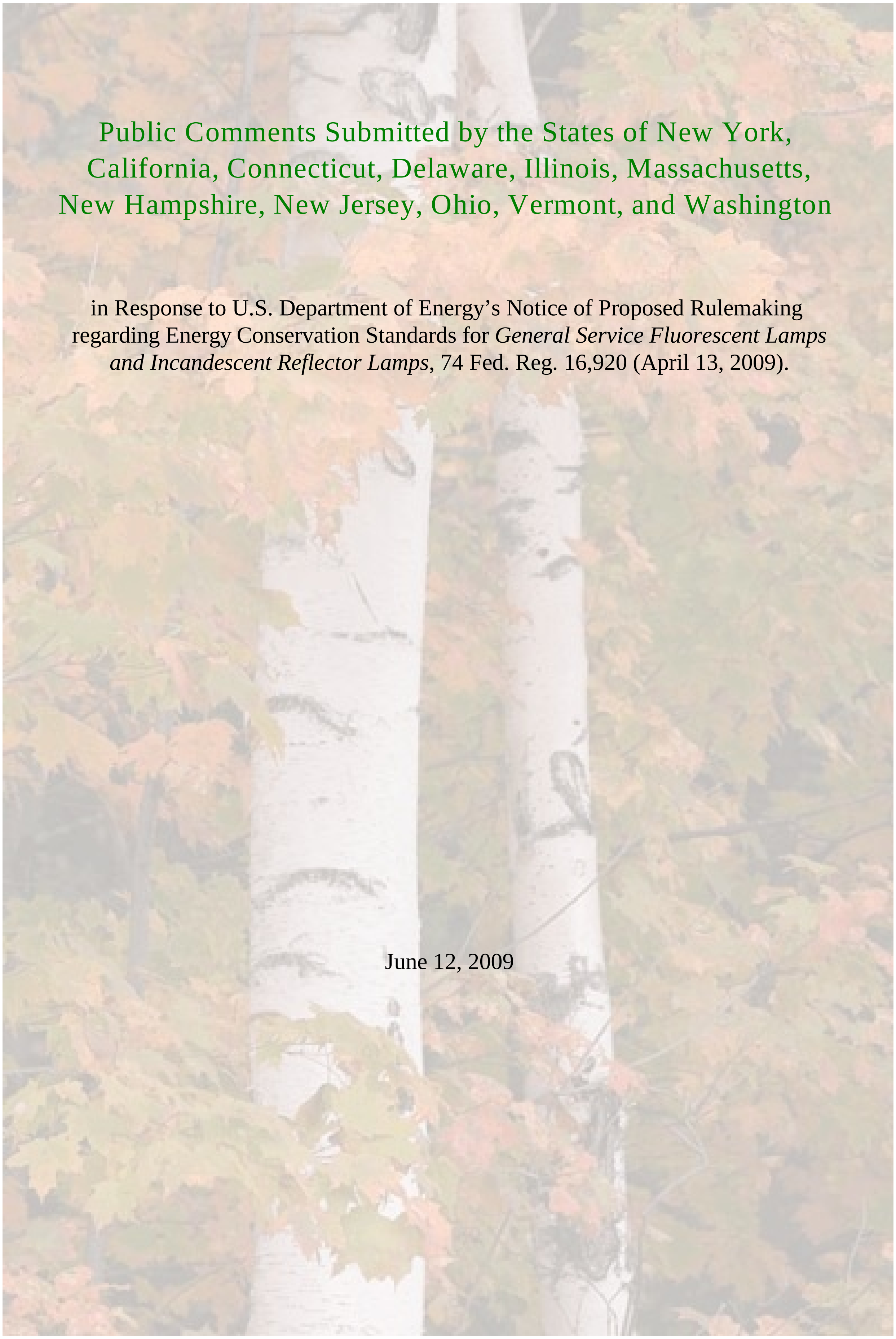

# Public Comments Submitted by the States of New York, California, Connecticut, Delaware, Illinois, Massachusetts, New Hampshire, New Jersey, Ohio, Vermont, and Washington

in Response to U.S. Department of Energy's Notice of Proposed Rulemaking regarding Energy Conservation Standards for *General Service Fluorescent Lamps and Incandescent Reflector Lamps*, 74 Fed. Reg. 16,920 (April 13, 2009).

June 12, 2009

June 12, 2009

Ms. Brenda Edwards-Jones
U.S. Department of Energy
Building Technologies Program
Mailstop EE-2J
1000 Independence Ave., S.W.
Washington, D.C. 20585-0121

Re: Energy Conservation Program: Energy Conservation Standards for General Service Fluorescent Lamps and Incandescent Reflector Lamps, 74 Fed. Reg. 16,920 (April 13, 2009)

Dear Ms. Edwards-Jones:

The States of New York, California, Connecticut, Delaware, Illinois, Massachusetts, New Hampshire, New Jersey, Ohio, Vermont, and Washington (collectively, "the States")[1] submit these comments in response to the United States Department of Energy's ("DOE's") Notice of Proposed Rulemaking ("NOPR") regarding Energy Conservation Standards for General Service Fluorescent Lamps ("fluorescent lamps") and Incandescent Reflector Lamps ("reflector lamps"), 74 Fed. Reg. 16,920 (April 13, 2009). The States focus their comments on the need for DOE to adopt energy efficiency standards that are consistent with the country's need to conserve energy and address global climate change.

The connection between heat trapping pollutants, such as carbon dioxide ("$CO_2$"), and climate change is now well documented, as are the effects of climate change on the States. Implementation of stringent energy efficiency standards remains the <u>most</u> cost-effective mechanism for reducing $CO_2$ emissions. The States thus recommend that, in amending the standards for fluorescent and reflector lamps, DOE apply a policy formulation that emphasizes the critical need to reduce $CO_2$ emissions. The States also recommend that DOE estimate the monetary benefits of reduced $CO_2$ emissions associated with each standard, and to base that estimate on the long-run marginal abatement cost of $CO_2$. Under this approach, the value of $CO_2$ emissions reductions is based on the cost of achieving a sustainability target of $CO_2$ in the atmosphere. This approach benefits from the growing consensus that $CO_2$ emissions need to be reduced by about 80% of pre-industrial levels in order to minimize the adverse public health and environmental impacts of global climate change.

We attach for your further consideration the States' more specific comments and the report of Synapse Energy Economics, Inc. that supports those comments.

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[1] Oregon, which has filed its own separate comment letter, also endorses the comments here.

Respectfully Submitted,

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## INTRODUCTION

The States are already being impacted adversely by global climate change and are undertaking numerous energy conservation efforts to address the matter. Unfortunately, the States lack authority over the most cost-effective means to reduce both energy demand and the $CO_2$ emissions associated with the generation of energy: Requiring appliance manufacturers to meet minimum energy efficiency standards. By contrast, DOE has broad authority under the Energy Policy Conservation Act ("EPCA"), 42 U.S.C. § 6291 et seq., to adopt stringent standards for a variety of appliances, such as furnaces, hot water heaters, ovens, and the lamps at issue here (more commonly called light bulbs). Throughout the years, however, DOE has failed to timely adopt new standards mandated under EPCA, and many of the standards the agency has adopted do not adequately address the imminent need to reduce energy demand and the effects of global climate change.

Through these comments, the States recommend that DOE apply an alternative approach to adopting energy efficiency standards that prioritizes the need for the country to conserve energy and reduce $CO_2$ emissions. DOE can do this in two ways: First, by changing its policy construct so that reduced $CO_2$ emissions associated with each standard are given a proper monetary value. And second, by the agency allocating at least as much weight to the monetary value of reduced carbon emissions as it does to other monetary impacts examined as part of its standards-setting responsibilities under EPCA. DOE appears to be open to just such a new direction, as indicated by Secretary Chu's and the Obama administration's recent statements.[1] Moreover, in the NOPR at issue here, DOE announced that, along with other Federal agencies, it "is currently reviewing various methodologies for estimating the monetary value of reductions in $CO_2$ and other greenhouse gas emissions." 74 Fed. Reg. at 17,012/1. Please accept these comments, as well as the attached report submitted by Synapse Energy Economics, to be used as part of that evaluation. The States look forward to working with DOE on these issues.

## I. THE STATES HAVE A SIGNIFICANT INTEREST IN REDUCING $CO_2$ EMISSIONS THROUGH IMPOSITION OF STRINGENT ENERGY EFFICIENCY STANDARDS

### A. *Impacts to the States*

The connection between human sources of greenhouse gas emissions and global climate change, and its adverse impact on the States, is now well recognized. See Massachusetts v. EPA, 127 S. Ct. 1438, 1455 (2007) ("The harms associated with climate change are serious and well recognized."); id. at 1457-58 ($CO_2$ considered a "greenhouse gas" that contributes to global warming). In its most recent report, the Intergovernmental Panel on Climate Change ("IPCC") confirmed that it is "unequivocal" that the world's climate is warming. See IPCC, *Climate Change 2007: Synthesis Report, Summary for Policymakers*, at 1 (Nov. 2007).[2] The average temperature increase across the globe during the 20th century was 1.33°F, while global sea levels have risen between 0.05 and 0.15 in/year since 1961. The IPCC also concluded that it is "very likely" (a greater than 90% certainty) that climate change is caused by greenhouse gases from human sources. Id. at 3.[3] The IPCC further established plausible projections of temperature increases in the 21st century, ranging from an increase of 3.2°F (if emissions are kept constant) to approximately 7.2°F (high emission scenario), with corresponding sea level rises between 7 and 23 inches. Id. at 8 (tbl. SPM.1).

Absent an immediate response from the world community, increased temperatures are likely to accelerate, resulting in changes in patterns of precipitation, higher sea levels, and impacts to freshwater availability and public health. Each region of the United States is projected to be impacted in distinct patterns. Indeed, increased temperatures have the potential to alter the very nature of the states, impacting not just the states' core economies but their traditions and basic characteristics. Some of the most pressing regional impacts are highlighted next.

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[1] For example,at the Alliance to Save Energy's Great Energy Efficiency Day on March 4, 2009, Secretary Chu announced that the agency would be "taking a much more aggressive role in appliance standards." Transcript available at http://www.eenews.net/tv/transcript/941. Similarly, in a Memorandum, dated Feb. 5, 2009, President Obama requested that DOE move expeditiously to adopt new standards, noting the "significant energy savings" that would result "for the American people." See http://www.whitehouse.gov/the_press_office/ApplianceEfficiencyStandards.

[2] Available at http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf.

[3] Worldwide emissions of $CO_2$, the most prevalent greenhouse gas, increased by about 80% between 1970 and 2004. The United States is currently responsible for about 25% of world's total $CO_2$ emissions – corresponding to 6.021 trillion metric tons of $CO_2$. See Energy Information Adm., *Emissions of Greenhouse Gasses in the U.S. 2007* (EIA 2007 *Report)*, DOE/EIA-0573, at 13 (2007), available at http: //www.eia.doe.gov/oiaf/1605/ggrpt/pdf/ 0573(2007). pdf.

