commercial and, to my knowledge, there are no other technology suppliers globally that can meet this criteria or are willing to make a normal commercial contract for CCS at commercial scale*;" and (2) by former DOE Fossil Energy Assistant Secretary McConnell: *"Commercial CCUS technology currently is not available to meet EPA's proposed rule."*[86,87] Similarly, another major technology vendor, B&W, provided comments stating: "As a developer and supplier of C02 capture technologies, we do not agree that these technologies are ready for commercial deployment on new EGUs today to meet this emission limit."[88] Another commenter cited a database of global CCS projects maintained by MIT, observing that only 2 of 55 CCS power projects tracked by MIT have reached the construction stage, none is operating, 20 have been cancelled, and 9 are on hold or dormant.[89] Key issues regarding technology feasibility included the integration of CCS's various capture components with the rest of an EGU's generation subsystems, uncertainties associated with saline storage of captured CO2, the parasitic power consumption and large cooling water requirements of currently available CCS systems, and non-technology issues that pose barriers to broad deployment of CCS such as proposed monitoring, reporting and verification requirements specified by the proposed rule. The feasibility of CCS is not a new issue. Three recent government reports cited the immaturity of this technology:

- The Report of the Interagency Task Force on CCS (2010) identified a series of technical and non-technical barriers to the broad deployment of CCS. For example, "CO2 removal technologies are not ready for widespread implementation on coal-based power plants, primarily because they have not been demonstrated at the scale necessary to establish

[83] 79FR1518, 2014.
[84] 79FR1484, 2014.
[85] 79FR1434, 2014.
[86] EPA-HQ-OAR-2013-0495-9683.
[87] Joint Hearing – Science of Capture and Storage: Understanding EPA's Carbon Rules, House Committee on Science, Space, and Technology, subcommittee on Energy and Subcommittee on Environment, March 12, 2014.
[88] EPA-HQ-OAR-2013-0495-8348.
[89] EPA-HQ-OAR-2013-0495-2658.

confidence for power plant application." "Other technical challenges associated with the application of these CO2 capture technologies to coal-based power plants include high capture and compression auxiliary power loads, capture process energy integration with existing power system, impacts of flue gas contaminants (NOx, SOx, PM) on CO2 capture system, increased water consumption and cost effective O2 supply for oxy-combustion systems."

- More recently, the National Climate Assessment report stated: "CCS facilities for electric power plants are currently operating at pilot scale, and a commercial scale demonstration project is under construction. Although the potential opportunities are large, many uncertainties remain, including cost, demonstration at scale, environmental impacts, and what constitutes a safe, long-term geologic repository for sequestering carbon dioxide."[90]
- USDOE/NETL has published its technology program plan for commercialization of carbon capture.[91] That document's cost of electricity (using NETL's approach to "first year cost of electricity") of current power systems with CO2 capture is $133-137/MWh (without storage). Including storage and converting to the more conventional "levelized cost of electricity" metric, this figure approaches $170/MWh – more than twice the $59/MWh cost of NGCC technology (without CCS) estimated by EPA in the proposed rule.[92] This report projects that, with adequate funding for RD&D, 2nd Generation capture technologies that are 20% cheaper than today's technologies can be available by 2030, and transformational technologies (40% cheaper) can be available by 2040. The high cost of current CCS and the decades needed for existing RD&D to lower those costs are indicative of the immaturity of CCS.

EPA's cost analysis was also criticized on multiple levels. The use of paper studies, some dating back several years, as a basis for system costs was considered an inferior approach to using the factual cost of power systems approaching the completion of construction, such as the Kemper County IGCC, and the Boundary Dam post-combustion capture system. EPA's estimated capital costs of power plants equipped with CCS, for example, were less than half the costs of these first-of-a-kind demonstration units.[93] EPA's comparison of alternative EGU systems (e.g., coal versus nuclear) used inconsistent approaches to calculate each system's cost of electricity.[94]

EPA's claim that a policy goal of achieving more substantial emission reductions contributed to its selection of CCS technology as BSER was contradicted by the agency's acknowledgment that the rule would result in no reduction in GHG emissions. One commenter expressed the view that, by discouraging continued development of CCS technology, the rule would lead to an increase in global CO2 emissions.[95]

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[90] Climate Change Impacts in the U.S. – U.S. National Climate Assessment, U.S. Global Change Research Program, 2014.
[91] Carbon Capture Technology Program Plan, USDOE/NETL, January 2013.
[92] 79FR1476, 2014.
[93] See EPA-HQ-OAR-2013-0495-0080, EPA-HQ-OAR-2013-0495-10036.
[94] EPA-HQ-OAR-2013-0495-10036.
[95] EPA-HQ-OAR-2013-0495-10952.

