Declaration of Nathaniel O. Keohane

Qualifications and Background

1. I am Chief Economist at Environmental Defense Fund (EDF). Prior to coming to EDF, I was an Associate Professor of Economics at the Yale School of Management. I received my B.A. from Yale University and my Ph.D. from Harvard University.

2. I am a widely recognized expert on the economics of climate change and on the design and economic performance of environmental policies. I have published papers in a number of academic journals including the *RAND Journal of Economics*, *Journal of Public Economics*, *Journal of Environmental Economics and Management*, *Journal of Economics & Management Strategy*, *Journal of Risk and Uncertainty*, and the *Harvard Environmental Law Review*. I am co-author (with Sheila M. Olmstead) of *Markets and the Environment* (Island Press, 2007), and co-editor (with Richard Brooks and Douglas Kysar) of *Economics of Environmental Law* (Edward Elgar, 2009). I am a member of the Environmental Protection Agency's Advisory Council on Clean Air Compliance Analysis, and a lead author for Working Group III of the Intergovernmental Panel on Climate Change Fifth Assessment Report. I have testified before Congressional committees in both the House of Representatives and the Senate. I have given invited presentations at conferences organized by the American Economics Association, the National Bureau of Economic Research, and the National Research Council, among a number of other forums; at the International Energy Workshop; and at seminars at universities including Harvard, Yale, Princeton, Stanford, UC-Berkeley, Texas, and Dartmouth, among others.

Summary of Principal Conclusions

3. My declaration presents three major findings. (1) The continued emission of greenhouse gases imposes measurable economic damages on the United States and the world. As a result, there are considerable benefits *today* from reducing greenhouse gas emissions — benefits which will be forfeited by staying regulation. These benefits must be taken into account when weighing the public interest of delaying action. (2) Contrary to the claims of Movants, there is no credible evidence that the Environmental Protection Agency's regulation of greenhouse gases under the Clean Air Act will cause significant harm to the U.S. economy. The analyses of prospective climate change legislation that Movants cite to support their claims are selectively chosen and deeply flawed. Objective, nonpartisan analyses of climate change policy have shown that even comprehensive, ambitious legislation that covers most of the U.S. economy will have very modest economic impacts. Moreover, the comparison itself is invalid, because the legislation proposed in Congress

would have required deep reductions over several decades from sources accounting for nearly 85% of U.S. greenhouse gas emissions, in contrast to the much narrower and more targeted regulations under the Clean Air Act. Finally, the specific claims of harm to certain industries, such as coal companies, fail to provide any evidence of a connection between trends in those industries and EPA regulation. (3) To the extent there are costs associated with greenhouse gas reductions, granting a stay will increase those costs, for three reasons. First, a stay will exacerbate rather than ameliorate regulatory uncertainty. Second, greenhouse gases build up in the atmosphere, and their effects are cumulative. The longer we wait to begin reducing greenhouse gas emissions, the faster we will have to cut emissions in the future in order to avoid the potentially catastrophic consequences of climate change. As a result, delay will only drive up the costs of meeting this challenge later. Third, delaying regulation also means delaying a critically important spur to the development of new technologies that can reduce costs in the long run.

I. There Are Significant Economic Benefits From Current Reductions in Greenhouse Gas Emissions

4. Actions to curb greenhouse gas emissions reduce the likelihood and potential extent of dangerous climate change. From an economic perspective, the benefits of reducing those emissions are the avoided damages that would otherwise occur from unchecked climate change.

There is a strong scientific consensus on anthropogenic climate change. The effects will be felt throughout the United States, and in many cases are already being observed.

5. The most respected scientific bodies in the world, including the national academies of 13 countries (including all of the G8 countries)[1], have reviewed the extensive scientific evidence and concluded that global warming is occurring and that it is due primarily to human-induced emissions of greenhouse gases. The Intergovernmental Panel on Climate change (IPCC), established by the United Nations and the World Meteorological Organization to provide the world with "a clear scientific view" on climate change, states that "Warming of our climate system is unequivocal, as is now evident from observations of increases in global average air

[1] Academies of Brazil, Canada, China, France, Germany, India, Italy, Japan, Mexico, Russia, South Africa, United Kingdom, United States. "G8+5 Academies' joint statement: Climate change and the transformation of energy technologies for a low carbon future," May 2009. http://www.nationalacademies.org/includes/G8+5energy-climate09.pdf

and ocean temperatures, widespread melting of snow and ice, and rising global average sea level."[2]

6. An independent and comprehensive review of the evidence earlier this year by the U.S. National Academy of Sciences reached a similar conclusion:

> Science has made enormous progress toward understanding climate change. As a result, there is a strong, credible body of evidence, based on multiple lines of research, documenting that Earth is warming. Strong evidence also indicates that recent warming is largely caused by human activities, especially the release of greenhouse gases through the burning of fossil fuels. Global warming is closely associated with other climate changes and impacts, including rising sea levels, increases in intense rainfall events, and intense heat waves, increases in wildfires, longer growing seasons, and ocean acidification. Individually and collectively, these changes pose risks for a wide range of human and environmental systems. While much remains to be learned, the core phenomenon, scientific questions, and hypotheses have been examined thoroughly and have stood firm in the face of serious scientific debate and careful evaluation of alternative explanations.[3]

7. While discussions about climate change often focus decades into the future, we are already seeing clear evidence of warming. According to the U.S. Global Change Research Program, the U.S. is already experiencing changes from global warming that are projected to continue and worsen, including rising temperatures and sea levels, retreating glaciers, thawing permafrost, lengthening growing seasons, lengthening ice-free seasons in the ocean and on lakes and rivers, earlier snowmelt, and alterations in river flows. Climate change is projected to stress water resources, challenge crop and livestock production, place coastal areas at risk from sea level rise and storm surge, and threaten human health (through changes such as increased heat stress and disease).[4] And a number of analysts have drawn attention to the potential threats to our national security as the effects of climate changes are felt in geopolitically unstable and resource-poor regions of the world.[5]

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[2] Intergovernmental Panel on Climate Change (IPCC). *Climate Change 2007: Synthesis Report*, 2007.
[3] National Academy of Sciences. "Advancing the Science of Climate Change: Report in Brief," 2010.
[4] U.S. Global Change Research Program. "Global Climate Change Impacts in the United States," 2009. http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf .
[5] *See, e.g.*, John M. Broder, *Climate Change Seen as Threat to U.S. Security*, N.Y. Times, Aug. 8, 2009; *Climate Change and Global Security: Challenges, Threats, and Global Opportunities: Hearing Before the S. Comm. on Foreign Relations*, 111th Cong. (2009) (statement of Vice Admiral Dennis McGinn), available at http://foreign.senate.gov/testimony/2009/McGinnTestimony090721p.pdf; U.S. Government Accountability Office, *Key Challenges Remain for Developing and Deploying Advanced Energy Technologies to Meet Future Needs*, 2006, available at http://www.gao.gov/new.items/d07106.pdf; Gen. Charles F. "Chuck" Wald et al., CNA Military Advisory Board, *Powering America's Defense: Energy and the Risks to National Security*, at i, vii, x, 2009, available at

8. A growing body of research has estimated the quantitative economic damages that would result from unmitigated climate change. These economic estimates are typically based on the results of integrated assessment models (IAMs), in which a scientific model of the predicted physical impacts of climate change is paired with a socio-economic model that evaluates the economic impact of these effects. The damages are often expressed as reductions in economic output as measured by gross domestic product. These GDP figures correspond to estimates of total damages resulting from a specified rise in mean global temperature. Alternatively, the damages from climate change can be expressed in *marginal* terms – that is, per ton of emissions. This measure is also known as the "social cost of carbon." As discussed below, however, these estimates – while crucial inputs to policy making – are also incomplete. Whether expressed in total or marginal terms, any quantitative measure of the damages from climate change is almost surely underestimated, due to the difficulties of accurately quantifying and valuing the full range of damages from climate change.