### *The Northeast Region*

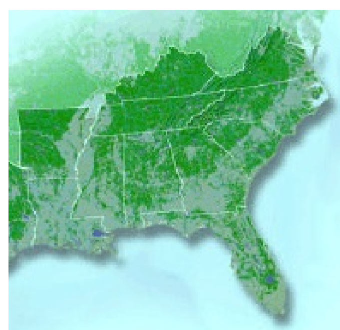
The Northeast region provides an excellent example of the predicament confronting the states. From the beaches of New Jersey, Delaware, and Cape Cod, to the snow-capped mountains of Vermont, New Hampshire, and upstate New York, to the brilliant fall foliage of New England, and to the cornfields of central Pennsylvania, the Northeast has an enormously diverse climate over a relatively small geographic area. See Northeast Climate Impacts Assessment, *Confronting Climate Change in the U.S. Northeast* (hereinafter, "NECIA Report"), at ix, 1-2 (July 2007).[4] Increased temperatures are already causing significant impacts, as the region's climate slowly takes on the characteristics of more southern states.[5] For example, the Long Island Sound used to boast one of the most-productive lobster stocks in the northern Atlantic but, as water temperatures have increased, lobster populations have fallen precipitously. Id. at 42-43. Cod will likely disappear from parts of the northern Atlantic as the maximum temperature for suitable habitat is exceeded. Id. at 39. Increased precipitation from climate change is also likely to impact Chesapeake and Delaware Bays, influencing the salinity of the water and the ability of key fish species to survive. See U.S. Global Change Research Program, *Climate Change Impacts on the United States* (hereinafter, "Global Change Res. Prog."), at 120-21 (Oct. 31, 2000).[6]

Warming trends have begun to create increased syrup production in the north (e.g., Canada), with declining maple syrup production in more southerly areas of the US. In addition, climate models indicate that this trend will be exacerbated by further expected changes to the climate. NECIA Report at 74. Winter sports, which bring approximately $7.6 billion per year to the regional economy, are also being impacted. Id. at 81-89. Pennsylvania's ski industry is struggling to survive, and ski areas in Connecticut and southern New York are projected to be highly vulnerable. Id. at 87. Cooler climate forests that are now dominated by spruce and fir trees are projected to become less suitable for these tree species. These include the North Woods of Maine that are vital to the pulp and paper industry. Id. at 50. Changes in forest habitat also means changes in wildlife that inhabit northeastern forests, including potential declines in resident birds, such as the ruffed grouse (Pennsylvania's state bird) and the black-capped chickadee (the state bird of both Maine and Massachusetts). Id. at 52.

Many densely populated urban areas – such as New York City and Boston – will see more frequent flooding. Beaches will see increased erosion. NECIA Report at 15-31. Rising seas also put coastal properties at risk as insurance companies become increasingly reluctant to provide insurance. Id. at 26. These coastal impacts are not unique to the Northeast.

### *The Southeast Region*

Because of its low-lying coastline, the Southeast may be the region most impacted by climate change. See J.B. Smith, *A Synthesis of Potential Climate Change Impact on the U.S.* (hereinafter, "*Synthesis Report*"), at 22 (Pew Center April 2004).[7] Climate models project increases of summertime temperatures of up to 2.3˚F by 2030 and more frequent El Niño like events – floods, droughts, and other disturbances. *Global Change Res. Prog.* at 144-45. Climatologists predict that, as sea surface temperatures rise, tropical storms and hurricanes will increase in intensity. See F. Ackerman et al., *Climate Change and the U.S. Economy: The Costs of Inaction*, at 9-10 (May 2008).[8] Between 1978 and 1998, the Southeast experienced 23 weather-related disasters that each resulted in over $1 billion in damages. *Global Change Res. Prog.* at 146. Damage assessments are very likely to increase; expected increases in coastal



[4] Available at http://www.climatechoices.org/assets/documents/ climatechoices/confronting-climate-change-in-the-u-s-northeast.pdf.

[5] Overall the Northeast United States has been warming at a rate of 0.5˚F per decade since 1970. Winter temperatures have risen even faster, at a rate of 1.3˚F per decade from 1970 to 2000. Temperature increases in the coastal areas of the state have been more dramatic. NECIA Report at 2.

[6] Available at http://www.usgcrp.gov/usgcrp/Library/national assessment/06MW.pdf

[7] Available at http://www.pewclimate.org/docUploads/Pew-Synthesis.pdf.

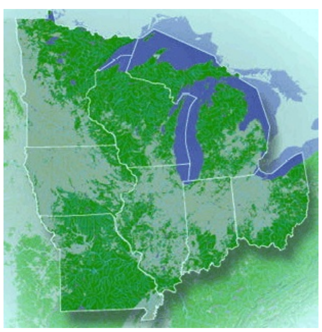
[8] Available at http://www.ase.tufts.edu/gdae/Pubs/rp/ US_Costs_ of_Inaction.doc.

development will lead to higher levels of damage from storms, as well as higher sea levels and more coastal erosion. Moreover, damage of natural shoreline protection will allow storm surges to reach farther inland to areas previously protected. Ackerman et al. at 10.

The Southeast region also contains most of the nation's coastal wetlands; Louisiana alone has 40% of them. *Synthesis Report* at 22. Gulf Coast wetlands provide food and refuge for fish and shellfish, and support for the region's commercial and recreational fishing industries. K.L. Ebi et al., *Regional Impacts of Climate Change*, at 42 (Pew Center Dec. 2007).[9] Wetlands also reduce storm surges. Id. at 43. Inundation of wetlands from increased storm activity and sea level rise from climate change makes these areas particularly vulnerable. Id. at 48-51.

### *The Midwest Region*

The biggest concern in the inland Midwest region is the potential drop in lake water levels. Over the last century, temperatures in the Midwest have risen by 4ºF in the North and 1ºF in the South. See Center for Integrative Envtl. Research, *The U.S. Economic Impacts of Climate Change & the Costs of Inaction* (hereinafter, "CIER Report"), at 22 (U. Md. Oct. 2007).[10] Should elevated temperatures accelerate, as predicted, levels of evaporation will increase, contributing to decreases in soil moisture and reductions in lake and river levels. Id. A higher emissions scenario, for example, is predicted to result in a reduction in the levels of the Great Lakes by as much as 4 to 5 feet over the next century. *Global Change Res. Prog.* at 174.



The Midwest region is particularly dependent on its plentiful lakes and rivers to move goods. Annually, around $3.4 billion and 60,000 jobs rely on the movement of goods within the Great Lakes-St. Lawrence shipping route. CIER Report at 22. If water levels drop significantly dredging, costing hundreds of millions of dollars, may be the only alternative to salvage this system. Id. at 23.

The Midwest boasts some of the country's most productive forestry-based industries – valued at $41.6 billion and employing 200,000 people. CIER Report at 23. However, model simulations assuming a high emissions scenario project the disappearance of the boreal forest and decreased coverage by other forest types from the region. *Global Change Res. Prog.* at 180.

The Midwest region is also well-known for its outdoor recreational activities. Most portions of the industry, however, are likely to suffer because of climate change. For example, the distribution of prominent game and other bird species (e.g. waterfowl, warblers, perching bird species) may be altered, affecting hunting and bird-watching. In Michigan, Minnesota and Wisconsin alone, $4.7 billion was spent in 1996 on hunting. Bird-watching generates $668 million in retail sales and supports 18,000 jobs. Skiing is likely to be affected as well. Lighter than usual snowfall during the 1997-1998 season, for example, resulted in business losses of $144 million. CIER Report at 24.

### *The Great Plains*

The greatest concern in the Great Plains states is that climate change will adversely impact the region's farming industry, which produces much of the nation's grain and meat. *Global Change Res. Prog.* at 192. For example, over 60% of the nation's wheat is produced in Montana, North and South Dakota, Nebraska, Kansas, Oklahoma, and Texas. Over 54% of the nation's barley and 36% of the cotton are produced in the region. Id. at 195. The agricultural sector in the region contributes $22.5 billion annually in market value of products.

Over the 20th century, temperatures in this region rose by more than 2ºF, with increases of up to 5.5ºF in some areas. Air temperatures are likely to rise over the next century. Increased evaporation due to increased temperatures is predicted to result in net soil moisture declines for large parts of the region. *Global Change Res. Prog.* at 192. The region's agricultural sector is very dependent on water, utilizing 40% of the total water supplies.

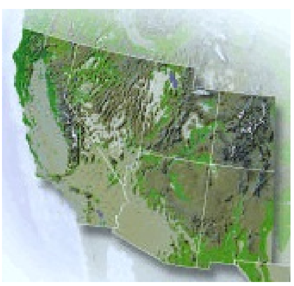
[9] Available at http://www.pewclimate.org/docUploads/Regional-Impacts-FullReport.pdf.

[10] Available at http://www.cier.umd.edu/climateadaptation/index.html.

Decreased availability of water may thus pose a significant problem. CEIR Report at 24. A recent study of the impact of climate change on Texas, for example, concludes that the net effect of climate change will be a 3.6˚F increase in air temperature and a 5% decrease in precipitation, with a consequent reduction in water flows by about 25% under normal conditions and 42% under drought conditions. G.H. Ward, *Impact of Global Climate Change on Texas, 2nd Edition*, Ch. 3, p. 28 (U. of Tx Press 2009).[11] There is a broad consensus amongst climate models that the Southwestern United States (including Texas, Oklahoma, and Kansas) will dry significantly in the 21st century and that the region is transitioning to a more arid climate. R. Seager et al., *Model Projections of an Imminent Transition to a More Arid Climate in Southwestern North America*, J. Science, at 1181(May, 25 2007).[12]

### *The Southwestern United States*

The Southwestern United States is also getting hotter and drier. In 2008, the IPCC found with high confidence that the Southwestern states are "particularly exposed to the impacts of climate change and are projected to suffer a decrease of water resources due to climate change." IPCC Technical Paper IV, Climate Change and Water, at Ex. Sum. 1 (June 2008).[13] In fact, the region is experiencing more warming than the rest of the nation, averaging 1.7ºF warmer temperatures from 2003 to 2007 than the average temperature over the 20th century. Sanders, et al., *Hotter and Drier: The West's Changed Climate* (hereinafter, "Hotter & Drier"), at 2-3 (2008).[14] This warming trend has already led to decreased water supplies. Millions of people depend on the Colorado River for agricultural, municipal, industrial, and hydroelectric needs. Id. at vi. Climate change, however, has resulted in lower water levels in the Colorado River and its two main reservoirs, Lake Powell and Lake Mead, are now only 45 and 50% full, respectively. Ibid.



If warming continues, the Southwest is expected to experience significant strains on water supplies as regional precipitation declines and mountain snowpacks are depleted. H. Frumkin, Centers for Disease Control Change and Public Health, at 3 (April 9, 2008).[15] Colorado is predicted to see an increase in the frequency, severity, and duration of droughts due to a greater amount of winter precipitation falling as rain and less as snow, which will result in less snowpack accumulation, earlier runoff, and more evaporation. Rocky Mtn. Climate Org., Final Report of the Climate Action Panel, at 8-2 (Nov. 2007).[16] Similarly, in Northern California, if climate change continues unabated, more precipitation will fall as rain instead of snow, and the snow that does fall will melt earlier, reducing the Sierra Nevada spring snowpack by as much as 70 to 90%. California Climate Change Center, *Our Changing Climate: Assessing the Risks to California* (hereinafter, "Our Changing Climate"), Doc. No. CEC-500-2006-077 (July 2006).[17]

Decreased snowpack also will devastate the winter tourism industry in the Sierra Nevada and lead to water shortages that will affect drinking water supplies and agriculture, including California's wine industry. Our Changing Climate, at 6-9. Additionally, in California, where hydropower comprises approximately 15% of in-state energy production, diminishing snowmelt flowing through dams will decrease the potential for hydropower production by up to 30%. Comm. on Envt. and Nat. Res., Scientific Assessment of the Effects of Global Change on the U.S., at 191 (May 2008).