Several commenters concluded that the rule would deter, rather than foster, technology development. One argument offered by commenters was that the additional cost of CCS required for coal, but not for NGCC, would heavily weight the comparative costs of the two generating options in favor of NGCC without CCS, thereby eliminating interest in new coal systems and new coal technology development like CCS.[96,97,98] In previously cited testimony before the House Science Committee, an executive with Alstom Power captured this concept succinctly: *"As detailed below, this regulation will essentially stop the development of CCS. Without new coal plants, it is unlikely technology developers will continue to invest in CCS development. Since the proposed regulation provides a significantly lower cost alternative (NGCC without controls) to the application of CCS to coal, there is unlikely to be a market for at least 10 years, and most R&D cannot be sustained for that period. Industry bases R&D on market potential and return on investment. With no market in sight, investment will stop."*[99] Another major technology vendor echoed these views in comments submitted to EPA.[100]

EPA argues that the proposed NSPS "promotes the utilization of CCS because any new fossil fuel-fired utility boiler or IGCC unit will need to install partial capture CCS in order to meet the emission standard."[101] Aside from the obvious error that the CCS requirement applies only to <u>solid</u> fossil fuels, the recent Supreme Court decision on EPA's "tailoring rule" moots EPA's argument. That decision clarifies that each new coal (and gas) fueled power plant must obtain a permit, and EPA's guidance requires that the permit must consider the application of CCS technology as part of its BACT analysis. Hence, a regulatory driver for CCS already exists, if the technology is indeed ready for commercial deployment. Moreover, the flexibility provided by new source permitting is much more accommodating to an emerging technology than fixed nationwide limits set pursuant to NSPS.

6.1.3. Peripheral CCS issues

Comments on the proposed rule also identified several additional critical issues. CCS advocates voiced concern that EPA "transition guidance" on the Underground Injection Control program stated that "Class II" injection wells used for enhanced oil recovery (EOR) could be reclassified as "Class VI" wells. Such a change could invalidate the contractual arrangements for the CO2 storage activity, in addition to significantly increasing cost and reducing project feasibility. Similarly, the rule requires EOR projects using captured CO2 to apply monitoring, verification, and reporting procedures designed for non-EOR injection facilities.[102] Both of these requirements would tend to limit the practical value of EOR as a CO2 storage option. Several commenters cited a paper by Denbury that stated the company would not purchase for its EOR projects CO2 that was encumbered by the proposed "subpart RR" reporting requirements.

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[96] EPA-HQ-OAR-2013-0495-9472.
[97] EPA-HQ-OAR-2013-0495-9426.
[98] EPA-HQ-OAR-2013-0495-10036.
[99] Op. cit., Joint Hearing, testimony of Robert Hilton, Vice President, Alstom Power.
[100] EPA-HQ-OAR-2013-0495-8348.
[101] 79FR1480, 2014.
[102] EPA-HQ-OAR-2013-0495-10786.

Another commenter observed that EPA has yet to issue a permit for injection via a Class VI well.[103] Class VI well permits are required for CCS projects using geologic storage of CO2.

The long-term liability created by a 50 year post-closure monitoring program for geologic CO2 storage was also cited as a barrier to broad deployment of CCS.[104]

Several comments cited EPA's use of the "Social Cost of Carbon" in justifying the proposed NSPS. EPRI observed that the economic models used by EPA had been peer reviewed, but those peer reviewed applications used dynamic discount rates, rather than the static rates used in analyses for EPA.[105] Discount rates are used to calculate the current value of future compliance costs and future environmental benefits. Assumed discount rates are perhaps the most critical parameter in evaluating future costs and benefits of climate change mitigation because benefits may be a century into the future.

Other commenters stated that additional elements of the analysis supporting EPA's decision have not undergone adequate peer review, as required by statute and regulation.[106,107]

The Electric Reliability Coordinating Council characterized the proposal as "a de facto prohibition on the construction of new [coal] power plants," and as such a threat to electricity reliability.[108]

6.2. Conclusions regarding EPA's proposed NSPS

Many of the views offered by commenters are judgments, not facts. However, some of these judgments appear to have broad acceptance, including:

- Little growth is expected in domestic electricity demand over the next decade. Between 2014 and 2023, EIA projects a total increase in electrical generating capacity of 0.5% and an increase in annual generation of 10%. Even without climate regulation, coal generation is projected to increase only 0.05%, and no new coal capacity not already under construction is expected to enter service over this decade.[109]
- Given the above, EPA offered no reason for establishing an NSPS for coal-fueled power plants at this time, and given the broad range of uncertainties associated with CCS technology, there are numerous reasons not to establish an NSPS at this time. There may be a basis for establishing an NSPS for NGCC systems, given that they may be built over the next decade, but the rule proposed by EPA simply requires use of the same technology already being employed on almost all new NGCC systems (95% of those commissioned between 2006 and 2010). In any event, EPA projects that no emission reduction will result from the proposed limits.

[103] EPA-HQ-OAR-2013-0495-9683.
[104] EPA-HQ-OAR-2013-0495-9472.
[105] EPA-HQ-OAR-2013-0495-8925.
[106] EPA-HQ-OAR-2013-0495-10036.
[107] EPA-HQ-OAR-2013-0495-1902.
[108] EPA-HQ-OAR-2013-0495-9196.
[109] Annual Energy Outlook – 2014, USDOE/EIA, reference case, December 2013.

- EPA has departed from its traditional approach to setting NSPS ("best adequately demonstrated technology"), and crafted a new four-part logic constructed around the potentially more flexible "best system of emission reduction" concept.
- Commenters raised significant issues with respect to each of the four elements of EPA's BSER approach. Perhaps most significantly, several commenters expressed the view that the rule would discourage further development (and cost reduction) in CCS technology, which could have the effect of increasing long-term global CO2 emissions.