The damages from climate change can be estimated in monetary terms, although those estimates are incomplete and very likely to underestimate the true damages. Even so, the estimates for aggregate damages are very large.

9. Although the science is clear, and the consequences real, expressing the damages from climate change in monetary terms is difficult. Unmitigated climate change could have catastrophic consequences on ecosystems and human health well beyond our experience. Many of these consequences will arise decades from now, making the estimation of the magnitude highly sensitive to how we trade off the welfare of future generations for our own. And while climate change will adversely affect economic sectors that produce market goods and services (such as agriculture and forestry), the non-market impacts are of greatest concern, including widespread species extinction, vector-borne diseases and heat-related illnesses, and the disruption of coastal communities. Because the economic value of non-market impacts is not revealed through market prices, these impacts are hard to quantify and can only be approximated through a range of imperfect economic techniques. Nonetheless, these impacts are real, indeed profound, and are likely to have a large impact on global prosperity, human health and well-being.

10. Fully capturing the damages from climate change remains a challenge for integrated assessment models. One problem is simply the mismatch between projected temperature changes under a business-as-usual emissions trajectory, and what is known about damages. As a recent National Academy report concludes,

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http://www.cna.org/documents/PoweringAmericasDefense.pdf; Peter Schwartz & Doug Randall, *An Abrupt Climate Change Scenario and Its Implications for United States National Security*, 2003.

> Estimates of total climate damage also depend critically on the degree of temperature change that is being assessed. … [Most studies] focus on a benchmark warming scenario of 2.5-3.0°C, corresponding to best estimates of eventual temperature change from a doubling of GHG concentrations. … Yet in the absence of substantial mitigation action, projections of baseline GHG emissions tend to imply estimates of likely temperature increases that are significantly greater than that associated with a doubling of GHG concentrations. For example, the IPCC [Fourth Assessment Report] references plausible projections … of about 5-6°C and a likely range from just under 4°C to over 8°C. But little is known about the precise shape of the temperature-damage relationship at such high temperatures.[6]

11. Beyond the *levels* of damages, the nonlinearity of climate responses remains a particular challenge. The distribution of damages from greenhouse gas emissions is highly skewed, with a long right-hand "fat tail" of relatively low-probability but potentially catastrophic events including fundamental disruptions in ocean circulation, irreversible sea level rise of several meters, or severe biodiversity loss. Recent work by Martin Weitzman at Harvard has demonstrated that such "fat tails" cause deep problems with the conventional cost-benefit analysis approach at the heart of integrated assessment modeling.[7] For this reason, the National Academy study found that IAMs are poorly equipped to incorporate such potentially catastrophic effects:

> [T]he possibility of extreme events is not well handled by IAMs in calculating the marginal damages of CO_2. … Clearly, the nature of the probability distribution of catastrophic outcomes matters, and is handled only imperfectly …. The key problem here is that low-probability extreme-impact events located in the fat tails, which are extremely difficult to quantity, might drive the results of cost-benefit analysis.[8]

12. In sum, the outputs of integrated assessment models are the best estimates available of the economic damages from climate change – but these estimates are very likely to understate the true damages, perhaps dramatically, because of the gaps in knowledge and the difficulty in quantifying potentially catastrophic damages.

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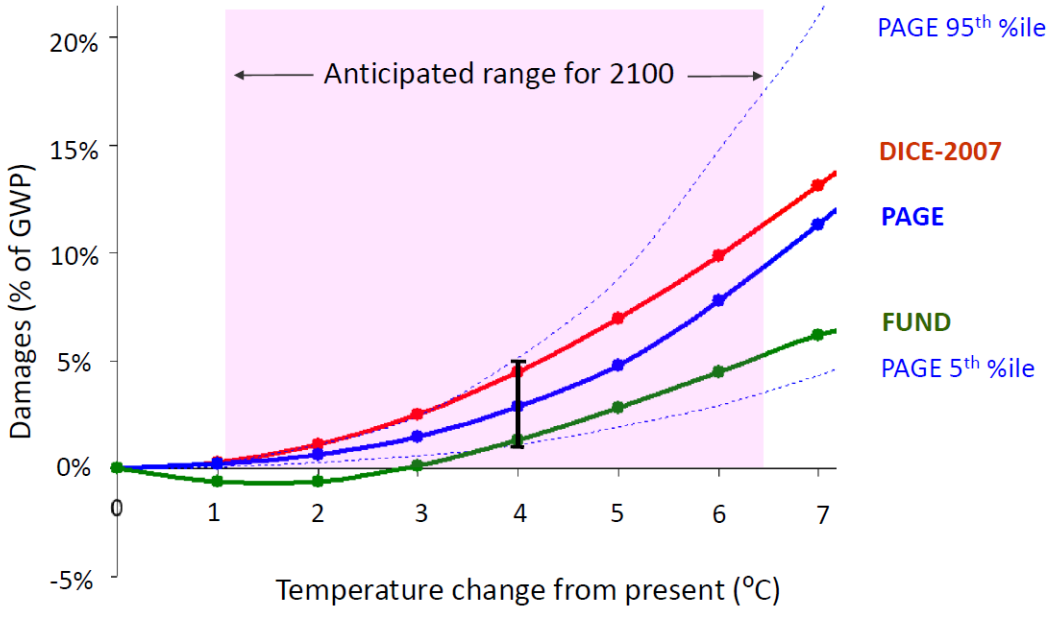
[6] National Research Council of the National Academies, *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use* (Washington D.C.: The National Academies Press, 2010), p. 213.
[7] Weitzman, Martin L. "On Modeling and Interpreting the Economics of Catastrophic Climate Change," *The Review of Economics and Statistics*, 91(1): 1-19 (2009).
[8] National Research Council, *Hidden Costs of Energy, op. cit.*, pp. 210-11.