While fresh water supplies decrease, rising sea levels resulting from climate change will move the mean high-tide mark farther inland. In California, this will push sea water into the Sacramento Delta, resulting in potential flooding, breach of levees, inundation of crop land, and saline water intrusion in aquifers used for drinking water. Isenberg et al., Delta Vision, California Delta Vision Blue Ribbon Task Force, at 25 (January 2008).[18]

Higher temperatures in the Southwest have caused and will continue to cause increased risk, frequency and severity of wildfires. Westerling, et al., *Warming and*

[11] Available at http://www.texasclimate.org/Portals/6/Books/ImpactTX/Ch3Ward.pdf.

[12] Available at http://www.colorado.edu/colorado_river/docs/seager_2007_arid_clim_sw.pdf.

[13] Available at http://www.ipcc.ch/pdf/technical-papers/climate-change-water-en.pdf.

[14] Available at http://rockymountainclimate.org.

[15] Available at http://www.cdc.gov/washington/testimony/2008/t20080409.htm.

[16] Available at http://www.coloradoclimate.org/ewebeditpro/items/O14F13892.pdf.

[17] Available at http://www.energy.ca.gov/2006publications/CEC-500-2006-077/CEC-500-2006-077.pdf.

[18] Available at http://www.deltavision.ca.gov.

*Earlier Spring Increase Western U.S. Forest Wildfire Activity* (hereinafter, "Warming and Earlier Spring"), J. Science, at 940-943 (Aug. 2006).[19] Specifically, warming since 1987 has led to a 78-day increase in the length of the fire season, a fourfold increase in the number of fires, a fivefold increase in the time needed to put out the average wildfire, and 6.7 times as much area being burned. Hotter & Drier, at vi. Climatologists predict that warmer weather will reinforce the tendency toward early spring snowmelt and longer fire seasons. Warming and Earlier Spring, at 943.

The public health implications of global warming are particularly pronounced in the Southwest. In New Mexico and other Western states, episodes of extreme heat are expected to become more severe and much more frequent, resulting in increases in heat-related illness and mortality. State of New Mexico, *Potential Effects of Climate Change on New Mexico*, at 3, 31 (Dec. 30, 2005).[20] Californians currently experience the worst air quality in the nation, with more than 90% of the population living in areas that are in violations of air quality standards for either ground-level ozone or airborne particulate matter. Indeed, ozone and particulate matter pollution together contribute to 8,800 deaths and $71 billion in healthcare costs every year. Our Changing Climate, at 5. Higher temperatures are expected to increase the frequency, duration, and intensity of conditions conducive to air pollution formation, exacerbating health effects. Ibid. see also, EPA, Climate Change in California, at 3, EPA 230-F-97-008e (September 1997).

### *The Pacific Northwest*

The Pacific Northwest is projected to experience four significant impacts from climate change: (i) reduced snowmelt, resulting in reduced freshwater stream flows and water supplies; (ii) increased forest fires; (iii) stresses to salmon; and (iv) coastline impacts related to increased sea levels. The region has undergone substantial growth over the last few decades, although about 50% of the land area remains federally owned. CIER Report at 29. Average air temperatures have increased over the last century by between 1-3ºF. Despite modest increases in precipitation over the region, further increases in temperature brought on by climate change are projected to result in reduced snow pack, jeopardizing water supplies. A study undertaken by researchers at the University of Washington estimates that by the end of this century, snowpack will be 72% below the 1960-90 average, which would diminish water supplies and potentially lead to a loss of lower elevation skiing destinations. Id. at 29-30.

The coniferous forests that dominate much of the Northwest landscape are also sensitive to summer moisture stress. Reduced moisture brought on by increased temperatures and other stresses have already resulted in an overall increase in the number of acres of forest burned each year. The amount of acreage subject to forest fires is expected to double by 2040. In Washington State alone, fire suppression efforts are predicted to cost well over $100 million annually. CIER Report at 30. Another climate-based stress on northwestern forests is beetle infestation. Bark beetles are major disturbance agents of western North American forests and can affect a larger area than fire does. K.F. Raffa et al., *The Dynamics of Bark Beetle Eruptions*, BioScience, 501, 502 (June 2008). In recent years, outbreaks have expanded into habitats that previously had only rarely been affected, and into previously unexposed habitats. Id. at 503. Mountain ranges in Idaho and Montana are particularly vulnerable to increased infestation.

Climate change is also expected to impact salmon stocks. Northwest salmon stocks, already highly stressed by intense fishing and threats to habitat from urbanization, dam building, and related issues, are also particularly sensitive to changes in climate conditions. For example, eggs are vulnerable to stream scouring caused by winter precipitation falling as rain instead of snow. Earlier snowmelt and peak streamflow also deliver juveniles to the ocean before they are prepared for the transition. Global Change Res. Prog. at 262-64.

Finally, as with the east coast of the United States, sea-level rise in the Northwest will likely require substantial investment to avoid coastal inundation, especially in low-lying communities of southern Puget Sound where the coast is subsiding. Projected heavier winter rainfall is likely to increase soil saturation, landsliding, and winter flooding. Global Change Res. Prog. at 269-70.

[19] Available at http://www.sciencemag.org/cgi/content/full/313/5789/940.

[20] Available at http://www.nmenv.state.nm.us/aqb/cc/Potential_Effects_Climate_Change_NM.pdf.

### B. *The States' Are Addressing the Challenge of Global Climate Change*

Many states are implementing programs to address global climate change in response to the impacts outlined above. For example, on March 17, 2008, Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island and Vermont committed to a $CO_2$ cap-and-trade program initially covering emissions from power plants in the region. The plan – called the Regional Greenhouse Gas Initiative or RGGI – requires $CO_2$ emissions from power plants to remain constant through 2014 and then be gradually reduced by 10% by 2019.[21]

California has also committed to ambitious reductions. In 2006 California enacted landmark greenhouse gas legislation – AB 32, the Global Warming Solutions Act of 2006. The law requires California to reduce its total greenhouse gas emissions to 1990 levels by 2020. The California Air Resources Board, which is charged with implementing AB 32, released its Climate Change Proposed Scoping Plan in October, 2008 and the board approved the plan on December 11, 2008. The Scoping Plan is a road map to reduce the state's greenhouse gas emissions by 30% over the next 12 years. Central to the plan is a cap-and-trade program that will cover 85 percent of the state's emissions. California also joined with Washington, Arizona, New Mexico, Oregon, Montana, Utah and 4 Canadian provinces to form the Western Climate Initiative ("WCI"). On August 22, 2007, WCI announced a regional goal to reduce greenhouse gas emissions to 15% below 2005 levels by 2020.

On November 15, 2007, six Midwestern states – Illinois, Iowa, Kansas, Michigan, Minnesota, and Wisconsin – agreed to establish greenhouse gas reduction targets for the region, including a long-term goal to reduce emissions by 60 to 80% below current levels, and develop a multi-sector cap-and-trade system to help meet the targets. Several other states, including Virginia and Colorado are also implementing plans to reduce $CO_2$ emissions.

Further, although not directly related to $CO_2$ emission reductions, 37 states have implemented standards specifying that power plant companies generate a certain amount of electricity from renewable sources. Most of these requirements take the form of renewable portfolio standards ("RPS"), which require a certain percentage of a power plant's generation to come from renewable sources. The use of renewable energy can deliver significant emission reductions. Texas, for example, is expected to avoid 3.3 million tons of $CO_2$ emissions annually with its RPS, which requires 2,000 megawatts of new renewable generation by 2009.

### C. *The States' Generally Lack Authority to Adopt Energy Efficiency Standards for Appliances*

While many states are undertaking comprehensive programs to address climate change, they nevertheless lack the full panoply of options to address the issue. For example, in 2007, the electric power sector represented almost 40.4% of the $CO_2$ emitted nationwide. See EIA 2007 *Report*, at 13-14. Yet, the States are generally preempted from adopting energy efficiency standards for appliances, see 42 U.S.C. § 6297, which represents the most cost-effective way to reduce $CO_2$ emissions (as explained on p. 9 below).[22] The states' role in this area is limited to apprising DOE of their concerns through public comments. By contrast, national standards adopted by DOE represent a key mechanism for the States to achieve energy efficiency improvements and its resultant benefits.

## II. DOE SHOULD ADOPT ENERGY EFFICIENCY STANDARDS IN A MANNER THAT IS CONSISTENT WITH THE CRITICAL NEED TO SAVE ENERGY AND REDUCE $CO_2$ EMISSIONS.

ECPA required DOE to amend by April 24, 1997 the existing energy conservation standards for fluorescent and reflector lamps. See 42 U.S.C. 6295(i)(1)(A), (i)(3) (2006). But DOE failed to timely meet this and other mandatory rulemaking deadlines under EPCA. As a result, several states and non-governmental organizations sued DOE in district court to compel the agency to adopt new appliance standards

[21] The New York State Department of Environmental Conservation are taking numerous other actions to reduce emissions of climate-changing greenhouse gases and to help New Yorkers adapt as the climate changes. See http://www.dec.ny.gov/60.html

[22] The States are not preempted from adopting standards for appliances that are not covered under EPCA and may petition DOE for a waiver from covered standards. The States are also generally preempted from regulating emissions from transportation sources, which represented 33.5% of $CO_2$ emissions nationwide in 2007. EIA 2007 at 13-14. On December 21, 2005, California filed an application for an auto emissions waiver with the Environmental Protection Agency ("EPA"), in an effort to reduce tailpipe $CO_2$ emissions. EPA subsequently denied the waiver request. On January 26, 2009, however, President Obama issued a Memorandum requiring EPA to reevaluate its denial of that waiver request.

by dates certain. See New York v. Bodman. Nos. 05 Civ. 7807 & 7808 (July 1, 2005 S.D.N.Y.). That lawsuit resulted in entry of a Consent Decree, requiring DOE to among other things issue a final rule with respect to fluorescent and reflector lamps by June 30, 2009. The now 11-year delay in adopting new standards for lamps and the consequent lost opportunity to conserve energy should act as an incentive for DOE to implement the most stringent, yet technically feasible, standards possible. The same can be said for other standards that the agency is late in adopting.

While the States do not take a position on the appropriateness of the specific proposed standards at issue here, we recommend that in determining "whether a standard is economically justified" under § 6295(o)(2)(A) DOE adopt a policy formulation that prioritizes energy savings and reduced $CO_2$ emissions. The States believe that only through such a policy formulation will DOE adopt standards that are consistent with the critical need to address global climate change. We start by highlighting some of our specific concerns with the NOPR.

### A. *Summary of the NOPR*

In the NOPR at issue here, DOE considered various efficiency standards for each of the classes of fluorescent and reflector lamps that are commercially available. DOE grouped each of these alternative efficiency standards into five Trial Standard Levels ("TSLs"). The agency then compared the impacts of each TSL as part of its analysis of whether the TSL is "economically justified" under 42 U.S.C. § 6295(o)(2).[23] *See* 74 Fed. Reg. 17,014-18.