These findings lead one to wonder why EPA issued the proposed rule. There are at least two possible motivating factors that go beyond the direct impact of the rule. The first was mentioned almost as an afterthought near the end of the preamble, within a section titled "X. Impacts of the Proposed Action."[110] There EPA states:

> *This proposed rule will limit GHG emissions from new sources in this source category to levels consistent with current projections for new fossil fuel- fired generating units. The proposed rule will also serve as a necessary predicate for the regulation of existing sources within this source category under CAA section 111(d). In these ways, the proposed rule will contribute to the actions required to slow or reverse the accumulation of GHG concentrations in the atmosphere, which is necessary to protect against projected climate change impacts and risks.*

Given that EPA is clearly saying (and the next paragraph in the preamble confirms) that EPA does not believe that the rule will change emissions from new fossil fueled power plants, the primary purpose of the rule could be to serve as the statutorily required prerequisite for additional regulations which EPA subsequently proposed for emissions from existing power plants.

Another possibility is related to the fact that major nations of the world are scheduled to gather in Paris in December 2015 for the purpose of establishing agreements to limit global GHG emissions in the post-Kyoto period. The existence of an aggressive domestic GHG regulatory program (including this NSPS and the subsequent Section 111(d) rule that it enables) could be seen as enhancing the U.S. negotiating position with countries that might be less enthusiastic about reducing their own emissions. As the Executive Director of the International Energy Agency stated, in reference to the Section 111(d) rule, "Crucially, it also sends a very clear signal to the international community ahead of the make-or-break climate talks in Paris next year."[111]

If, indeed, these are the reasons for pursuing the rule, EPA should clearly state this in the preamble and explain the agency's legal authority to issue a regulation based on its impact on the potential outcome of a subsequent regulation, or based on future international negotiations on climate change mitigation.

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[110] 79FR1496, 2014.

[111] Maria van der Hoeven, Executive Director, International Energy Agency, Speech to USEIA annual energy conference, Washington, DC, July 14, 2014.

7. EPA's proposed rule under Section 111(d)

On June 18, 2014, EPA proposed a rule which would provide enforceable guidelines for state environmental agencies to follow when they establish performance standards limiting CO2 emission from existing power plants.[112] The rule proposed numerical emission rate limits (a statewide average pounds of CO2 emitted per megawatt-hour of generation) for each state. These limits represented EPA's estimate of the combined effects of: (a) improving efficiency at coal-fueled EGUs; and (b) reducing the use of coal-fueled EGUs by increased use of NGCC EGUs, renewable energy EGUs, and demand-side efficiency measures. Note that three of these four sources of emission reductions derive not from controlling emissions from the affected source, but rather from controlling use of the affected facilities. EGU compliance with the rules resulting from this regulatory program will begin in 2020. EPA projected that the effect of the rule would be a 30% reduction in CO2 emissions from U.S. fossil fueled power plants by 2030, relative to emissions in 2005. EPA projected an overall reduction in coal-fueled generation of 25% in 2025 and 2030, compared to baseline or "business as usual" coal-fueled generation in those years.[113] The two major issues impacting the viability of the proposed regulation will likely be:

- Whether CAA Section 111(d)(1) precludes emission standards for power plants under Section 111(d) because EPA has set standards for that source category under Section 112, and
- The validity of EPA's interpretation of its legal authority to allow setting performance standards based on measures that reduce use of the affected facility.

This paper will not review the proposed 111(d) regulation in detail because that rule rests almost entirely on these legal issues. However, regarding the use of CCS as a basis for the Section 111(d) performance standards, it should be noted that EPA stated*: "The EPA also examined application of CCS technology at existing EGUs. CCS offers the technical potential for CO2 emission reductions of over 90 percent, or smaller percentages in partial applications. … However, application of CCS at existing units would entail additional considerations beyond those at issue for new units. Specifically, the cost of integrating a retrofit CCS system into an existing facility would be expected to be substantial, and some existing EGUs might have space limitations and thus might not be able to accommodate the expansion needed to install CCS. Further, the aggregated costs of applying CCS as a component of the BSER for the large number of existing fossil fuel-fired steam EGUs would be substantial and would be expected to affect the cost and potentially the supply of electricity on a national basis. For these reasons, although some individual facilities may find implementation of CCS to be a viable CO2 mitigation option in their particular circumstances, the EPA is not proposing and does not expect to finalize CCS as a component of the BSER for existing EGUs in this rulemaking."*[114]

[112] Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, USEPA, 79FR34830, June 18, 2014.
[113] Regulatory Impact Analysis for the Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants, Table 3-11, USEPA, June 2014.
[114] 79FR34857, 2014.