13. Figure 1 illustrates the range of climate damage estimates for three commonly cited integrated assessment models: DICE, FUND, and PAGE. The increase in mean global temperature from the present (measured in degrees Celsius) is plotted on the horizontal axis, while the estimated damages are on the vertical axis. The estimated damages represent annual reductions in gross world product (GWP) due to climate change as a function of temperature. The three solid lines in the figure represent the damage functions for the three leading integrated assessment models; the dashed lines represent the 90-percent confidence interval for one of the models (PAGE) that explicitly incorporates uncertainty. The shaded area on the figure spans 1.1 to 6.4 °C (2 to 11.5 °F) – the range of anticipated temperature increases relative to the present day by the end of this century, according to scientific modeling. That expected increase is additional to the 1.4 °F (0.6 °C) temperature increase already experienced over the past century.[9]

14. Two conclusions emerge from Figure 1. First, for a central estimate of global warming by the end of this century (4°C), expected economic damages could be as high as 5 percent of GWP. (For reference, this is more than the entire economic output of France or the United

Figure 1. Estimated damages from climate change (percent reduction in gross world product) as a function of mean global temperature change relative to the present, for three integrated assessment models (IAMs). The anticipated range of temperature increases by the end of this century is denoted by the shaded area. (*Source*: Interagency working group report on the social cost of carbon, cited in footnote 13.)



[9] National Academy of Sciences. "Advancing the Science of Climate Change: Report in Brief," 2010.

Kingdom). These damages are substantially greater than the estimated costs of reducing emissions, as we will see below. Second, damages rise rapidly with temperature, and at an increasing rate. For a temperature rise of 6 °C – well within the range of possible outcomes during this century – these models estimate damages of 5 to 10 percent of GWP. Moreover, in the absence of measures to reduce greenhouse gas emissions, atmospheric concentrations and temperatures will continue to climb, causing damages to rise even further. And as we have seen above, these estimates almost certainly *understate* the true costs of climate change, since they do not fully account for impacts on non-market amenities such as human health and ecosystems.

15. These estimates are consistent with the findings of the IPCC, which estimates annual damages of 1.5 to 3.5% of GWP resulting from a doubling of atmospheric greenhouse gas concentrations relative to preindustrial levels, with damages increasing dramatically to 11% of GWP for a warming of 6°C.[10] As the IPCC emphasizes, the reported range should be regarded as a lower bound, because the studies underlying these estimates considered only a subset of possible impacts from climate change, in some cases ignoring nonmarket impacts or catastrophic consequences altogether.[11]

The damages from climate change can also be measured as the present value of damages, today, per ton of carbon dioxide emitted.

16. The "social cost of carbon" (SCC) is a measure of the incremental damage resulting from one additional metric ton of greenhouse gas emissions (on a CO_2-equivalent basis), expressed in present-value terms. Conceptually, the SCC captures the full economic cost to society of emitting a ton of greenhouse gases *today*, taking all future impacts into account. It is derived using the same integrated assessment models as described above. As a result, the omissions and gaps in our understanding of the full economic damages from climate change imply that the available estimates of the SCC are almost surely biased downward, understating the true cost of greenhouse gas emissions.

17. A comprehensive review of the SCC was recently completed by an interagency working group in the federal government, comprising representatives from the National Economic

[10] Intergovernmental Panel on Climate Change (IPCC). *Climate Change 1995: Impacts, Adaptation, and Vulnerability,* Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change, R.T. Watson, M.C. Zinyowera, and R.H. Moss, eds. (Cambridge, UK: Cambridge University Press, 1996); and IPCC, *Climate Change 2001: Impacts, Adaptation, and Vulnerability,* Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change, J.J. McCarthy, O.F. Canziani, N.A. Leary, D.J. Dokken, and K.S. White, eds. (Cambridge, UK: Cambridge University Press, 2001).

[11] See the discussion in Yohe, G. *et al.*, "Perspectives on climate change and sustainability," *Climate Change 2007: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson, eds. (Cambridge, UK: Cambridge University Press, 2007).

Council, the Council of Economic Advisers, the Office of Management and Budget, the Environmental Protection Agency (EPA), the Council on Environmental Quality, the Departments of Energy, Transportation, and Interior, and the National Highway Transportation Highway Association (NHTSA).[12] This review represents the most up-to-date assessment of the growing literature on the social cost of carbon. The interagency working group selected four SCC estimates for use in the analysis of prospective federal regulations. For the year 2010, these estimates were $5, $21, $35, and $65 per metric ton of CO2-equivalent emissions (in 2007 dollars) – with each of those values growing over time in real terms (i.e., above inflation). The first three estimates are based on the average SCC across models and socio-economic and emissions scenarios assuming a discount rate of 5, 3, and 2.5 percent, respectively. The fourth value of $65 corresponds to the 95th percentile of the estimated SCC distribution, assuming a 3 percent discount rate; it is included to represent the possibility of higher-than-expected impacts from temperature change further out in the tails of the SCC distribution.

18. One of the central factors in estimating the social cost of carbon is the choice of discount rate, which determines the weight given to future impacts (a lower rate translating into higher weight on the future): in the interagency working group's report, for example, a discount rate of 3% yields an SCC of $21, while a discount rate of 2.5% yields an SCC of $35. As I have argued in detail elsewhere, there are a number of reasons that a relatively low discount rate is appropriate in the case of climate change, including the long time horizon and intergenerational nature of the impacts; uncertainty about future rates of return on capital, which brings down the appropriate long-term discount rate; the disproportionate impact of climate change on nonmarket goods, weakening the correlation with market rates of return; and the risk of catastrophic damages.[13] These arguments support the use of a discount rate at the lower end of the range considered by the interagency group, corresponding to an SCC of between $21 and $35 per ton in 2010.

19. This conclusion is consistent with the results of a recent survey conducted by researchers at the Institute for Policy Integrity at New York University School of Law.[14] The researchers surveyed economists who had published articles related to climate change in one of the top

[12] U.S. Department of Energy(DOE). "Final Rule Technical Support Document (TSD): Energy Efficiency Program for Commercial and Industrial Equipment: Small Electric Motors," Appendix 15A (by the Interagency Working Group on Social Cost of Carbon): "Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866," 2010. http://www1.eere.energy.gov/buildings/appliance_standards/commercial/sem_finalrule_tsd.html.

[13] Joint comments by New York University Institute for Policy Integrity and Environmental Defense Fund, DOCKET ID No. EPA-HQ-OAR-2009-0472; "*Proposed Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emissions Standards and Corporate Average Fuel Economy Standards*" 74 Fed. Reg. 49,454 (Sept. 28, 2009), submitted November 27, 2009.

[14] J. Scott Holladay, Jonathan Horne & Jason A Schwarz, *Economists and Climate Change: Consensus and Open Questions* (Institute for Policy Integrity Policy Brief No. 5, 2009).

twenty-five economics journals during the past fifteen years, asking for their views on the appropriate choice of discount rate (among other questions). The responses centered around 2.5 to 3%, with a median of 2.4%, mode of 3%, and mean of 2.9%; moreover, the middle 75% of participants selected discount rates in the range of 1% to 3.9%. These results support the use of a discount rate of 3% or lower in estimating the social cost of carbon.

20. In addition, the "fat tail" of damages from climate change, discussed above, suggests the importance of considering not only average estimates of the social cost of carbon, but also estimates on the high end of the range. From a public policy perspective, reductions in greenhouse gas emissions can be thought of as a prudent insurance policy against the possibility of catastrophic impacts. For this reason, high-end estimates of the SCC – such as the $65/ton cited in the interagency working group's report, representing the 95th percentile of the estimated distribution of SCC values – are also highly relevant to policy evaluation.