#### *1. DOE Rejected an Approach to Valuing $CO_2$ Emission Reductions that Considers the Value of $CO_2$ Emission Allowances Under a National Cap-and-Trade Program*

One of the impacts that DOE measured was the reduced $CO_2$ emissions associated with each TSL. DOE estimated both the amount of emission reductions (in tons) and the economic value of such reductions.[24] The agency based its valuation of $CO_2$ emission reductions on an estimate of the societal cost of $CO_2$ emissions ("SCC"), 74 Fed. Reg. at 17,012-13, which amounts to an estimate of the damages caused by $CO_2$ emissions to the environment and public health. In choosing to estimate the value of $CO_2$ emission reductions in this manner, DOE rejected an alternative methodology based on the market value of emission allowances under a cap-and-trade program. Id. at 17,012/2. We address this issue in more detail on pages 9-10 below and in the attached report.

#### *2. DOE Should Include in its Manufacturer Impact Analysis the Benefit of Increased Sales of Exempt Lamps*

DOE preliminarily rejected the more stringent TSL 5 slate of standards, finding that such standards are not "economically justified" under 42 U.S.C. § 6295(o)(2). 74 Fed. Reg. at 17,016, 17,108. The agency based this finding, in part, on a determination that imposition of the TSL 5 standards would potentially result in lost revenues for lamp manufacturers. Id. In making this determination, however, DOE ignored an important benefit to manufacturers. Specifically, in assessing the impacts of higher standard reflector lamps, DOE concluded that some consumers would switch to certain types of lamps that DOE found to be exempted from regulation. Id. at 17,002/3. Our understanding, however, is that the exempted lamps are sold by the very same manufacturers that sell the regulated lamps. Section 6295(o)(2)(B)(i)(I) of EPCA requires DOE to examine "the economic impact of the standard on the manufacturers . . . of the products subject to such standard." Under the plain language, DOE must examine impacts on the unlimited "manufacturers of the products subject to the standard." Thus, because "the manufacturers of the products subject to the standard" also manufacture the exempt lamps, DOE must examine the positive impacts from increased sales of those lamps

[23] EPCA requires DOE to base its "economic justification" analysis on several factors, including (i) the economic impact of the standard on consumers and manufacturers of the product at issue, (ii) the savings in operating costs over the lifetime of the covered product from imposition of the standard, (iii) the projected energy savings resulting from imposition of the standard, and (iv) the need for the energy conservation. Id. at § 6295(o)(2)(B)(i). As part of its analysis concerning the need for energy conservation, DOE considers the environmental effects of each standard, including the estimated impacts on emissions of $CO_2$ emissions. 74 Fed. Reg. at 17,009-10.

[24] DOE historically did not monetize the benefits associated with $CO_2$ emission reductions, making it impossible to compare the benefit of $CO_2$ emission reductions to impacts that the agency did monetize. See Process Rule, 61 Fed. Reg. 36,974, at 36,987/3 (July 15, 1996) ("The Department . . . will not determine the monetary value of these environmental externalities."); Furnace Rule, 72 Fed. Reg. 65,136, 65,148/1 (Nov. 19, 2007) (deciding against monetizing value of $CO_2$ emission reductions in "keeping with the guidance of the 1996 Process Rule"). DOE has reversed course in its most recent rulemakings. See, e.g., Final Standards for Packaged Terminal Air Conditioners and Packaged Terminal Heat Pumps, 73 Fed. Reg. 58,772, 58,813-14 (Oct. 7, 2008) (monetizing $CO_2$ emission through same formulation applied here).

as well.[25]

### *3. It is Unclear What Role Energy Savings and $CO_2$ Emission Reductions Play in DOE's Policy Structure*

DOE proposed to adopt TSL 3 for fluorescent lamps and TSL 4 for reflector lamps. DOE estimates that by 2042 the proposed standards would save up to 9.65 quadrillion BTUs ("quads") of energy, with a corresponding net present value ("NPV"), at a 3% discount rate, of $33.3 billion.[26] DOE also estimated that the proposed standards would result in cumulative greenhouse gas emission reductions of up to 510 million metric tons ("MMT") of $CO_2$, with the economic value of these reduced emissions estimated to save between $0 and $5.6 billion over the 42-years of analysis. 74 Fed. Reg. at 17,006, 17012-13.

By contrast, DOE estimated that the more stringent TSL 5 slate of standards for both classes of lamps would have much greater beneficial effects:

- Energy Savings of up to 15.77 quads.
- NPV of up to $67.45 billion (at a 3% discount rate).
- $CO_2$ Emission Reductions of up to 800 MMT, with a corresponding value of $9.0 billion. 74 Fed. Reg. at 17,006, 17,008, 17012-13.

In the final analysis, the energy savings associated with the proposed standards are substantial, although the more stringent TSL 5 standards would achieve even greater savings. While we applaud DOE's broad consideration of energy savings in the NOPR – which constitutes a departure from more recent rulemakings,[27] it remains unclear precisely what role energy savings play in DOE's examination of whether a standards is "economically justified," under § 6295(o)(2) of EPCA. For example, DOE estimates that the TSL 5 slate of standards would result in 63% greater energy savings and twice the NPV of the proposed standards. Moreover, while DOE characterizes the manufacturer impacts associated with the TSL 5 standards as "very significant," id. at 17,015/1, the monetization of that impact (in the millions) is dwarfed by the monetary value of the energy savings (in the billions). The public is thus left without an understanding of the precise role energy savings play in the analysis of whether a standard is "economically justified." In these times when the need for the country to conserve energy is more critical than ever, the public needs to understand the point at which impacts on manufacturers are too great to justify substantial energy savings.

Additionally, while DOE has provided a value for reduced $CO_2$ emissions associated with each standard, it does not appear that this value was given any consideration in the final analysis. See generally 74 Fed. Reg. at 17015-18. DOE's estimate of the monetary value of reduced $CO_2$ emissions, like the NPV associated with energy savings, is in the billions of dollars. As already pointed out, because of the adverse impact of global climate change on the states and the nation as a while, DOE must prioritize – not ignore – the value of reduced $CO_2$ emissions in determining whether a standard is "economically justified."

### *B. EPCA Supports the Agency Giving Priority to Energy Savings and $CO_2$ Emission Reductions in Setting Energy Efficiency Standards*

The text and legislative history of EPCA supports DOE giving priority to energy savings and $CO_2$ emission reductions in considering whether a standard is "economically justified" under § 6295(o)(2).[28] EPCA was originally enacted in "response to the energy crisis precipitated by the [oil] embargo" of 1973 as a mechanism to "reduc[e] demand for energy through such measures as conservation plans and improved energy efficiency of consumer products." NRDC v. Abraham, 355 F.3d 179, 185 (2d Cir. 2004). Indeed, one of the primary purposes of EPCA was "to conserve energy supplies through energy conservation programs, and, where necessary, the regulation of certain energy uses." 42 U.S.C. § 6201(4). In amending the statute, Congress has repeatedly stressed the important domestic and foreign policy reasons underlying the need for the

[25] Notably, DOE ignored similar benefits to manufacturers in the furnace rulemaking. See 72 Fed. Reg. at 65,149 (agency failed to take into account that a decline in sales of natural gas furnaces associated with the 90% standard would result in increased sales of electric heat pumps and electric furnaces – sold by the same manufacturers that make natural gas furnaces). Several states initially challenged this and other aspects of that rule. See New York v. DOE, 08-0311ag(L) (2nd Cir.). DOE ultimately filed a motion for voluntary remand, which the Court granted.

[26] The NPV analysis is a measure of the cumulative benefit of the standards to the entire country.

[27] For example, DOE initially adopted an amended efficiency standard for natural gas furnaces that would have resulted in 299 times less energy savings and 68 times less economic savings to the Nation than imposition of the more stringent standard advocated by some States. See 72 Fed. Reg. at 65,136. Again, we applaud DOE's decision to reconsider this standard.

[28] To be clear, the States believe that manufacturer and consumer impacts are also important.

country to conserve energy. See Legislative History of Nat'l Appliance Energy Conservation Act, S. Rep. No. 100-6, at 2 (1987), reprinted in 1987 U.S.C.C.A.N. 52 (principal goal "to reduce the Nation's consumption of energy"); Energy Policy Act of 2005, Pub.L.No. 109-58, 119 Stat. 594 (August 8, 2005) (purpose "[t]o ensure jobs for our future with secure, affordable, and reliable energy"); Energy Independence and Security Act of 2007, Pub.L.No. 110-140; 121 Stat. 1492 (Dec. 19, 2007) (purpose includes "mov[ing] the United States toward greater energy independence and security, [and] . . . increas[ing] the efficiency of products, buildings, and vehicles"); see also Ctr. of Biological Diversity v. NHTSA, 508 F.3d 508, 527 (9th Cir. 2007) (EPCA's "overarching goal [is] fuel conservation"), quoting Ctr. For Auto Safety v. NHTSA, 793 F.2d 1322, 1340 (D.C. Cir. 1986).

To implement the goal of energy conservation, Congress provided DOE with authority to, among other things, periodically update the energy efficiency standards for a variety of appliances. See 42 U.S.C. §§ 6292, 6295. In establishing these updated standards, the statute specifies that DOE is to prioritize energy savings in two ways: First, by adopting a standard that is "designed to achieve the maximum improvement in energy efficiency . . . which the Secretary determines is technologically feasible and economically justified;" and second, by requiring DOE to consider projected energy savings and the need for national energy conservation in determining whether a standard is "economically justified." Id. § 6295(o)(2)(A), (B)(i). As already explained, DOE has historically examined the environmental benefits associated with strengthened standards as part of its examination of the need for energy conservation. See p. 7 n. 23. This is consistent with the obligation under DOE's enabling statute to "[a]ssure incorporation of national environmental protection goals in the formulation and implementation of energy programs." 42 U.S.C. § 7112(13).

In sum, EPCA certainly gives the agency authority to prioritize energy conservation and air pollution reduction in setting updated standards for appliances.

### C. *Stringent Efficiency Standards Are the Most Cost-Effective Means to Save Energy and Reduce $CO_2$ Emissions*

Not only do stringent energy efficiency standards address the country's need to reduce energy usage, it turns out that the imposition of such standards represents the most cost-effective means to save energy and reduce $CO_2$ emissions. Indeed, as DOE has recognized in other contexts, "[e]nergy is one of the most critical issues facing America . . . and energy efficiency is the quickest way to reduce energy intensity." See Hearings on S. 1115 Before the Comm. on Energy & Natural Resources, 110th Cong. 46 (2007), at 3 (statement of John Mizroch, Principal Deputy Assistant Secretary for Energy Efficiency & Renewable Energy, DOE).

Several studies support this testimony. For example, a recent meta-analysis of state-level energy conservation programs (such as RPS) found that for every dollar invested in energy efficiency programs, total energy bill savings averaged $1.95. See J. Laitner & V. McKinney, *Postitive Returns: State Energy Efficiency Analyses Can Inform U.S. Energy Policy Assessments*, at 4 (ACEEE, June 2008) (The meta-analysis also showed "there would be a net increase in jobs resulting from a more productive investment in energy-investment technologies.") Another study concerning the impact of previously adopted appliance efficiency standards shows that every dollar invested in more efficient appliances resulted in $1.58 of energy savings. See K. Gillingham et al., *Retrospective Examination of Demand-Side Energy Efficiency Policies*, at 3 (RRF Sept. 2004). Of note, neither analysis considers the additional economic benefits associated with reduced $CO_2$ emissions. There are also a number of other benefits that flow from stringent efficiency standards, including preserving cleaner domestic sources of energy such as natural gas, and reducing the country's reliance on foreign sources of energy.