8. June 2014 Supreme Court decision

On June 23, 2014, the Supreme Court issued a decision on challenges to EPA's "Tailoring Rule." The Court reviewed the logic of the D.C. Circuit's decision on air pollutants subject to permitting requirements, and concluded that: *"The Court of Appeals reasoned by way of a flawed syllogism … [y]et no one – least of all EPA – endorses that proposition, and it is obviously untenable."*[115] Citing EPA's interpretation of the CAA, the court stated, *"EPA's interpretation is also unreasonable because it would bring about an enormous and transformative expansion in EPA's regulatory authority without clear congressional authorization. When an agency claims to discover in a long-extant statute an unheralded power to regulate 'a significant portion of the American economy,' Brown & Williamson , 529 U. S., at 159, we typically greet its announcement with a measure of skepticism. We expect Congress to speak clearly if it wishes to assign to an agency decisions of vast 'economic and political significance.' … We are not willing to stand on the dock and wave goodbye as EPA embarks on this multiyear voyage of discovery. We reaffirm the core administrative-law principle that an agency may not rewrite clear statutory terms to suit its own sense of how the statute should operate."*[116] The court reversed, in part, the DC Circuit's decision that had affirmed EPA's Tailoring Rule.

With respect to requirements for BACT under the new source review program, the Court clearly endorsed EPA's traditional approach to restrict BACT to direct air pollution control measures and that BACT *"may not be used to require 'reductions in a facility's demand for energy from the electric grid' … [and] should not require every conceivable change that could result in minor improvements in energy efficiency, such as the aforementioned light bulbs."*[117] The Court was comfortable with a narrow interpretation of BACT because it *"is not so disastrously unworkable, and need not result in such a dramatic expansion of agency authority, as to convince us that EPA's interpretation is unreasonable."*[118] This discussion seems highly relevant to EPA's proposed rule under Section 111(d), published a week before the Supreme Court decision on the tailoring rule. <u>EPA's proposed Section 111(d) rule included exactly those types of measures that the Court cautioned against for BACT determinations under the new source review program.</u> Some readers inferred the decision was suggesting to EPA that the agency be less creative in its interpretations of the CAA.[119]

9. The need for a new paradigm and possible paths forward

9.1. Overview

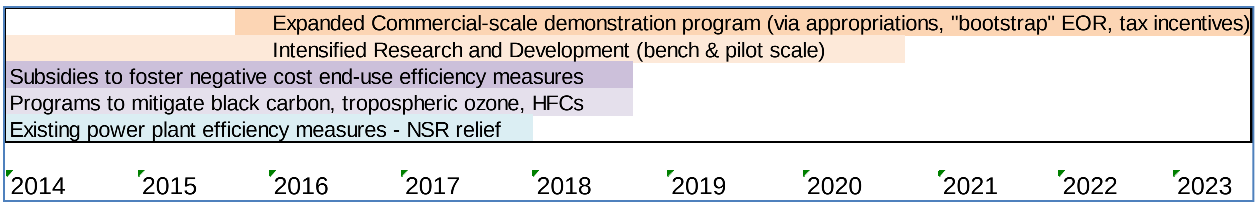
Attempts to drive technology development and GHG emission reductions with regulations predicated on flawed legal and technical analysis reflect a failure of imagination by policy makers. Alternative approaches offer the potential for nearer term benefits at much lower cost to the nation. The basic elements of such an alternative path include:

[115] Utility Air Regulatory Group v. EPA et al., Case No. 12-1146, at p.11, U.S. Supreme Court, June 23, 2014.
[116] Ibid. at p.19, 23.
[117] Ibid. at p.27.
[118] Ibid. at p.28.
[119] <u>Debate rages on what ruling means for power plant curbs</u>, J. Chemnick, E&E News/Greenwire, June 23, 2014.

- Near-term measures for inexpensive reduction of GHGs. These include reduction of non-CO2 GHGs like black carbon and tropospheric ozone to reduce global warming in 2050 by half, while reducing global premature mortality from indoor air pollution by millions of lives per year; cost-saving end use efficiency measures; and cost-saving power plant efficiency measures.
- Substantial increases in federal funds for RD&D for CCS technology.
- Creative approaches to raising funds needed accelerate and expand CCS technology RD&D.

A general depiction of how these programs might be applied over time is provided in Figure 9.1.

Figure 9.1. Technology-driven measures.



CCS technology is recognized as essential to the ability of the global community to meet posited goals for addressing global climate change, while providing continued access to the fossil fuels that will dominate energy consumption for the foreseeable future.

There is evidence, however, that EPA's proposed requirement for CCS technology on new coal-fueled power plants will not survive litigation, and even if it did, will not achieve the larger goal of CCS development and broad deployment. The objections posed in comments on EPA's proposed CO2 NSPS under CAA Section 111(b), and issues raised by the Supreme Court that are relevant to the rule that EPA proposed under CAA Section 111(d) suggest that both of these rules, once promulgated, are likely to be at least subject to lengthy litigation, and may possibly be subject to remand or vacatur by a reviewing court. Moreover, if the net impact of these rules is declining interest in private sector development of CCS technology, society could lose critical time with very limited progress on improved CCS technology. Consider that over four years elapsed between the issuance of EPA's Tailoring Rule and the Supreme Court's decision that reversed, in part, the DC Circuit's decision affirming the Tailoring Rule. Moreover, the litigation process will not generally proceed before final rules and guidelines are issued for CO2 emissions from power plants – probably in 2015 – suggesting final court opinion in perhaps 2019. If rules are remanded or vacated, revised regulations could easily require another year or two, and at the end of all that the provisions for CCS could still be unworkable.