21. The crucial point, for present purposes, is that the social cost of carbon represents the *present value* of the damage that is incurred by society from each ton of GHG emitted *today*. This directly refutes a key claim of Movants, namely that a stay will not impose any harm on any parties or on the environment. To the contrary, the scientific and economic evidence is overwhelming that every ton of GHG emissions emitted today imposes a measurable and significant harm on the environment and on society as a whole. To the extent that a stay would allow increased GHG emissions by delaying regulation, therefore, it undermines the public interest.

22. The SCC values developed by the interagency working group have been incorporated into the analysis of several federal regulations, including greenhouse gas emissions standards for cars and trucks jointly issued by EPA and NHTSA and finalized earlier this year. In that case, using the central estimate of $21/ton, EPA estimated the total monetized benefits from the vehicle rule (over the lifetime of vehicles produced in model years 2012-2016) to be in the range of $192 billion to $240 billion, corresponding to *net* benefits (benefits minus costs) of $140 billion to $189 billion. Environmental Protection Agency, *Final Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards: Regulatory Impact Analysis* (April 2010), Table 1, p. ES-2. That analysis demonstrates, in quantitative terms, the enormous public interest in reducing emissions of greenhouse gases.

II. EPA Regulations of GHGs Under the Clean Air Act Would Not Impose Undue Economic Burden

23. Movants' claims of irreparable harm without a stay are without grounding in evidence. In particular, Movants National Association of Manufacturers, et al. rely heavily on the declarations of Roger Bezdek and Margo Thorning, Exhibits 13 and 19, for macroeconomic evidence of economic harm. These declarations, however, are based on demonstrably biased economic studies and contain rudimentary errors and faults of reasoning. The errors and degree of bias are so great as to call into serious question the expertise of declarants Bezdek and Thorning on these matters. Meanwhile, Movants Coalition for Responsible Regulation, et al., provide no hard evidence of claims of harm to the coal mining industry as a result of EPA regulation; moreover, their claims are contradicted by evidence showing that recent trends in coal demand have been driven by other factors, as well as by market analysis suggesting a *positive* short-term outlook for coal mining companies.

Thorning does not provide any evidence of an increase in the cost of capital, or decrease in investment, associated with EPA's GHG regulations.

24. Movants National Association of Manufacturers, et al., claim that "the uncertainty surrounding EPA's regulatory regime will increase the cost of capital by 6 to 8.5%," citing Thorning's declaration. NAM Motion p. 43. However, this is purely speculation on Thorning's part, and is not based on any objective evidence. The economics literature cited by Thorning concerns the general relationship between the cost of capital and investment (i.e., the elasticity of investment), and says absolutely nothing about the effects of EPA's regulatory action. Nor does Thorning provide any actual evidence that EPA's regulatory regime is affecting investment. Thorning claims that "A recent survey of energy companies by AON Analytics found that regulatory uncertainty is one of the largest risk factors facing new capital investments." Thorning ¶ 20. In fact, the report she cites is focused on general risk management and insurance, and makes no mention whatsoever of the EPA, GHG regulation, or even how regulatory uncertainty might affect capital investment *per se* (as opposed to general corporate risk management).[15]

25. Instead, Thorning simply asserts that a "risk premium" of 30% to 40% would be "appropriate." Thorning ¶ 22. This estimate has no basis in fact; nor does Thorning provide any evidence to support it. Yet this claim is the crucial step in her chain of calculations claiming economic harm. Since her alleged "risk premium" lacks any basis in evidence, the same holds true for her calculated increase cost of capital, and the alleged decrease in U.S.

[15] AON Analytics, *2010 U.S. Industry Report: Energy* (January 2010), available at http://img.en25.com/Web/AON/Aon%20Analytics%20Energy%20Industry%20Report%20Final.pdf .

investment — both of which are based on the supposed risk premium. In summary, Thorning provides absolutely zero evidence for any increase in the cost of capital resulting from EPA's actions, or for any corresponding reduction in investment.

Claims by Bezdek and Thorning of the harm to the U.S. economy from EPA GHG regulations are based on demonstrably biased analyses of climate legislation as well as faulty logic.

26. Both Bezdek and Thorning make grossly exaggerated claims about the economic impacts of EPA regulation on the U.S. economy. In both cases, their claims depend on a two-step argument: first, that an economy-wide cap-and-trade program created by Congressional legislation would have imposed significant costs on the U.S. economy; second, that the regulations at issue adopted by EPA would be more costly than such an economy-wide cap and trade program. Bezdek ¶¶4-5; Thorning ¶¶ 30-33. Neither of the steps in their argument survives scrutiny. The first step in the argument fails because their allegations about the costs of an economy-wide program are based on demonstrably biased analyses. The second step fails on logical grounds, because it inappropriately compares two programs of very different scope, scale, and ambition.

The analyses of cap-and-trade legislation cited by Bezdek and Thorning are severely flawed and demonstrably biased..

27. The first step in the arguments made by both Bezdek and Thorning is a grossly exaggerated claim about the likely impacts of an economy-wide cap and trade program on the U.S. economy. Thorning relies heavily on an analysis paid for by her own organization, the industry-supported American Council for Capital Formation, along with another industry group, the Small Business and Entrepreneurship Council (ACCF/SBEC). Thorning ¶ 33. This analysis, which focuses on the legislation proposed in the Senate by Senators Kerry and Lieberman (the American Power Act (APA)), makes a number of assumptions that are clearly designed to inflate the apparent costs of the legislation. As the study itself proclaims, the assumptions provide the views and judgment of the study's sponsors. However, those assumptions are clear outliers when compared to the assumptions used in credible, objective analyses by government agencies. For example:

- The APA would have allowed regulated entities to meet their compliance obligations by using up to 2 billion "offsets," or credits from verified emissions reductions from uncapped sectors and other countries; ACCF/SBEC arbitrarily assume that only half of the offsets will be available.

- The APA would have allowed unlimited banking of emission allowances as an important way to help smooth costs; ACCF/SBEC arbitrarily limit the extent of banking in the model.

- Standard economic analyses have assumed that allowance prices rise at a rate of 5%, reflecting the rate of return available to alternative investments; ACCF/SBEC arbitrarily set that rate at 10%, resulting in a much steeper rise in prices. (In explaining this choice, they demonstrate a complete lack of understanding about the underlying economic theory behind this rate; it is determined by an arbitrage condition and must equal the outside market rate of return available on other investments, but ACCF/SBEC apparently treat it as independent of the interest rate. This demonstrates a lack of understanding of an elementary concept taught in undergraduate economics courses.)

- Perhaps most importantly, ACCF/SBEC arbitrarily restrict investment in low-emitting electricity generation. This is the most glaring example of bias. For example, ACCF/SBEC assume that new investment in wind power capacity can never exceed 10 MW of capacity in their "Low Cost" case, and 5 MW in their "High Cost" case. This amount is supposed to represent a ceiling on what is technically or financially feasible. In 2009, however, nearly 10 MW of new wind generating capacity was installed — the third straight year in which new capacity exceeded 5 MW, the upper limit ACCF/SBEC assume can never be exceeded in their "High Cost" case.[16]

- Similarly, ACCF/SBEC impose artificial and implausible restrictions on investment in nuclear energy. Their analysis assumes that the cumulative net addition to nuclear generating capacity cannot exceed 10 to 25 GW over the next two decades. By comparison, the Department of Energy's Energy Information Administration (EIA) projected that nuclear capacity would increase by 94 GW over the same period under climate legislation (in a scenario with much lower prices for emission allowances than in the ACCF/SBEC analysis, and therefore much less incentive to build nuclear power plants).