## III. DOE SHOULD BASE THE VALUE OF $CO_2$ EMISSION REDUCTIONS ON THE LONG RUN MARGINAL CONTROL COSTS

In the NOPR, DOE bases the value of $CO_2$ emissions reduced on an estimate of the damage costs associated with greenhouse gas emissions. As discussed in the attached report, we believe that the damage-based estimate that DOE proposed to adopt in the NOPR is too uncertain to apply in estimating the value of reduced $CO_2$ emissions. Damage-based estimates suffer from scientific uncertainty that is compounded by uncertainties associated with economic valuation. Further, DOE applies the mean damage-based value from assorted studies undertaken prior to 2005 but ignores the significant range of values in those studies, calling into question the applicability of the value for DOE's purposes. Each of the studies that underlies DOE's proposed value applies an economic model to arrive at a monetary value range associated with impacts on a variety of resources, such as agriculture, forestry, drinking water, sea level rise, ecosystems, and human health. Many of these impacts are hard to monetize and rely on the value judgments of the modelers on issues that are more appropriate resolved in a public policy forum.

Rather than using a damage-based approach, we recommend that DOE estimate the value of $CO_2$ emissions reduced associated with each of the TSLs based on evaluation of the long-run marginal abatement cost of $CO_2$. Under this approach, one relies on current scientific understanding to first identify the concentration of $CO_2$ in the atmosphere likely to avoid the most dangerous climate change impacts (designated as a "sustainability target" for ease of reference) and to then identify what levels of emission reductions are necessary to achieve that target. Next, one selects a value (or range of values) for $CO_2$ based on analyses of the long-run marginal costs of achieving the "sustainability target." This approach has the benefit of being based on current scientific understanding of the magnitude of emissions reductions necessary to avoid the most dangerous impacts of climate change, as well as recent analyses of available and anticipated technologies.[29] The approach is consistent with what appears to be a growing consensus regarding emission reduction targets for greenhouse gases. Indeed, the most recent budget submitted to Congress by the Obama administration seeks to establish a cap-and trade system to reduce greenhouse gas emissions to 14 percent below 2005 levels by 2020 and to 83 percent below 2005 levels by 2050; and similar reductions targets are contained in legislative proposals in Congress. Based on recent studies of the cost and availability of technologies to achieve reductions of similar magnitude, we recommend that DOE apply a long-run abatement cost (in 2009$) of $80 per short ton of $CO_2$.

All of these issues are discussed in more detail in the attached report.

[29] Although there are uncertainties associated with this approach as well, those uncertainties are relatively well understand and straightforward compared to the uncertainties and ethical valuation assumptions (e.g., value of a human life, value of ecosystems and species, aggregating over developed and developing countries, discounting over very long time periods) that are a required part of the "damage based societal cost of carbon" approach applied in the NOPR.

## CONCLUSION

DOE should assure that, in finalizing amended standards for fluorescent and reflector lamps, i) the agency prioritizes the benefits associated with reduced $CO_2$ emissions, and ii) bases the monetary value of such benefits on the long run marginal costs of control approach, as discussed in the attached report. We also recommend that DOE devote a work shop and/or additional rulemaking that focuses on incorporating into the agency's policy apparatus the compelling need for the country to reduce $CO_2$ emissions.

Synapse
Energy Economics, Inc.

**REPORT**
**Incorporating Carbon Dioxide Emissions Reductions in Benefit Calculations for Energy Efficiency:**

**Comments on the Department of Energy's Methodology for Analysis of the Proposed Lighting Standard**

**A Report for the New York Office of Attorney General**

**By**

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**May 13, 2009**

# 1. Executive Summary

The New York Office of the Attorney General has requested that Synapse Energy Economics conduct a review of the Department of Energy (DOE's) methodology for taking into account a monetary benefit of carbon dioxide ("$CO_2$") emissions reductions associated with proposed energy efficiency standards for general service fluorescent lamps (GSFL) and incandescent reflector lamps (IRL). In its recently published Notice of Proposed Rulemaking ("NOPR") regarding these standards, DOE proposes using values that range from $0 to $20 per metric ton of $CO_2$.[1]

Our key findings and recommendations with regard to taking into account a monetary value of $CO_2$ emissions reductions are as follows:

- We commend DOE for tackling the difficult, but necessary, task of determining an appropriate method for taking into account a monetary benefit of $CO_2$ emissions reductions associated with proposed energy conservation standards. Given the direction of the scientific, policy, and public debate, we anticipate that carbon constraints in the U.S. will soon result in an allowance cost for greenhouse gas emissions. However, it is important for DOE to incorporate a value for $CO_2$ emissions reductions prior to a Federal carbon constraint, and even in tandem with a carbon constraint since allowance prices (when they exist) may not embody the full cost of greenhouse gas emissions.

- We find that DOE's proposed range of values for $CO_2$ emissions is not well-founded due in large part to DOE's reliance on estimates of the monetary costs of physical damages associated with climate change. Adopting a single damage-based value belies the uncertain and evolving status of scientific understanding of the physical impacts of climate change; and incorporates myriad assumptions regarding regional and temporal equity and other important policy issues in assigning an economic value to those uncertain physical impacts. The current NOPR focuses on an estimate of the aggregate net economic cost of damages contained in a report from the International Panel on Climate Change.[2] The source document for that value, a 2005 paper authored by Richard Tol, shows considerable range and a large number of high values that should not be ignored. While easy to comprehend, a damage-based dollar per ton value oversimplifies the complex policy and societal choices that must be made in developing policies to address climate change.

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[1] "Energy Conservation Program: Energy Conservation Standards for General Service Fluorescent Lamps and Incandescent Reflector Lamps, Proposed Rules" 69 Federal Register 16920-17027 (April 13, 2009).

[2] IPCC, 2007: Summary for Policymakers. In: 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 University Press, Cambridge, UK, 7-22.

- We also dispute DOE's proposal to restrict its estimate of monetary value to those costs and benefits likely to be experienced in the United States. The impacts of $CO_2$, and other greenhouse gasses, are global and have significant physical, social, and economic consequences throughout the world. Thus, to the extent that DOE uses a damaged-based approach to value $CO_2$ emission reductions, the agency should consider the damages inflicted upon the world – not just the United States.

- We find that an estimate of the long-run marginal abatement cost of $CO_2$ is a practical and conservative measure of the social cost of carbon, and is well-suited for use in DOE's decision-making. In developing our recommendation, we review current literature on emissions reductions necessary to avoid the most dangerous impacts of climate change, as well as analyses of technologies available to achieve those emission reductions. We recommend that DOE uses a marginal abatement cost value, which is based on the cost of controlling emissions instead of monetized estimates of damages.

- We recommend that DOE use a long-run marginal abatement cost (2009$) of $80 per short ton of $CO_2$. ($88 per metric ton) Our recommendation incorporates findings from a recent meta-analysis of greenhouse gas marginal abatement cost estimates and from recent abatement cost analyses published by both international agencies and multinational consultancies. All of these studies find marginal abatement cost values whose upper range is much higher than the $20 per metric ton of $CO_2$ ($18.91 per short ton in 2009$) value proposed by DOE in the NOPR.

In this report we summarize DOE's methodology for incorporating $CO_2$ emissions in the benefits calculations, explain the deficiencies and uncertainties that we find in that approach, and make recommendations for DOE to improve the treatment of $CO_2$ emissions reduction benefits in its calculations.

# 2. Background

## *DOE's Method for Quantifying and Calculating $CO_2$ Emissions and Benefits*

DOE calculated the reduction of $CO_2$ emissions at different trial standard levels using the National Energy Modeling System (NEMS) model developed by DOE's Energy Information Administration (EIA). DOE estimates $CO_2$ emissions reductions resulting from the standards ranging up to 679.7 million metric tons of $CO_2$ for the highest GSFL trial standard level 5 ("GSFL TSL 5").[3] As detailed in Appendix I to this report, we note that the model DOE used to estimate $CO_2$ emission reductions does not include any allowance prices for $CO_2$ or other greenhouse gas emissions. The results for DOE's $CO_2$ calculations are presented on tables VI.39 and VI.40 in the NOPR and summarized here in Table 1.[4]

In response to numerous comments by stakeholders, DOE also analyzed the monetary benefit of the $CO_2$ emissions reductions associated with the proposed standard. DOE estimated $CO_2$ emission reductions benefits between zero and $4.0 billion (in 2007 present value dollars) over the study period at a 7% discount rate; and between zero and $7.7 billion (in 2007 present value dollars) at a 3% discount rate.[5] The results for DOE's $CO_2$ valuation analysis are presented on Tables VI.39 and VI.40 of the NOPR and summarized here in Table 1.[6]

In order to estimate the monetary benefit of $CO_2$ emission reductions, DOE identified a range of values for the benefits of reducing a ton of $CO_2$ emissions. DOE chose a value of $0/ton $CO_2$ as its lower bound. DOE based its upper bound upon an analysis of economic costs of damages contained in a report of the Intergovernmental Panel on Climate Change ("IPCC") [7] that, in turn, incorporated a 2005 paper by Richard Tol – a meta-analysis of marginal damage cost assessments.[8] In Tol's 2005 meta-analysis, the mean value of all estimates is $97 per metric ton of carbon. Tol distinguishes the studies that were subject to peer-review, and calculates the mean for those peer-

[3] DOE reports carbon dioxide emissions in metric tons. Our analysis will follow the Environmental Protection Agency and US utilities convention of using short tons. For the purposes of converting, one metric ton equals 1.102 short tons. Hence, 679.7 million metric tons of $CO_2$ would be about 749 million short tons of $CO_2$.
[4] 74 Fed. Reg. at 17,012-13
[5] In our analysis, we have converted values to 2009$ using a Gross Domestic Product (GDP) chain values. The GDP inflator for 2007$ to 2009$ is 1.105. Therefore, the above values would be approximately 0 to $4.1 billion at a 7% discount rate and $0 and $8.5 billion at a 3% discount rate in 2009$.
[6] 74 Fed. Reg. at 17,012-13.
[7] IPCC. "*IPCC Fourth Assessment Report: Working Group II Report Impacts, Adaptation and Vulnerability*". Ed. M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, and C. E. Hanson. Cambridge University Press, 2007.
[8] Tol, R.S.J., "The marginal damage costs of carbon dioxide emissions: an assessment of the uncertainties," Energy Policy 33 (2005) 2064-2074.

reviewed estimates to be $43 per metric ton of carbon (1995$), which is equal to $14.76 (2009$) per short ton of $CO_2$.[9] DOE's high value of $20 per metric ton of $CO_2$ ($18.91 in 2009$ per short ton) is based upon the mean of peer-reviewed estimates reported by Tol and incorporates a 2.4% annual growth rate.[10] In economic literature, estimates of net economic costs of damages from climate change are often referred to as the "social cost of carbon" ("SCC").

The range that DOE examines for the monetized carbon emissions benefits is based "on an assumption of no benefit to an average benefit reported by the IPCC."[11] DOE's low value is zero. Thus, the range used by DOE is from a low of zero to a high of $20 per ton of $CO_2$ ($18.91 in 2009$ per short ton).