In the interim, interest in new coal-fueled power plants would be extremely low given the regulatory uncertainty, the price advantage of new NGCC systems that are not required to use CCS technology, limited demand in the U.S. for additional electricity supply, non-technical barriers to CCS, and high cost of current CCS technology. Similarly, efforts to improve CCS could be hindered by budget proposals to reduce CCS funding, and declining interest by the private sector in the absence of a viable market for coal-based systems. The existing coal fleet would be at least five years older and more units would be beyond a practical age for retrofitting CCS. And CCS opportunities in Asian power markets, which continue to build coal units at an astounding pace, will have been delayed at least five more years.

In short, it is easy to envision a scenario in which another five years pass and the nation is not only no better prepared for meeting climate goals, but it is actually less prepared than today: five years squandered in litigation, appeals, and rudderless uncertainty.

The remainder of Section 9 offers concepts that could form an alternative path forward – a better use of the next few years. Implementing these concepts could provide near-term reduction in both GHGs and global temperature, something that more aggressive and more costly climate mitigation efforts do not promise. These concepts also offer multiple approaches to raising the revenues needed to accelerate and improve the likelihood of successful RD&D on CCS technology that is critical to meeting longer term climate goals.

9.2. Near-term climate change mitigation

CO2 is a long-life GHG; emissions can remain in the atmosphere more than 100 years. As a result, reducing future emissions of CO2 will require decades to have a significant impact on atmospheric concentrations and secondary global warming impacts. Other GHGs have much shorter atmospheric lifetimes. The opportunity for a near-term reduction in global temperature increases centers around reduction of these non-CO2 GHGs. A report by the United Nations Environment Programme (UNEP)[120] concluded that strategies aimed at reducing emissions of "black carbon" (BC - basically soot from diesel engines and primitive residential cooking stoves) and methane (leakage from natural gas production and transport, and from agricultural activities) that generates tropospheric ozone (TO) could provide nearly immediate reductions in global temperature. Unlike CO2 emission reductions, which are unlikely to have a meaningful impact on atmospheric temperatures before 2100,[121,122] reductions in BC and TO could reduce temperature increases predicted for 2050 by 0.5 ^{o}C, or about one half. Warming in the Arctic over the next 30 years would be reduced by about two-thirds, thereby reducing risks of changing weather patterns. Moreover, controlling these emissions is supportable on other merits: eliminating 2.4 million premature deaths per year (primarily from indoor air pollution); and reducing global crop losses (corn, rice, soybean, wheat) by 50 million tonnes per year (about 2%).[123] Additional reports on black carbon have been published by EPA[124] and others.[125] An assessment of methane reduction strategies, which would impact tropospheric

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[120] Integrated Assessment of Black Carbon and Tropospheric Ozone, UNEP & WMO, June 2011.
[121] The IEA has concluded that the climate commitments proposed at the 2009 Copenhagen Climate Conference, if they were implemented, would lead to a long term (year 2300) global temperature increase of 3.5 ^{o}C, far more than the announced policy goal of 2 ^{o}C. World Energy Outlook 2010, International Energy Agency, OECD, 2010, p.384.
[122] Temperature differences in 2050, based on a "Copenhagen" emission scenario versus a business as usual case, can be gleaned from comparing the IPCC's 650ppm scenario to its 1000ppm scenario. The difference is less than 0.1 ^{o}C. Climate Change 2001: The Scientific Basis, IPCC 3rd Assessment Report, Figure 26.
[123] Op.Cit., Integrated Assessment of Black Carbon and Tropospheric Ozone.
[124] Report to Congress on Black Carbon, USEPA, March 2012.
[125] An Analysis of Black Carbon Mitigation as a Response to Climate Change, Baron, Montgomery, & Tuladhar, 2009.

ozone, has been published by German researchers.[126] A climate strategy including BC and TO mitigation would effectively reduce warming while additional research is conducted to produce cheaper technologies to address longer term mitigation of CO_2. Hence, the effort would provide a near-term climate benefit, while allowing technology cost reductions that would make longer-term climate goals economically practicable.

The EPA Regulatory Impact Analysis (RIA) published in support of the agency's Section 111(d) proposed rule suggests that, by 2030, aggressive measures to reduce electricity demand (i.e., end-use efficiency measures like low-energy lighting, more energy efficient appliances, and installation of building insulation) will be almost cost free. It seems reasonable, therefore, that many of the lower cost end-use efficiency measures could be deployed immediately if provided a modest financial incentive. Quantification of an appropriate deployment target and funding level is beyond the scope of this paper.

A recent report to the Secretary of Energy by the National Coal Council[127] provided documentation that deployment of available measures to improve the efficiency of existing coal-fired power plants has been and continues to be deterred by EPA regulations. These regulations characterize such efficiency improvements as "major modifications" that, if implemented, would invoke costly procedural and control technology requirements. Hence, it appears that a portion of the heat rate (or efficiency) improvement proposed to be implemented under EPA's Section 111(d) regulations could be accomplished by simply eliminating the existing regulatory barrier.