Quite simply, imposing such arbitrary and binding constraints is not a matter of "judgment." Taken together, they present a clear example of bias. The ACCF/SBEC study, for which Thorning had primary responsibility, would not be considered for publication in any academic journal.

[16] http://www.awea.org/pubs/factsheets/Market_Update_Factsheet.pdf

28. Thorning cites the analysis of Senate legislation by the Department of Energy's Energy Information Administration (EIA) in her declaration as support for her conclusions. However, she focuses on the very highest-cost scenario considered by EIA (labeled their "Limited Technology/No International Offsets" scenario). That scenario did not reflect the judgment of EIA analysts about likely outcomes, but instead was requested by certain Senators specifically as a high-cost case. Not surprisingly, that scenario represents an "outlier," with results that are very different from the results in EIA's other scenarios, including the "Basic" scenario that represents the analysts' best estimate of the likely outcome from legislation. For example, the estimated allowance price under the "Limited Technology/No International Offsets" scenario is nearly three times as high as the allowance price in the "Basic" case, and 50% higher than the next most costly scenario. Similarly, the estimated impact of GDP under the "Limited Technology/No International Offsets" case is five times the impact under the "Basic" case, and two and a half times the impact under the next most costly scenario. As Thorning herself points out, her results in the ACCF/SBEC study are similar to those in the EIA's "Limited Technology/No International Offsets" scenario. But since that effectively represents a "worst case scenario" in the EIA analysis, the resemblance does not provide validation for the ACCF/SBEC analysis: to the contrary, it demonstrates how extreme the ACCF/SBEC study's findings actually are.

29. In Bezdek's case, his claim of severe economic harm from an economy-wide cap and trade program is based on a highly selective and demonstrably biased discussion of modeling analyses. Bezdek relies exclusively on three studies of the bill enrolled by the House of Representatives (H.R. 2454, the American Clean Energy and Security Act (ACES)). All three of the studies cited by Bezdek were paid for directly or indirectly by industry groups: the American Council on Capital Formation and National Association of Manufacturers (ACCF/NAM); the National Black Chamber of Commerce (NBCC); and the Heritage Foundation. It is noteworthy that Bezdek neglected to consider the studies performed by government agencies, including EPA and EIA, or by academic researchers.

30. The studies considered by Bezdek include assumptions that are evidently and systematically designed to bias the results of the modeling upward. I have already documented the errors made in the ACCF study of the Senate legislation cited by Thorning: the same errors are also present in the ACCF/NAM analysis of ACES that Bezdek relies on (e.g., artificial constraints on new technologies and on the use of offsets). Similarly, the report by the Heritage Foundation puts drastic and artificial limits on the development of low-carbon technologies. The most glaring example is its assumption that carbon capture and sequestration technology "will not be available in significant quantities" over the next twenty-five years at any carbon price — despite the facts that CCS is technically feasible today, that four CCS projects are

already up and running, that nearly two hundred planned CCS projects in 28 countries have been identified, and that continued research, development, and deployment of CCS is the subject of massive continued investment in both the EU and the U.S. Heritage simultaneously and arbitrarily assumes that no additional nuclear power generation will be built as a result of climate legislation (in other words, it restricts new nuclear capacity to be the same as under "business as usual," despite the very high carbon prices that the Heritage analysis predicts will occur as a result of cap and trade legislation). Finally, Heritage sharply restricts the available supply of offset credits (emissions reductions from uncapped sectors) and appears to ignore allowance banking, a crucial tool for cost containment. All of these assumptions act in concert to drive up the modeled costs of legislation. In making such assumptions the authors of these reports have deliberately placed a very heavy "thumb on the scale" to generate their desired conclusion.

31. Table 1 (next page), taken from a report by the nonpartisan Congressional Research Service, illustrates the extreme nature of the technological assumptions in the Heritage and ACCF/NAM studies. The table compares the assumptions about the availability of key electricity generating technologies through the year 2030 in various modeling analyses. What is striking from the table is the extreme nature of the arbitrary limits placed on multiple low-carbon technologies in the ACCF/NAM and the Heritage Foundation (labeled HF/GI) analyses — limits that are far below the levels that other models predict will be built. For example, the Heritage Foundation restricts both nuclear power and CCS to levels far below the forecasts of most of the other studies. Similarly, the ACCF/NAM study places sharp limits on nuclear power and renewables, as well as constraining CCS. The inevitable result is to bias the estimated costs of climate legislation upward.

Table 1. New electric generating capacity in economic models of climate legislation: projections and constraints. (*Source:* Reproduced from Congressional Research Service, *Greenhouse Gas Legislation: Summary and Analysis of H.R. 2454 as Passed by the House of Representatives* (July 27, 2009), p. 54).

Case	Nuclear Power	Renewable Power	Natural Gas-Fired	Coal with CCS	Baseline Year
EPA/ADAGE	69 GW (built)	77 GW (built)	little	43 GW (built)	2010
EPA/IPM (2025)	1 GW (built)	41 GW (built)	5 GW (built)	16 GW (new)	2010
				9 GW (retrofit) (built)	
NBCC/CRA/LOW	42 GW (built)	76 GW (built)	59 GW (built)	3 GW (built)	not stated
HF/GI	17 GW (limit)	92 GW (limit)	substantial (built)	insignificant (limit)	not stated
EIA/NEMS/BASIC	100 GW (built)	120 GW (built)	40 GW (built)	68 GW (built)	2007
ACCF-NAM/NEMS/LOW	25 GW (limit)	15 GW/year (limit)	substantial (built)	30 GW (limit)	not stated
MIT/EPPA	0 GW (built)	about 73 GW (built)	about 145 GW (built)	21 GW (built)	2010
EIA AEO April 2009 Baseline	10.6 GW	87.5 GW	138.9 GW	36.6 GW (no CCS)	2007