These values as presented in the NOPR are summarized in Table 1.

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[9] Tol's 2005 paper identifies 103 estimates of SCC from 28 studies done between 1991 and 2003 expressed in 1995 dollars. As noted in Footnote 80 on page 17,011 of the Fed. Reg., DOE arrives at its upper bound monetary value of $CO_2$ by converting $43 per metric ton of carbon into $CO_2$ by dividing by 3.66 (to get from tons of carbon to tons of $CO_2$). This results in a value of $11.74 dollars in 1995$. That number is then multiplied by 1.33 to convert the value from 1995 dollars to 2007dollars or $15.61 per ton of $CO_2$ in 2007$. The approximate value of $20 per metric ton is arrived by applying an annual growth rate of 2.4% from 1995 to 2007. .

[10] 74 Fed .Reg. at 17,012.

[11] *Ibid.* at 17,011..

| **Table VI.39 Preliminary Estimate of Savings from $CO_2$ Emissions Reductions for General Service Fluorescent Lights** | | | |
|---|---|---|---|
| Trial Standard Level | Estimated Cumulative $CO_2$ (MMt) Emission Reductions | Value of Estimated $CO_2$ Emissions Reductions (Billions 2007$) at 7% discount rate | Value of Estimated $CO_2$ Emissions Reductions (Billions 2007$) at 3% discount rate |
| 1 | 85.7 to 236.4 | $0 to 1.2 | $0 to 2.5 |
| 2 | 103.5 to 233.7 | $0 to 1.2 | $0 to 2.5 |
| 3 | 184.3 to 395.2 | $0 to 2.1 | $0 to 4.3 |
| 4 | 239.7 to 597.7 | $0 to 3.5 | $0 to 6.8 |
| 5 | 312.8 to 679.7 | $0 to 4.0 | $0 to 7.7 |

| **Table VI.40 Preliminary Estimate of Savings from $CO_2$ Emissions Reductions for Incandescent Reflector Lights** | | | |
|---|---|---|---|
| Trial Standard Level | Estimated Cumulative $CO_2$ (MMt) Emission Reductions | Value of Estimated $CO_2$ Emissions Reductions (Billions 2007$) at 7% discount rate | Value of Estimated $CO_2$ Emissions Reductions (Billions 2007$) at 3% discount rate |
| 1 | 10.3 to 17.7 | $0 to 0.1 | $0 to 0.2 |
| 2 | 25.1 to 44.8 | $0 to 0.3 | $0 to 0.5 |
| 3 | 46.2 to 88.1 | $0 to 0.5 | $0 to 1.0 |
| 4 | 58.6 to 114.1 | $0 to 0.6 | $0 to 1.3 |
| 5 | 79.3 to 118.8 | $0 to 0.7 | $0 to 1.3 |

Table VI.39 and VI.40 from **Federal Register** (pp.17012 & 17013)
Metric tons to short tons conversion (1.102)
2007$ to 2009$ (1.042 based on GDP chain type price index)

**Table 1 Summary of DOE Carbon Dioxide Emission Reduction Benefits**

Our analysis of those estimates follows.

# 3. Addressing $CO_2$ Emissions

DOE's efforts to take into account in decision-making the benefits of $CO_2$ emissions reductions are part of a broad context of policy action to address climate change. Although $CO_2$ emissions are currently not regulated in this country at the Federal level, it is widely and reasonably believed that regulation of $CO_2$ emissions will happen soon, and that the required reductions in $CO_2$ emissions will be significant. In the March 23 update of the NOPR, DOE noted:

> The Department of Energy, together with other Federal agencies, is currently reviewing various methodologies for estimating the monetary value of reductions in $CO_2$ and other greenhouse gas emissions. This review will consider the comments on this subject that are part of the public record for this and other rulemakings, as well as other methodological assumptions and issues, such as whether the appropriate values should represent domestic U.S. or global benefits (and costs). Given the complexity of the many issues involved, this review is ongoing. However, consistent with DOE's legal obligations, and taking into account the uncertainty involved with this particular issue, DOE has included in this rulemaking the values and analyses previously conducted. (p.328)

We commend DOE and the other Federal Agencies and note that the Obama Administration indicated in its recently released federal budget that it would seek to establish a cap-and-trade system to reduce greenhouse gas emissions to 14 percent below 2005 levels by 2020 and to 83 percent below 2005 levels by 2050. There are two likely avenues for federal regulation of greenhouse gases. Congress could pass legislation, or the U.S. Environmental Protection Agency could adopt regulations to limit greenhouse gas emissions. Both paths are currently under active consideration. While the details in terms of timing and form are uncertain, it is widely accepted that power plants in the US will soon be subject to $CO_2$ emissions regulation. [12] In addition, EPA recently announced that $CO_2$ and other greenhouse gases "endanger public health" and therefore can be regulated under the Clean Air Act.[13] This finding alone should encourage DOE to reconsider its analysis of $CO_2$ emissions in the context of its energy modeling and include projections of emissions reductions under federal greenhouse gas emission constraints.

**What Others are Doing**

Across industry sectors, there is growing consensus that $CO_2$ legislation is imminent and should be internalized into financial decisions.[14] Private companies are, in their planning

[12] See, for example, recent articles in the *New York Times* and CNN suggest that the current administration has begun to respond to the Supreme Court's decision in Massachusetts vs. EPA to regulate carbon dioxide as a pollutant under the Clean Air Act. Additional articles suggest that the current administration is beginning to determine if $CO_2$ should be regulated under the Clean Air Act. http://www.nytimes.com/2009/02/19/science/earth/19epa.html?hp

[13] "Proposed Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act; Proposed Rule," 74 Fed. Reg. 18,886 (April 24, 2009)

[14] The Carbon Disclosure Project (http://www.cdproject.net/) has 3,700 companies across the globe providing climate change data. Additional corporate information and reports has also been collected by Ceres (http://www.ceres.org/) to promote corporate responsibility.

and investment decisions, using price forecasts for $CO_2$ emissions.[15] A number of investment banks are now considering carbon legislation in their capital financing process.[16]

At the regional and state level, there are a variety of agreements and policies that address $CO_2$ and other greenhouse gas emissions.[17] In the United States, several states have adopted state greenhouse gas reduction targets of 50% or more reduction from a baseline of 1990 levels or then-current levels by 2050 (California, Connecticut, Illinois, Maine, New Hampshire, New Jersey, Oregon, and Vermont). In 2001, the New England states joined with the Eastern Canadian Premiers in also adopting a long-term policy goal of reductions on the order of 75-80% of then-current emission levels.[18] And in 2008, the ten Northeast and Mid-Atlantic States forming the Regional Greenhouse Gas Initiative (RGGI) held its first auctions for $CO_2$ emission permits.[19]

[15] A number of corporations have announced goals to reduce greenhouse gas emissions. For example, Disney joins a growing number of companies announcing goals to reduce greenhouse gas emissions from fuel usage by 50% by 2013. http://corporate.disney.go.com/news/corporate/2009/2009_0309_cr_release.html

[16] http://online.wsj.com/article/SB120209079624339759.html

[17] For example, in 2006, Governor Schwarzenegger signed Bill AB32, the California Global Warming Solutions Act of 2006 that commits the state of California to cap greenhouse gas emissions for 2020 based on 1990 emissions (http://gov.ca.gov/press-release/4111/). RGGI commits ten northeastern and mid-Atlantic states to reduce $CO_2$ from power generation sources by 10% from 2009 levels by 2018 (http://www.rggi.org/about).

[18] New England Governors/Eastern Canadian Premiers, *Climate Change Action Plan 2001*, August 2001. NEG/ECP reiterated this commitment in June 2007 through Resolution 31-1, which states, in part, that the long term reduction goals should be met by 2050.

[19] Another market signal of the price of carbon dioxide emissions is the selling of climate futures on the Chicago Climate Exchange. Current carbon financial instrument (CFI) futures show a big jump in future contracts that expire in December 2010 compared to January 2013. Contracts that expire in 2010 range in the $2 per metric ton range while contracts set to expire in 2013 range much higher in anticipation of future federal regulation of $CO_2$ emissions. The first RGGI auction on September 25, 2008 cleared all 12.5 million allowances at a price of $3.07. The second auction on December 17, 2008 cleared all 31.5 million allowances at a price of $3.38.

# 4. Analysis of DOE's Proposed Value for Carbon Dioxide

DOE and other Federal Agencies are in the midst of a difficult and essential task of estimating the monetary value of reductions in $CO_2$ and other greenhouse gas emissions. In the interim, DOE proposes to use a limited range of values to reflect the monetary cost of physical damages associated with $CO_2$ emissions. On its face, it makes sense to equate the benefits of avoided emissions with the economic value of damages that would otherwise be incurred.

However, analysis of the sources underlying DOE's chosen number for its high estimate reveals that adopting a damage-based value belies the uncertain and evolving status of scientific understanding of the physical impacts of climate change; and incorporates myriad assumptions regarding regional and temporal equity and other important policy issues in assigning an economic value to those uncertain physical impacts. DOE relies on the IPCC's Fourth Assessment Report, and in turn, a 2005 paper authored by Richard Tol as its basis for its high estimate for the monetary value of $CO_2$ emission reductions[20] Even if DOE had considered a range of damage cost studies, including more recent updates from Professor Tol, as the basis for its monetary value of $CO_2$, damage cost estimates contain too much scientific uncertainty about physical impacts, and too many embedded assumptions about very significant policy issues. In instances where a damage-based estimate is used, selection of the value should acknowledge scientific uncertainties about physical damages, and should include a discussion and explicit consideration of value judgments that are embedded in specific monetized damage estimates.

For its low value, DOE chose to use zero as the monetary value for $CO_2$. A zero value for the damaged-based cost of carbon implies that the emission of carbon dioxide into the atmosphere is not causing any damages to our society. We believe that the preponderance of scientific evidence is pretty clear that climate change has an associated cost that is greater than zero to society.

**The Analysis Underlying DOE's Proposed Value – Tol 2005**

The range of the damage-based SCC values in the papers collected and summarized by Tol is tremendous. This range is presented in Tol's paper, and is reported by the IPCC; however, it is not addressed in DOE's NOPR. For the peer-reviewed studies, Tol's mean value of \$43/tC in 1995\$ (\$14.76 in 2009\$ per short ton of $CO_2$) has an "uncertainty range" (the "standard deviation") of \$43/tC, which constitutes a high variability in values. The mean value for all 103 estimates is \$97/tC (\$32.54 in 2009\$ per short ton of $CO_2$) with a standard deviation of \$203/tC (\$68.10 in 2009\$ per short ton

[20] The term "Social Cost of Carbon" is used in economic literature and by the IPCC to denote economic costs of damages from climate change aggregated across the globe and discounted to the present (See IPCC Fourth Assessment Report: Working Group II, 2007). As such the SCC can be considered a proxy of the seriousness of climate change.

of $CO_2$), suggesting an even larger "uncertainty range" in values. DOE only references the "mean of peer reviewed studies" in its decision to use Tol as the basis of its damage-based value.