9.3. Funding CCS – how much is enough?

An initial question regarding determination of the resources needed for development of CCS technologies is: how many different CCS technologies are necessary? A top level matrix might propose development of capture technologies that are appropriate for pre-combustion (gasification), post-combustion (pulverized coal), oxy-combustion, and chemical looping technologies. CO_2 storage technologies might be needed for a range of geologies and CO_2 reuse options, including carbonate rock formations, silicate rock formations, basalt formations, EOR applications, and other types of CO_2 reuse purposes. However, each of the above categories of capture and storage has diverse technology alternatives, such as CO_2 separation mechanisms that employ membranes, solid sorbents, or liquid sorbents; multiple approaches to reduce the cost of oxygen production for oxy-combustion technologies; or multiple approaches to use of CO_2 in unconventional EOR projects. The DOE/NETL strategy for coping with such an impressive array of possible technological solutions is to conduct broad initial evaluations at bench and small-pilot scale, where research costs are relatively small, and take only the most promising solutions to evaluation at a large-pilot scale or commercial demonstration scale, where costs are much higher. The entire DOE FY14 budget for coal and CCS technology development was $392 million, and the Administration's proposal for FY15 was $302 million. Compare these amounts to the capital cost of the Kemper County IGCC/CCS demonstration

[126] An Analysis of Methane Mitigation as a Response to Climate Change, Kemfert & Schill, 2009. The proposed mitigation strategy focuses on emissions from livestock, rice cultivation, solid waste management, coal mine methane control, and natural gas production & use.
[127] Expedited CCS Development: Challenges & Opportunities, National Coal Council, March 18, 2011.

project: over $5 billion. Or, compare the CCS budget to other energy programs. The Congressional Research Service reports that FY2013 appropriations for energy efficiency and renewable energy technology development totaled $3.9 billion,[128] and production tax incentives for wind energy alone were an equivalent amount.[129] These figures seem even more out of balance when one considers that in 2013 the U.S. consumed over 10 times as much fossil energy as renewable energy.[130] The U.S. government has never published an estimate of how much money is needed for a multi-year program to reach published cost and performance goals for CCS technologies.

A rational approach to scoping the overall multi-year program might separate R&D activities from demonstration activities. A good starting point would be DOE's program plans for CO2 capture technologies and CO2 storage technologies – which identify logical technology components but not multi-year development costs – or the coal technology roadmap prepared by the Coal Utilization Research Council and EPRI.[131] Important elements to an RD&D program include timing and the integration of R&D with subsequent demonstrations. Policy goals and existing power plant demographics must be combined with consideration of needed technology elements so that program resources are responsive to the dimensions of the challenge, including the time dimension.

Technologies to address past environmental issues associated with coal-fueled power plants have been developed in part through collaboration of the federal government and the private sector. Improvements to flue gas desulfurization (FGD), selective catalytic reduction (SCR), low-NOx burners, and mercury capture technologies flowed from such collaborative efforts. The government's share of the funds for these efforts was provided via annual appropriations assigned to and administered by the DOE. In general, congress allowed the government share of basic research activities to be as much as 80% of the cost of a project, while the government's share of a commercial-scale demonstration project was limited to 50% of the cost of a project.

Consider a hypothetical RD&D program consisting of research activity expanded slightly over FY14's $392 million to accelerate the pace of development – perhaps a total of $500 million per year. Add to that a demonstration program aimed at building 10 commercial scale power plants with CCS costing $5 billion each, over a 15 year period (a total of $50 billion over 15 years). Assuming a government share of 50-75% for the demonstration units (an increase that reflects the relatively high risk of accelerating CCS technology development) suggests a federal contribution of $1.7 to 2.5 billion per year. Total federal budget: $2.2 – 3.0 billion per year, for more than a decade – a five or six-fold increase over FY14.

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[128] Renewable Energy And Energy Efficiency Incentives: A Summary of Federal Programs (Appx A), Congressional Research Service, R40913, October 18, 2013.

[129] Reliable & Resilient – The Value of Our Existing Coal Fleet, National Coal Council, May 2014.

[130] Monthly Energy Review – July 2014, Tables 1.1 and 10.1, USDOE/EIA, July 2014. For 2013, EIA reports that fossil energy consumption was 82% of the U.S. total; non-hydro renewable energy was 7%.

[131] The CURC-EPRI Coal Technology Roadmap, prepared by the Coal Utilization Research Council and the Electric Power Research Institute, August 2012.

Once the scope and timing of the RD&D program are established, the most challenging aspect of a successful program is identifying sources of funds to conduct research and to build the relatively expensive commercial scale demonstration projects that fit that scope and timetable. Several generically different options for generating funds are discussed below.

9.4. Traditional appropriations

Appropriations for coal and CCS technology development have averaged less than $400 million per year over the past decade. A budget proposal such as that posited above (a five or six-fold increase) would likely be opposed by those who favor other energy forms such as renewable energy and demand-side efficiency measures, those who want to reduce federal spending in general or direct increases to other areas, and those who oppose demonstration projects because they view large demonstrations as a private sector responsibility. However, increased funding of CCS technologies might be supported because CCS is considered necessary to achieving global climate change goals, could preserve a portfolio of base load electric power options, and could provide a long-term payoff in the reduced cost of future electric power.