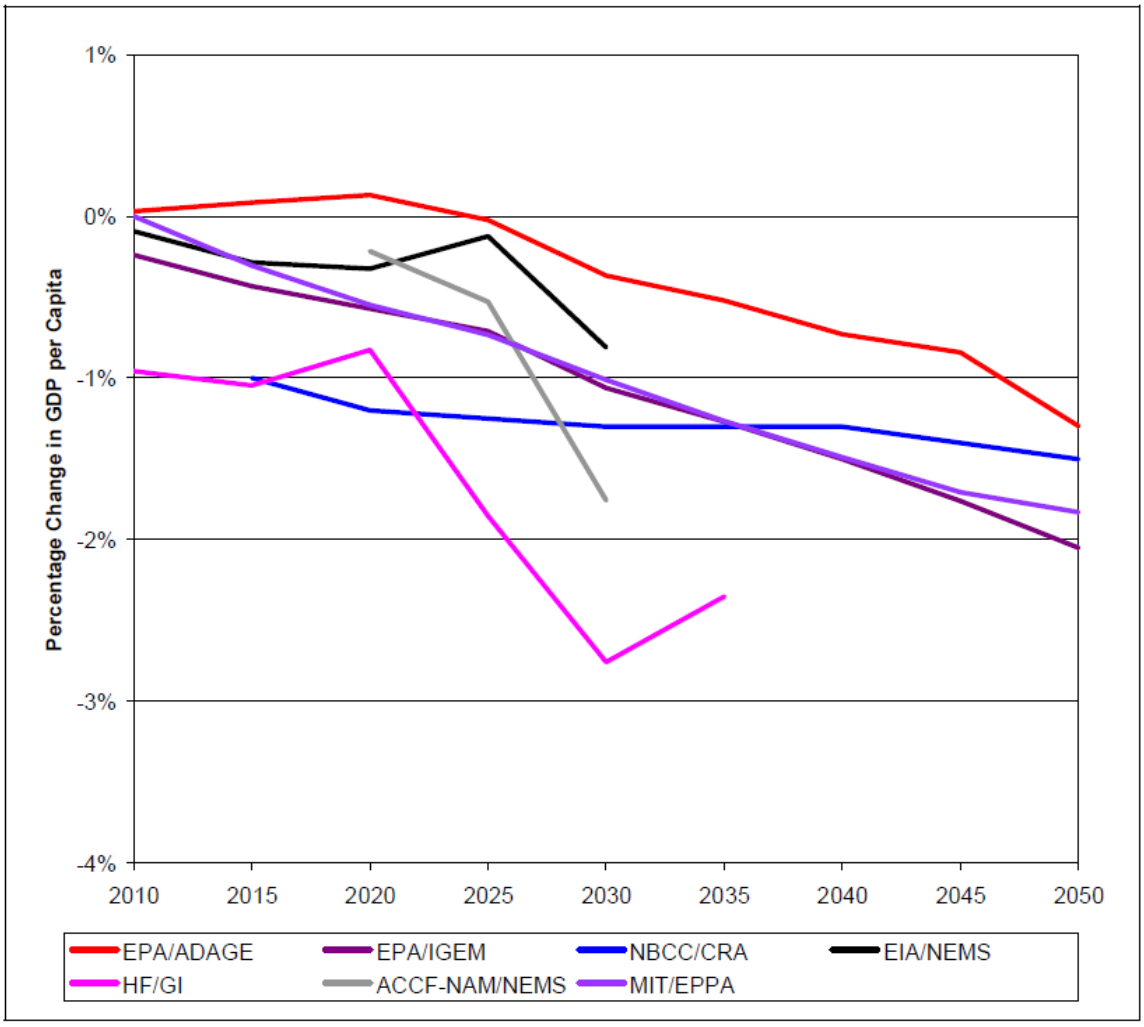
Source: EPA/ADAGE and EPA/IPM: "Data Annex" available on the EPA website at http://www.epa.gov/climatechange/economics/economicanalyses.html. MIT/EPPA: Sergey Paltsev, et al., "Appendix C" of Paltsev et al., *The Cost of Climate Policy in the United States*, MIT Joint Program on the Science and Policy of Global Change (2009). EIA/NEMS: EIA, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009*, (August 2009). ACCF-NAM/NEMS: SAIC, *Analysis of The Waxman-Markey Bill "The American Clean Energy and Security Act of 2009" (H.R. 2454) Using The National Energy Modeling System (NEMS)*, report by the ACCF and NAM (2009). NBCC/CRA: CRA International, *Impact on the Economy of the American Clean Energy and Security Act of 2009 (H.R. 2454)* (May 2009). HF/GI: The Heritage Center for Data Analysis, *The Economic Consequences of Waxman-Markey: An Analysis of the American Clean Energy and Security Act of 2009* (August 5, 2009).

Notes: "Limit" means the analysis limited the amount of capacity that could be built—it is not necessarily the amount the model determined would be built if the limitation was removed. **"Built"** is the amount the model projected to be built. **"About"** is an estimate by CRS of the additional capacity necessary for the increased electricity production projected by the model between 2010 and 2030 under H.R. 2454 in the absence of capacity data being provided. The estimates were calculated assuming an 80% capacity factor for biomass, 90% for nuclear power and coal, 48% for renewables, and 85% for natural gas.

32. Not surprisingly, they results of the studies represent dramatic outliers relative to more credible and objective analyses. Figure 2 (next page), also taken from the CRS report, demonstrates this pattern with respect to the predicted impacts of climate policy on GDP per capita. The impacts on three studies cited by Bezdek consistently show the largest impacts In the year 2030 — the year used as a reference point by Bezdek in his testimony (see, e.g., p. 3 of Bezdek's attached study) — the three studies cited by Bezdek show the largest estimated impacts on GDP per capita of the analyses considered by CRS. Notably, the other studies considered by CRS were performed by government and academic researchers. The clear

conclusion from the figure is that the analyses cited by Bezdek are outliers, outside of the mainstream of credible, respected analyses. Indeed, they appear to have been selected to exaggerate the economic impacts of climate legislation.

Figure 2. Estimated percentage difference in GDP per capita under cap-and-trade legislation (H.R. 2454) relative to a reference case without policy (*Source:* Reproduced from Congressional Research Service, *op cit.*, p. 37).



Note: Reductions are relative to each model's reference case baseline.

Sources: CRS Analysis of data from each model. EPA/ADAGE and EPA/IGEM: "Data Annex" available on the EPA website at http://www.epa.gov/climatechange/economics/economicanalyses.html. MIT/EPPA: Sergey Paltsev, et al., "Appendix C" of Paltsev et al., *The Cost of Climate Policy in the United States*, MIT Joint Program on the Science and Policy of Global Change (2009). EIA/NEMS: EIA, *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009*, (August 2009). ACCF-NAM/NEMS: SAIC, *Analysis of The Waxman-Markey Bill "The American Clean Energy and Security Act of 2009" (H.R. 2454) Using The National Energy Modeling System (NEMS)*, report by the ACCF and NAM (2009). NBCC/CRA: CRA International, *Impact on the Economy of the American Clean Energy and Security Act of 2009 (H.R. 2454)* (May 2009). HF/GI: The Heritage Center for Data Analysis, *The Economic Consequences of Waxman-Markey: An Analysis of the American Clean Energy and Security Act of 2009* (August 5, 2009).

33. In summary, Bezdek's report is based on a highly selective and biased set of analyses. Moreover, as argued above, Bezdek compounds the error by drawing a faulty and completely inappropriate comparison between a comprehensive cap-and-trade program and a dramatically narrower program under the Clean Air Act. The bottom line is that Bezdek's study is simply irrelevant to the question of the impacts of EPA regulation on the U.S. economy.