Indeed, based on the wide range of values, the IPCC concludes that the damage-based approach may underestimate monetary damages associated with climate change. For example, in its "Summary for Policymakers" from the Fourth Assessment in the same paragraph in which Tol's 2005 study is cited, the IPCC states:

> The large ranges of SCC are due in the large part to differences in assumptions regarding climate sensitivity, response lags, the treatment of risk and equity, economic and non-economic impacts, the inclusion of potentially catastrophic losses, and discount rates.

The IPCC further explains:

> It is very likely that globally aggregated figures underestimate the damage costs because they cannot include many non-quantifiable impacts. Taken as a whole, the range of published evidence indicates that the net damage costs of climate change are likely to be significant and to increase over time."[21]

**Update of SCC meta-analysis -Tol 2008**

To the extent that DOE relies on an damage-based approach, it should adjust its analysis to account for the fact that Tol's 2005 paper has been superseded by a more recent paper in 2008. The newer paper is titled "The Social Cost of Carbon: Trends, Outliers and Catastrophes." It has a larger database of estimates, now up to 211 estimates of SCC from 47 studies in the 2005 paper, done between 1982 and 2006.[22]

We analyzed of the SCC estimates collected by Tol in order to discern the trends over time, the shape of the distribution, and other characteristics of the data set to illustrate the rapid advancement in climate change research. Further discussion of our analysis of the Tol paper may be found in Appendix II to this report.

In the figure below, we show a scatter plot of the estimates over time. The horizontal axis is the year of the estimate of the specific study. The vertical axis is the SCC estimate that we have converted in 2009 dollars per short ton of $CO_2$, expressed in log terms because of the wide range of the distribution.[23] As shown, the reported SCC estimates appear to vary widely across time with no particular pattern emerging associated with when individual studies were performed.

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[21] IPCC. *Summary for Policymakers* in "*IPCC Fourth Assessment Report: Working Group II Report Impacts, Adaptation and Vulnerability*". 2007. Page 17.
[22] It should be noted that many of the studies in Tol's database were authored or co-authored by Tol himself.
[23] $100 in 1995 dollars is equal to $135.6 in 2009 dollars.

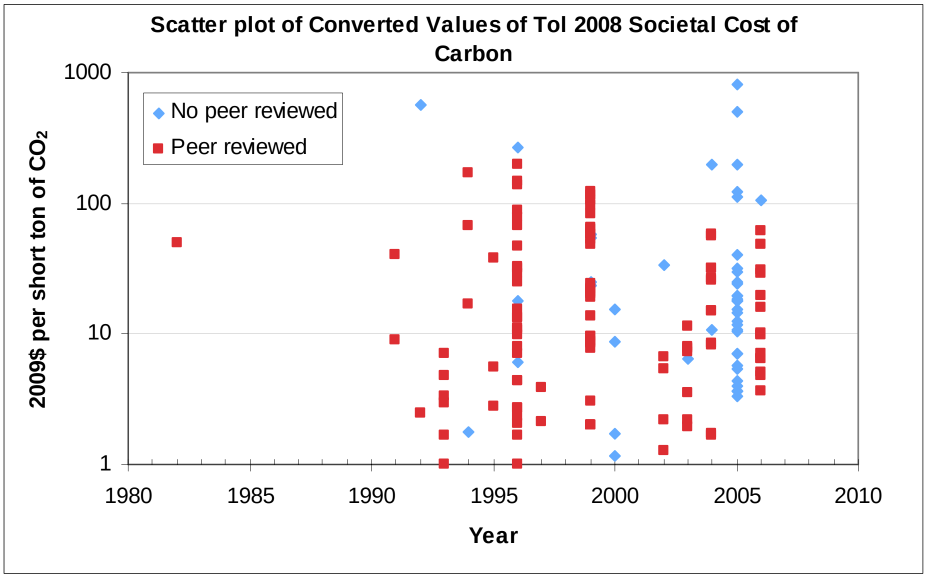


**Figure 1 Tol 2008 SCC Scatter plot**

In Figure 2, below, we show a frequency distribution of the SCC observations. Note that the higher estimates from the paper are not shown in the figure since they would be far beyond the right edge of the figure. The depicted data in the figure show the highly skewed or asymmetrical shape of the distribution. This skewed distribution highlights the conundrum facing policy makers dealing with climate change. While the median or 50th percentile value may represent serious damages resulting from climate change, the outlying values represent damages of relatively low probability, but potentially catastrophic impact.

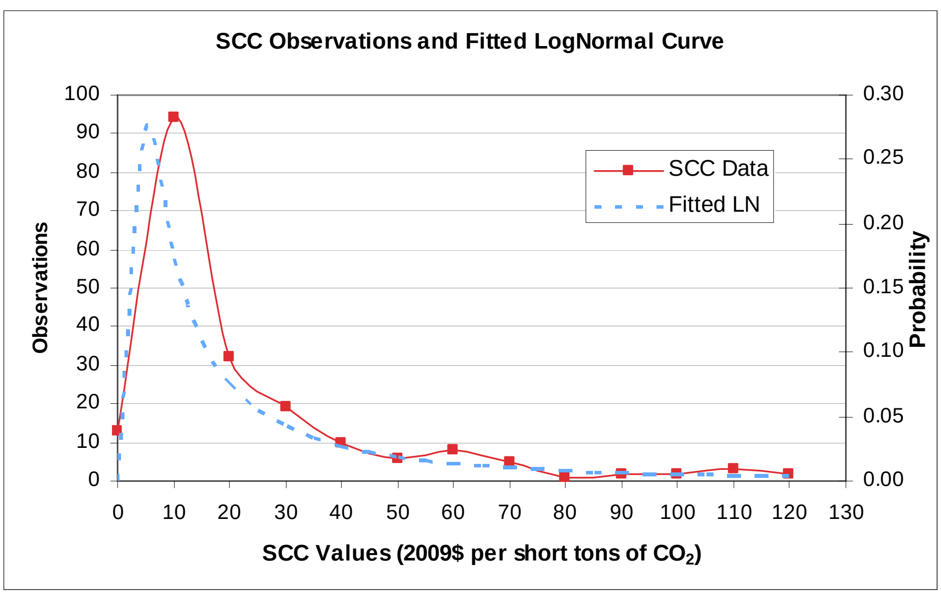


**Figure 2 Frequency Distribution of SCC values**

In general terms, we can draw parallels between climate policy and insurance. Insurance is not purchased because it is cost effective in the most likely future scenario, or even because it is cost-effective in many future scenarios. One purchases insurance to address the high consequence, but low probability scenario. How these consequences are reflected in a damage-based value is discussed in the next section.

### Shortcomings of Damage-based $CO_2$ Valuation

We have referred to Tol's SCC estimates as "data" but it is important to note that this data is the construct of economic modeling, and not simply observations of physical phenomena. These SCC or damage-based studies are the result of human researchers grappling with a very complex task (some might say impossible) of estimating all of the significant damages from climate change, attaching economic values to them, and then aggregating them over all of the countries and over long periods of time.

There are various methods available for monetizing environmental externalities such as air pollution from power plants. These include various "damage costing" approaches that seek to value the damages associated with a particular externality, and various "control cost" approaches that seek to quantify the marginal cost of controlling a particular pollutant (thus internalizing a portion or all of the externality).

The "damage costing" methods generally rely on travel costs, hedonic pricing, and contingent valuation techniques to value non-market impacts or damages. These are forms of "implied" valuation, asking complex and hypothetical survey questions, or extrapolating from observed behavior. For example, travel cost valuation utilizes data such as how much people spend on travel to go on a fishing trip. That information can be then used to quantify the value of the fish, or more accurately, the associated value of *not* killing fish via air pollution. However, this methodology ignores the existence value of the fish. Human lives are sometimes valued based upon wage differentials for jobs that expose workers to different risks of mortality. In other words, comparing two jobs, one with higher hourly pay rate and higher risk than the other can serve as a measure of the compensation that someone is "willing to accept" in order to be exposed to the risk.

To monetize the avoided damages from GHG emissions, economists make significant assumptions to deal with tremendous uncertainties and value judgments.[24] Reducing the monetized damage values into a single value incorporates determinations made with respect to the impact and value of each of the following:

- **Heating and cooling energy requirements**: Assumes lower heating requirements and increasing cooling requirements if global temperatures rise.

- **Agriculture and Forestry**: Using a simple regression and limited data, models estimate if higher temperatures will result in higher or lower crop yields.

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[24] A detailed discussion of this issue is found in Ackerman, F. *Can We Afford the Future?: The Economics of a Warming World.* Zed Books, 2009.

- **Water Resources**: The impact on water availability or unavailability will have a significant impact on a local and regional level. Scaling this into a single number is difficult.

- **Sea Level Rise**: Rising sea levels inundate drylands and wetlands. Individuals who are forced to leave flooded areas will face infrastructure losses, lost commerce, the opportunity costs of using the land, or more complex costs such as the value of existing buffers against storm surge, reduction in fish nurseries in coastal wetlands, or lost coastal groundwater resources, much less the social unrest of displaced persons.

- **Ecosystem Impacts**: The value of species, biodiversity, and landscapes are difficult to monetize, the services provided by natural ecosystems (such as clean air and water, moisture, temperature, and dust regulation, and buffers against natural disasters) cannot be denied and may be quickly lost in a highly uncertain single valuation.

- **Human Morbidity and Mortality**: Increasing evidence suggests that climate change may impact human health across a wide range of factors, from the increasing range of malaria, dengue, and plague, to malnutrition, water shortages leading to cholera, diarrhea, and schistosomiasis, amongst others (Khasnis and Nettleman, 2005).[25] In a social cost model, all of these debilitating and deadly factors simply result in a loss of economic productivity.

- **Human migration**: The impacts of global climate change including sea level rise, water shortages, increasing aridity, and spreading diseases may result in significant forced human migration. Social cost models represent these events as a shifting population with less disposable income.

It is understandable that for the purpose of decision-making, DOE would strive to select a single number that could reflect the vast array of damages from carbon emissions. However, because the impacts of climate change are so varied, spread out geographically, affect such a wide swath of economic activities, and continue to be the subject of scientific analysis, it is important to also understand the projected physical impacts that are being combined into that single dollar value.

Once physical damages have been identified, a damage-based estimate requires making numerous and challenging value judgments in assigning a monetary value to these physical impacts.

One such value judgment that influences the damage-based valuation but is not of a scientific nature is the equity or country weighting across different economic conditions throughout the world. In other words, is the value of an individual life greater in a

[25] Khasnis, A. A. and M.D. Nettleman. 2005. Global Warming and Infectious Disease. *Archives of Medical Research*. **36**:689-696

developed country or an undeveloped country? Sometimes, for example, lost earnings are used as a metric for human life. How this value judgment is incorporated into the development of a damage-based valuation has a profound influence on the modeled output.

Another value judgment arises during the final step in damage-based cost aggregation. Economists typically choose a discount rate, or a time value of money that represents how much should be paid today to avoid a future damages..[26] For short term capital investments, these rates can be quantified relatively easily. But, for long-term cost streams (on the order of centuries), standard discount rates are inappropriate.

With regard specifically to the selection of an appropriate discount rate, we recommend that DOE uses a method for valuing $CO_2$ that does not discount future impacts to the point that they are effectively ignored. It should be noted that the discount rate applied to near term costs (e.g., manufacturing costs for appliances, or electricity prices for consumers) need not be the same discount rate used for long-term climate change damages. These are fundamentally different impacts.