9.5. Targeted tax and financial incentives

Several approaches have been used to provide CCS projects, or coal-fueled power plants using CCS, with tax or financial incentives. These include:

- Internal Revenue Code (IRC) Section 48A investment tax credits. Tax credits of up to 30% of the qualified investment were provided for certain types of advanced coal-fueled power projects using CCS. The credits were limited by the total amount of credit authorized by Congress.[132]
- IRC Section 45Q production tax credits for captured CO2. A credit of $10/tonne CO2 or $20/tonne CO2 from qualified facilities and permanently stored via EOR or geologic storage was provided for a total of 75 million metric tonnes of CO2.[133]
- EPAct 2005 Section 1307 loan guarantees. Section 1703 of Title XVII of the Energy Policy Act of 2005 authorized USDOE to provide loan guarantees to certain eligible projects, including advanced coal projects, that avoid, reduce, or sequester anthropogenic GHG emissions. Loan guarantees are attractive to project developers with shallow pockets and higher-than-normal risk technologies. DOE issued a rule in 2009 governing the process for loan guarantee applications and reviews.[134]

In general, these tax credit approaches to fostering early deployment of emerging coal-based CCS projects have met with mixed results. Individually, the incentives tend to be less than the cost of adding CCS to a power project. Some projects selected to receive these incentives have subsequently declined the funds because of changing economic conditions in the power sector. However, they have helped other projects, particularly if additional financial incentives were provided from other programs.

9.6. EOR bootstrap

[132] Internal Revenue Bulletin: 2009-16, April 20, 2009, Notice 2009-24.
[133] Internal Revenue Bulletin: 2009-44, November 2, 2009, Notice 2009-83.
[134] Loan Guarantees for Projects That Employ Innovative Technologies, USDOE, Final Rule, 74FR63544, December 4, 2009.

Several technical reports[135,136,137] and at least two bills introduced in Congress[138,139] have proposed a concept that would provide funds for CCS subsidies from the additional taxes generated by deployment of CCS systems as part of EOR expansion.[140] The basic proposition is that captured CO2 would enable increased domestic oil production via EOR. The EOR activity would generate federal revenues in the form of royalties on oil produced from federal lands, and from income taxes from the profitable sale of produced oil. Given the time lag between the beginning of construction of the power plant, the injection of CO2 into a partially depleted oil field, and the production of oil, there would be a lag between when taxes were spent via the subsidy versus when taxes were collected via the oil production, but various analyses have concluded that the overall operation would be "revenue positive" for the government – i.e., provide more tax income than tax outlays.

9.7. NCEP-type fee & directed trust fund

A 2004 report by the National Commission on Energy Policy (NCEP) concluded that aggressive goals for reducing emissions of GHGs could not be met with currently available technologies due to their high cost. NCEP recommended a climate policy that recycled fees from early climate regulation to conduct research on less costly mitigation technologies.[141]

Such a fee, aimed primarily at developing less costly mitigation technology, would be quite different from a "carbon tax" or "Cap&Trade" approach aimed at deterring use of fossil fuels. For example, EPA estimated that the marginal cost of H.R. 2454 (a "cap&trade" bill passed by the House of Representatives in 2009) began at $13/tonne CO2 in 2015, and rose to $70/tonne in 2050 (in 2005 dollars).[142]

In contrast, a $1 per tonne CO2 fee on crude oil, natural gas, and coal consumption in the U.S. would generate $6 billion per year in revenues. Half of this could be directed toward CCS RD&D (which would be applicable to coal and gas power plants, and large industrial facilities such as refineries and cement plants). The remainder could be divided between incentives for demand-side energy efficiency to reduce electricity demand, and mitigating non-CO2 GHG emissions that can materially reduce global temperatures by 2050 (see discussion of tropospheric ozone and black carbon in subsection 9.8).

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135 An Early Deployment Strategy for Carbon Capture, Utilization, and Storage (CCUS) Technologies, L.D. Carter, for United States Carbon Sequestration Council, June 2012.

136 The Value of Enhanced Oil Recovery, L.D. Carter, Presentation to The CO2 Carbon Management Workshop, Houston, TX, December 2011.

137 Carbon Dioxide Enhanced Oil Recovery: A Critical Domestic Energy, Economic, and Environmental Opportunity, National Enhanced Oil Recovery Initiative, February 2012.

138 S. 2152 (Heitkamp), Section 203, introduced March 25, 2014.

139 S. 2288 (Rockefeller), introduced May 5, 2014.

140 Enhanced Oil Recovery is a technique that injects CO2 into partially depleted oil reservoirs to allow extraction of additional crude oil. The U.S. leads the world in use of this technology. Current EOR projects generally use "natural" CO2 produced from underground deposits, but these sources of CO2 are limited.

141 Ending the Energy Stalemate, National Commission on Energy Policy, December 2004.

142 EPA Analysis of the American Clean Energy and Security Act of 2009 – H.R. 2454 in the 111th Congress, USEPA, June 23, 2009.

The increased cost of energy due to a $1/tonne CO2 fee would be 0.4%, 1.4%, and 4.8% for crude oil, natural gas at distribution hubs, and coal at the mine. The relative price impact on delivered fuels would be less.

9.8. Regulatory incentives

The NCEP principle was employed in climate change mitigation bills introduced in 2007-2009, in the context of "bonus allowances."[143] Under these allowance-based "cap & trade" bills, power plant owners reducing emissions via CCS technology would be provided more than one allowance for each tonne of CO2 captured and stored (hence the term "bonus") for up to 60 GW of such facilities. Rather than provide direct financial subsidies, the bonus allowance approach provided a regulatory allowance, which had monetary value. Ultimately, the subsidy came from electricity rate payers. In theory, these early deployments of CCS technology would provide the knowledge base to drive down the cost of CCS and eliminate the need for subsidies in the future. This type of regulatory incentive has never been used in a traditional pollution control regulation. However, it might be possible to do so in a rule defined as broadly as EPA has interpreted its statutory authority under CAA Section 111(d), i.e., as part of a "system" of emission reduction.