34. In contrast to the alarmist findings cited by Thorning and Bezdek, credible economic analyses of economy-wide cap-and-trade legislation have projected much smaller impacts on the U.S. economy. For example, together with colleagues at Environmental Defense Fund, I recently surveyed the economic analyses of climate legislation by EPA, EIA, and researchers in academia and government laboratories. [17] In those analyses, the median estimated impact on U.S. economic output over the period 2010 to 2030 is less than half a percent (0.5%), with an average of under 0.6% (measured in present-value terms, relative to a scenario without climate policy). Moreover, these estimated impacts are relative to a growing economy. Over the next two decades, for example, the U.S. economy is projected to grow by somewhat more than 2.5% per year, reaching a level in 2030 that is 70% larger than today. Against that backdrop, the estimated effect of climate legislation on the rate of economic growth would be almost imperceptible: just two to five hundredths of a percentage point annually (0.02 - 0.05%). To put these numbers in context: the models suggest that if the American economy will reach a size of $25 trillion in January 2030 under "business as usual," it will get there sometime between March and May of that year with a cap on carbon. In short, the overwhelming conclusion from credible, objective analyses of economy-wide climate legislation is that ambitious reductions in greenhouse gas emissions are entirely consistent with robust economic growth.

Bezdek and Thorning draw an invalid comparison between economy-wide cap-and-trade legislation and the narrowly targeted EPA regulations at issue in this case.

35. The second step in the argument made by Bezdek and Thorning is logically flawed because it is based on an invalid comparison between policies with very different aims. Both Bezdek and Thorning claim that the cost of the challenged EPA regulations must be higher than the costs of economy-wide cap-and-trade legislation, appealing to the standard result from economic theory that market-based policies such as cap and trade are cost-effective. It is true

[17] Environmental Defense Fund. "What will it cost to protect ourselves against potentially catastrophic global warming?," EDF Climate Economics Brief, October 2009. http://www.edf.org/documents/10458_EDF_Cost-Brief_Oct2009.pdf. The studies considered included the analyses of H.R. 2454 by EIA, EPA, and MIT; analyses by the same groups of previous Senate legislation (S. 2191 in the 110th Congress, the Lieberman-Warner Climate Security Act of 2007); and a set of earlier analyses of "generic" cap and trade legislation by researchers at MIT, Research Triangle Institute, and the Department of Energy's Pacific Northwest National Laboratory.

that market-based policies can (in theory) achieve a given level of abatement at the lowest total cost, and therefore that prescriptive regulations are generally more costly *for a given emissions reduction target*. But that is simply irrelevant in the current context, where the two programs are of such vastly different scope and scale:

- The cap-and-trade programs proposed under Congressional legislation would have had a time horizon of forty years (through the middle of the century), achieving reductions of more than 80% relative to 2005 levels by the year 2050. To meet that goal, the proposed legislation would have covered nearly 85% of U.S. greenhouse gas emissions, across all major sectors of the U.S. economy: over 10,000 new and existing stationary sources (emitting above a threshold of 25,000 tons per year of greenhouse gases), including the electric power sector; oil refiners and importers of refined petroleum products; and natural gas distributors. The tradeable emission allowances created by such legislation would have put a price on emissions of carbon dioxide and greenhouse gases, estimated at roughly $15 to $20 per metric ton of CO_2 in the initial years. This price, transmitted throughout the economy, is what creates the economic incentive to reduce emissions.

- In contrast, the regulations promulgated by EPA are much narrower and more targeted. They address emissions from mobile sources by strengthening fuel economy standards and limiting greenhouse gas emissions for newly manufactured vehicles. Only the largest stationary sources (with emissions above 75,000 tons per year) will be required to meet EPA's Best Available Control Technology (BACT) standard. Even among those sources the regulations will affect only new and modified stationary sources and will be carried out on a case-by-case basis taking cost into account. EPA anticipates that the preconstruction review BACT requirement for GHGs will affect only about 900 additional projects a year.

In sum, the estimated costs of comprehensive economy-wide legislation over the next several decades are irrelevant to an assessment of the impacts of the limited and targeted EPA regulation in this case. Given the narrow scope of EPA's actions, there is no reason to anticipate any significant increase in the prices of electricity, fuels, or consumer products as a result of EPA's actions over the next 18 months, the period relevant to a potential stay.

36. Crucially, the claims Bezdek and Thorning make about the costs of EPA regulation provide the basis for much of the rest of their declarations. As a result, the fundamental flaws in their analysis of costs must also prove fatal for their other claims. In particular, Thorning's claims regarding the impacts of EPA regulations on the competitiveness of U.S. manufacturing (Thorning ¶¶ 36-37, 39) relies on the invalid comparison with economy-wide cap and trade

legislation (e.g., "Therefore, analyses like the one performed on the Kerry/Lieberman bill can be used to benchmark the harm from EPA's Clean Air Act GHG program," Thorning ¶36; "EPA regulation of GHGs will raise production costs for regulated entities similarly to cap and trade systems," Thorning ¶37). In fact, Thorning presents no evidence that EPA regulations will have such effects, especially over the near-term period relevant to a stay. Instead, her reasoning depends entirely on the flawed analysis of completely different legislation, as discussed above.

37. Similarly, the biased and flawed studies of cap and trade legislation that Bezdek relies on provide the crucial foundation for everything that follows in his report. As Bezdek himself states, "We analyze the available studies on the costs of economy-wide greenhouse gas controls. Importantly, the available analyses are all related to the costs of such controls implemented by legislation – through cap-and-trade proposals" (Bezdek, attached study, at iii). Because those analyses reveal nothing about the cost of EPA regulation at issue here, Bezdek has failed to provide any evidence whatsoever to support his claims that EPA regulations would reduce GDP, employment, or household income, or raise prices. By extension, he fails to provide any evidence for any of his subsequent claims. Literally the *entire body* of the study attached to his declaration ("Potential Harm of EPA Greenhouse Gas Control Regulations to Minorities, Low-income Persons, the Elderly, and Those Living on Fixed Incomes") – all 62 pages (including front matter) – is utterly and completely irrelevant to the questions at issue in this case.

Movants provide no evidence of harm to the coal mining industry from EPA regulation. On the contrary, available evidence underscores the role of other economic factors in recent trends in coal demand. In addition, recent market analysis suggests a positive short-term outlook for specific coal companies, contradicting their claims of impending harm.

38. Movants Coalition for Responsible Regulation, et al., claim that EPA regulation will cause irreparable harm to coal mining companies, relying heavily on the declarations by Michael Peelish (CRR Exh. 22) and James R. Barker (CRR Exh. 24), which claim that impending EPA regulations are lowering demand for coal. For example, Peelish speculates that "a number of our utility customers are switching units to natural gas, dropping planned expansions, or shutting down coal-fired facilities altogether as a result of, in large part, costs associated with the pending regulation of greenhouse gases." Peelish ¶12. However, he altogether ignores other compelling economic factors that have contributed to the trends he observes. For example, the major driver of coal-to-gas switching is the price of natural gas relative to coal. According to statistics compiled by the Energy Information Administration, natural gas prices plummeted by over two-thirds from a peak in July 2008 to September

2009, and have remained at relatively low levels over the past year.[18] Market analysts have singled this out as a major factor in reduced demand for coal, e.g., a recent report by Goldman Sachs Global Investment Research: "we estimate [coal to gas substitution] destroyed more than 45 MM tons of demand in 2009 and 7 MM tons through March 2010."[19] Coal demand is also closely tied to overall demand for electric power generation, which decreased in 2008 and again in 2009 as a result of the economic downturn.[20]

39. Similarly, observed cancellations in coal-fired power plants have been driven by other factors. For example, more than two dozen coal power plant projects were cancelled or delayed indefinitely between 2006 and early 2008 — well before the regulations at issue in this case were being contemplated by EPA.[21] A major factor cited in several of the cancellations has been rising construction costs: According to the Power Capital Costs Index (PCCI) developed by IHS and Cambridge Energy Research Associates (CERA), power plant construction costs rose 76% between 2005 and 2008.[22]

40. Ironically, contrary to the predictions of "irreparable harm" to coal companies predicted by Peelish, Wall Street analysts are quite favorable. For example, as recently as July 2010, Goldman Sachs rated the stock of Alpha Natural Resources a "Buy." Citing the probability of strengthening coal demand as well as the company's own market position, Goldman projected robust returns in the near term. No mention at all is made of these EPA regulations.[23]

III Delaying Regulation Will Drive Up the Costs of Reducing GHG Emissions

Granting a stay will exacerbate rather than ameliorate uncertainty.