Another regulatory incentive approach would be to enact legislation requiring a national "clean energy portfolio," similar to state renewable energy portfolios. To minimize cost, the design of the program (eligibility) could be tailored to ensure that it encouraged advanced technologies, rather than subsidizing additional deployment of already commercialized clean energy approaches. The goal of such a program would be technology advancement, rather than direct achievement of climate mitigation goals, but the technologies deployed would clearly contribute emission reductions.

9.9. Recent legislative proposals

Table 9.1 presents a selection of bills recently proposed in Congress that take various approaches to some of the concepts identified in this section. Several additional bills have been introduced aimed at limiting or revoking EPA's authority to regulate GHG emissions from the electric power sector.

Table 9.1.

Bill / Sponsor	Date introduced	Scope
S.2152, Sen Heitkamp	March 25, 2014	Very broad scope, including: • Authorizes expanded CCS RD&D, loan guarantee program • Provides for limited government indemnification of CO2 storage projects and long-term monitoring • Rapid amortization for efficiency improving capital expenditures at existing coal-fired power plants • Investment tax credits for CCS projects • Provides a CCS-EOR "bootstrap" tax incentive program similar to that described in Section 9.6, above.

[143] See, for example, H.R. 2454 (2009), passed by the House of Representatives, but not by the Senate.

S.2287, Sen. Rockefeller	May 5, 2014	Authorizes funds for CCS R&D. Modifies provisions in IRC Section 45Q tax credits for storing CO2. Expands DOE loan guarantee authority for CCS projects. Provides new investment tax credit (IRC Section 48E) for CCS projects.
S.2288, Sen. Rockefeller	May 5, 2014	Provides a CCS-EOR "bootstrap" tax incentive program similar to that described in Section 9.6, above.
S.2776, Sen. Walsh	August 1, 2014	Establishes a $10 billion fund to promote establishment of 10 commercial scale CCS projects over the next 10 years.
Sen. Murphy & Collins	Text released (but not introduced) June 26, 2014[144]	Authorizes multiple actions to reduce emissions of black carbon, methane, and HFCs (Climate change "Super Pollutants")

9.10. Complementary efforts

It is important to recognize that many programs are already underway to directly or indirectly reduce GHG emissions. These include state renewable portfolio standards and state energy efficiency resource standards, which are now required by more than half the states and which are tailored to the specific resources and economic priorities of each state.[145] As noted above, there is an existing program (new source review, including a requirement for BACT) that can require the application of CCS technology on new coal or gas-fueled power plants, where circumstances allow CCS to meet the statutory criteria for BACT. Additionally, in 2012, EPA and the Department of Transportation promulgated GHG emission standards for light-duty vehicles that will lead to an average of 54.5 miles per gallon for model year 2025 vehicles.[146]

10. Conclusions

Various scientific assessments have concluded that there is significant risk of increased global temperatures due to anthropogenic emissions of GHGs, including CO2. Mitigation assessments by these same groups have concluded that, without affordable CCS technologies, achieving aggressive global warming mitigation goals will be either impossible, or more than twice as costly as the cost if CCS technology can be deployed.

EPA has proposed regulations to restrict CO2 emissions from new and existing coal-fueled power plants. However, the supporting legal and technical basis for these rules has been questioned, and the Supreme Court has indicated a low tolerance for highly creative interpretations of long-extant statutes like the CAA. It seems at least plausible, if not probable, that these regulations could be in a state of limbo as legal and technical issues are litigated, and at the end of that process there might still be no clear process for achieving large reductions in GHG emissions from the electric power sector. In the meantime, the uncertainty in how coal

[144] Press Release by Sen. Murphy, June 26, 2014, http://www.murphy.senate.gov/newsroom/press-releases/murphy-collins-to-introduce-super-pollutants-act-of-2014 .

[145] See Database of State Incentives for Renewables & Efficiency (DSIRE), an information source operated by the N.C. Solar Center at N.C. State University, and funded in part by USDOE, http://www.dsireusa.org/ .

[146] EPA and NHTSA Set Standards to Reduce GHGs and Improve Fuel Economy for Model years 2017-2025 Cars and Light Trucks, USEPA, EPA-420-F-12-051, August 2012, http://www.epa.gov/otaq/climate/documents/420f12051.pdf .

units will be regulated could reduce interest in developing improved coal-based technologies, including CCS, further delaying meaningful GHG emission reductions.

There is a clear need for a better path forward. This paper has identified several generically different approaches to obtain resources for a dramatic increase in RD&D for CCS technology, thereby increasing the likelihood that an affordable approach to mitigate GCC will be available sooner, rather than later or not at all. Additional efforts include a strategy to reduce near-term temperature increases by addressing short-lived GHGs such as black carbon and tropospheric ozone, and policies to foster low or no-cost efficiency measures that reduce CO2 from the electric power sector.