41. I showed above that Thorning fails to provide any evidence for her claims of an increased cost of capital (with resulting decreases in investment) resulting from EPA regulations. If anything, the reverse is more likely to be true. To the extent that uncertainty about GHG regulations may delay capital investment, a stay would *exacerbate* such uncertainty. EPA has already promulgated regulations clarifying the nature and scope of its anticipated

[18] Energy Information Administration, *Natural Gas Monthly* (September 2010), Table 21.
[19] Goldman Sachs Global Investment Research, *Americas: Energy: Coal*, July 9, 2010, p 12.
[20] Energy Information Administration, *Electric Power Annual 2008* (August 2010), p. 1; *Electric Power Monthly* (October 2010), Table 1.1.
[21] Rick Duke and Dan Lashof, "The New Energy Economy: Putting America on the Path to Solving Global Warming," Natural Resources Defense Council Issue Paper (June 2008), p. 9; available at www.nrdc.org/globalwarming/energy/eeconomy.pdf.
[22] http://energy.ihs.com/News/Press-Releases/2008/North-American-Power-Generation-Construction-Costs-Rise-27-Percent-in-12-Months-to-New-High-IHS-CERA.htm
[23] Goldman Sachs Global Investment Research, *Americas: Energy: Coal*, *op. cit.*, p. 20.

regulation of stationary sources. By delaying those regulations, a stay will prolong the period of "limbo" before the regulations take effect. The most important step that could be taken to enhance certainty would be to allow EPA to move ahead with its obligations under the law, and implement the regulations it has already announced.

Delaying emissions reductions now will make more rapid reductions necessary in the future, driving up the costs.

42. Given the overwhelming scientific evidence of anthropogenic climate change, and the concomitant need for action to reduce GHG emissions, the most economically sensible approach is to start as soon as possible. A crucial aspect of climate change is that it results from the accumulation of GHGs in the atmosphere; current emissions of carbon dioxide will contribute to elevated atmospheric CO_2 concentrations for hundreds of years. As a result, the higher emissions are in the near term, the more sharply they must be reduced in the future in order to stabilize atmospheric concentrations at any desired level. Delaying emissions reductions today — as would result from an injunction on GHG regulations — therefore makes it more expensive to meet any given target.[24]

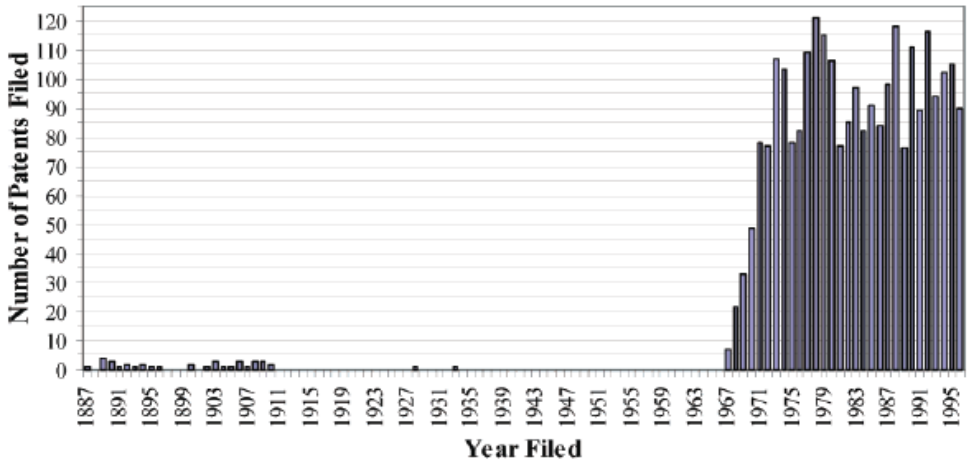
Technological innovation spurred by regulation can play a crucial role in reducing future costs.

43. Delaying EPA regulation can also drive up future costs in another way, by delaying the process of technological innovation. The history of experience with environmental policy demonstrates that regulation plays a central role in spurring new technologies.[25] Figure 2, below, provides a particularly dramatic example of this linkage between regulation and innovation: patent filings for technologies to control sulfur dioxide emissions from power plants, which were essentially zero before the advent of air pollution regulations, increased dramatically skyrocketed in the years immediately following the passage of clean air legislation in the U.S. Congress.

[24] *See* Gary Yohe, Natasha Andronova, and Michael Schlesinger, "To Hedge or Not Against an Uncertain Future?", *Science* 306 (15 October): 416-17 (2004).

[25] *See* Jean Olson Lanjouw and Ashoka Mody, "Innovation and the International Diffusion of Environmentally Responsive Technology," *Research Policy;* Adam B. Jaffe and Karen Palmer, "Environmental Regulation and Innovation: A Panel Data Study," *Review of Economics and Statistics*, 79 (4): 610-619 (1997); Margaret R. Taylor, Edward S. Rubin, and David A. Hounshell, "Effect of Government Actions on Technological Innovation for SO_2 Control," *Environmental Science & Technology* 37(20): 4527-4534 (2003); and David Popp, "International innovation and diffusion of air pollution control technologies: the effects of NO_x and SO_2 regulation in the US, Japan, and Germany," *Journal of Environmental Economics and Management* 51(1): 46-71 (2006). *See also* Bansari Saha, Barry Galef, Lou Browning, and Jim Staudt, *The Clean Air Act Amendments: Spurring Innovation and Growth While Cleaning the Air*, report prepared by ICF Consulting for the EPA Office of Air and Radiation (October 27, 2005).

Figure 3. U.S. patent filings relevant to sulfur dioxide control technology, by year. The Air Quality Act was passed in 1967; the landmark Clean Air Act, establishing a system of federal clean air standards and controls on stationary sources, was passed in 1970. (*Source*: Reproduced from Taylor *et al.*, *op. cit.*))



As I have written elsewhere, and as the economics literature has established, a market-based system (such as a cap-and-trade program) is preferable in this respect to a prescriptive approach, even one that (like Best Available Control Technology) takes into account cost. Nonetheless, a prescriptive approach is strongly preferable on these grounds to no regulation at all, since in the absence of regulation there is little to no incentive for technological innovation.

I, Nathaniel O. Keohane, declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct to the best of my knowledge. Executed this 31st day of October, 2010.

Nathaniel O. Keohane