**DOE's Focus on Damages in the United States**

DOE's valuation of $CO_2$ emission benefits is restricted to those costs likely to be experienced in the United States (US). DOE surmises that the costs will likely be a small fraction of the total damages from $CO_2$ emissions.[27] According to DOE's reasoning, this approach justifies using a low $CO_2$ value of zero and a high $CO_2$ value based on the "mean" of the damage-based values estimated in the Tol (2005) article.

While we do not recommend using a damage cost estimate, it is informative to consider damages to get a sense of the scale of the problem. For example, one important recent report by the Stern Review on the Economics of Climate Change, concluded that "the benefits of strong and early action far outweigh the economic costs of not acting." Based on a review of results from formal economic models, the Stern Review estimated that, in the absence of efforts to curb climate change, the overall costs and risks of climate change will be equivalent to losing at least 5% of global GDP each year, now and forever, and could be as much as 20% of GDP or more. In contrast, the Stern Review concluded that the costs of action – the cost of implementing actions to curb climate change – can be limited to around 1% of global GDP each year.[28]

In our view, DOE's decision to exclude the cost of damages which occur outside of the US is unreasonable. US emissions have impacts on others in the world, as other

[26] A more detailed discussion of discount rates, specific to the 2005 Tol article is presented in Appendix II.
[27] This is discussed on page 17012 of the **Federal Register**: "DOE also believes that it is reasonable to allow for the possibility that the U.S. portion of the global cost of carbon dioxide emissions may be quite low. In fact, some of the studies looked at in Tol (2005) reported negative values for the SCC. DOE is using U.S. benefit values, and not world benefit values, in its analysis, and future, DOE believes that the U.S. domestic values will be lower than the global values."
[28] Stern, Sir Nicholas; *Stern Review of the Economics of Climate Change*; Cambridge University Press, 2007.

countries' emissions have an impact on us. As climate change affects the global environment, regional disasters have and will continue to impact the US both domestically and internationally. In terms of cost, the Office of Foreign Disaster Assistance of United States Agency of International Development reported for Fiscal Year 2007 that it had spent $573.4 million to respond to approximately 77 disasters affecting 94 million people in 57 countries.[29] It is impossible to apportion these damages to climate change but the US is clearly spending resources to address natural disaster outside of the US. Within this country, the FY 2007 budget for the Federal Emergency Management Administration (FEMA) was $5.2 billion.[30]

We believe that any monetized $CO_2$ value should be supplemented by estimating and presenting ranges for the tangible non-monetized impacts (i.e., human morbidity and mortality, number of people displaced by flooded coastlines and water shortages, number of species lost, and so on). Such information would be based in science and would not incorporate the ethical considerations of analysts. The numerous assumptions entailed in consolidating a wide range of impacts into a single value render the dollar value less meaningful than a full representation of physical impacts.

[29] USFDA. Annual Report for FY 2007 Office of US Foreign Disaster Assistance at p. 8.
[30] Department of Homeland Security. Budget-in-Brief FY 2008.

# 5. Synapse's Recommended Cost of Carbon for Use in Proposed Energy Conservation Standards

The other approach for assigning a monetary value to $CO_2$ emissions is to estimate the marginal cost of achieving a given emissions target through emissions abatement. The marginal abatement cost approach requires identifying an emissions reduction target for the purpose of the analysis. In this case, we rely on current scientific understanding of the level of atmospheric greenhouse gas concentration (and the associated emissions level) that could avoid the most dangerous climate change impacts. For ease of reference we call this a "sustainability target," though we understand that scientific knowledge continues to evolve and that the use of the term "sustainable" applied to climate change is almost an oxymoron. We then review estimates of the marginal cost of achieving that target through emissions abatement. It is important to note that, at this stage in our collective understanding of the science of climate change, as well as its social, economic, and physical impacts, the notion of a "sustainability target" is a construct useful for discussion, but not yet numerically definitive.

The "sustainability target" approach relies on the assumption that the nations of the world will not tolerate unlimited damages. It also relies partly on an expectation that policy leaders will realize that emission reduction will be cheaper now than the cost of addressing climate change at a future date.[31] It is worth noting that, in theory, a cost estimate based on a sustainability target will likely be a bit lower than a comprehensive damage cost estimate because the choice of a "sustainability target" reflects an assessment of the relative costs of damages and costs that will be incurred to avoid those damages.

### Estimating the Long-Run Marginal Abatement Cost of $CO_2$

We recommend that an estimate of the long-run marginal abatement cost of $CO_2$ is a practical and conservative measure of the social cost of carbon, and is well-suited for use in DOE's decision-making. To develop that estimate, we reviewed the most recent science regarding the level of emissions that is likely to avoid the most dangerous climate change impacts, as well as the literature on costs of controlling emissions at that level.

Given the daunting challenge of valuing climate damages in economic terms as noted in the previous section, Synapse takes a practical approach consistent with the concepts of "sustainability" and "avoidance of undue risk." Specifically, the carbon externality can be valued by looking at the marginal costs associated with controlling total carbon

[31] A more thorough examination of this issue has been presented in the Stern Review. (Stern, N.H. et al. 2006. *Stern Review: The Economics of Climate Change.* Cambridge University Press, Cambridge). A detailed introduction of strategies to address the idea of stabilizing atmospheric concentrations of carbon dioxide can be found in Socolow and Pacala, "Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies." *Science* (vol. 305) August 13, 2004 (pp. 968-72).

emissions at, or below, the levels that is currently thought to avoid the major climate change risks.

Because the environmental costs of energy production and use are so significant, and because the climate change impacts associated with power plant $CO_2$ emissions are urgently important, it is worthwhile to attempt to estimate the externality price and to put it in dollar terms that can be incorporated into electric system planning.

**What is the Current Understanding of an Appropriate Target Level of $CO_2$ Emissions?**

In order to determine what is currently deemed a reasonable "sustainability target", we reviewed current science and policy regarding the avoidance of dangerous climate change. In 1992, over 160 nations (including the United States) agreed to "to achieve stabilization of atmospheric concentrations of greenhouse gases at levels that would prevent dangerous anthropogenic (human-induced) interference with the climate system…." (United Nations Framework Convention on Climate Change or UNFCCC).[32] Achieving this commitment requires determining the maximum temperature increase above which impacts are anticipated to be dangerous, the atmospheric emissions concentration that is likely to lead to that temperature increase, and the emissions pathway that is likely to limit atmospheric concentrations and temperature increase to the desired levels.

The determination of an acceptable level of temperature change will ultimately be established by politicians, as it requires value judgments about what impacts are tolerable regionally, globally, and over time.[33] We expect that such a determination will be based upon what climate science tells us about expected impacts and mitigation opportunities.

While uncertainty and research continue, a growing number of studies identify a global average temperature increase of $2^oC$ above pre-industrial levels as the temperature above which dangerous climate impacts are likely to occur.[34] Temperature increases greater than $2^oC$ above pre-industrial levels are associated with multiple impacts, including sea level rise of many meters, drought, increasing hurricane intensity, stress on and possible destruction of unique ecosystems (e.g., coral reefs, the Arctic, alpine regions), and increasing risk of extreme events.[35] The European Union has adopted a

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[32] There are currently over 180 signatories.
[33] For multiple discussions of the issues surrounding dangerous climate change, *see* Schnellnhuber, Cramer, Nakicenovic, Wigley and Yohe, editors; *Avoiding Dangerous Climate Change*; Cambridge University Press, 2006. This book contains the research presented at The International Symposium on Stabilization of Greenhouse Gas Concentrations, Avoiding Dangerous Climate Change, which took place in the U.K. in 2005.
[34] Mastrandrea, M. and Schneider, S.; *Probabilistic Assessment of "Dangerous" Climate Change and Emissions Scenarios: Stakeholder Metrics and Overshoot Pathways;* Chapter 27 in *Avoiding Dangerous Climate Change*; Cambridge University Press, 2006.
[35] Schnellnhuber, 2006.

long-term policy goal of limiting the increase in global average temperature to 2$^{o}$C above pre-industrial levels.[36]

Because of multiple uncertainties, it is difficult to define with certainty what future emissions pathway is likely to avoid exceeding a 2$^{o}$C temperature increase. We reviewed several sources to determine reasonable assumptions about what level of concentrations are deemed likely to achieve the sustainability target, and what emission reductions are necessary to reach appropriate emissions levels. The IPCC's most recent Assessment Report indicates that concentrations of 445-490 ppm $CO_2$ equivalent correspond to 2$^{o}$ – 2.4$^{o}$C increases above pre-industrial levels.[37] A comprehensive assessment of the economics of climate change, the Stern Review, proposes a long-term goal to stabilize greenhouse gases at between the equivalent of 450 and 550 ppm $CO_2$.[38] Recent research indicates that achieving the 2$^{o}$C goal likely requires stabilizing atmospheric concentrations of $CO_2$ and other heat-trapping gases near 400 ppm $CO_2$ equivalent ($CO_2$-eq).[39]

The IPCC indicates that reaching concentrations of 450-490 ppm $CO_2$-eq requires reduction in global $CO_2$ emissions in 2050 of 50-85 below 2000 emissions levels.[40] The Stern Review indicates that global emissions would have to be 70% below current levels by 2050 for stabilization at 450ppm $CO_2$-eq.[41] To accomplish such stabilization, the United States and other industrialized countries would have to reduce greenhouse gas emissions on the order of 80 – 90% below 1990 levels, and developing countries would have to achieve reductions from their baseline trajectory as soon as possible.[42]

But even this relationship between emissions and atmospheric abundance is fraught with uncertainty because scientists are still working to understand factors. For example, scientist do not know the ultimate GHG absorption capacity of the oceans, how the oceans will change with increasing acidity or altered circulation patterns, and what system feedback loops might be affected. Modeling studies suggest that (1) the slow and predictable impacts increase with increasing $CO_2$ abundance in the atmosphere, and (2) the likelihood of catastrophic impacts (i.e., hitting thresholds) is lower with lower $CO_2$ in the atmosphere. On this second point, the IPCC has determined that a 2°C

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[36] The European Union first adopted this goal in 1996 in "Communication of the Community Strategy on Climate Change." Council conclusions. European Council. Brussels, Council of the EU. The EU has since reiterated its long-term commitment in 2004 and 2005 (*see*, *e.g.* Council of the European Union, Presidency conclusions, March 22-23.)
[37] IPCC AR4, WGIII Summary for Policy Makers, 2007. Table SPM5.
[38] Stern, Sir Nicholas; *Stern Review of the Economics of Climate Change*; Cambridge University Press, 2007.
[39] Meinshausen, M.; *What Does a 2$^{o}$C Target Mean for Greenhouse Gases? A Brief Analysis Based on Multi-Gas Emission Pathways and Several Climate Sensitivity Uncertainty Estimates;* Chapter 28 in *Avoiding Dangerous Climate Change*; Cambridge University Press, 2006.
[40] IPCC AR4, WGIII Summary for Policy Makers, 2007. Table SPM5.
[41] Stern Review, Long Executive Summary, 2007. Page xi.
[42] den Elzen, M., Meinshausen, M; *Multi-Gas Emission Pathways for Meeting the EU 2$^{o}$C Climate Target;* Chapter 31 in *Avoiding Dangerous Climate Change*; Cambridge University Press, 2006. Page 306.

temperature increase is the level at which we are unlikely to hit the thresholds and the impacts will be more manageable.

The sobering news is that a long term stabilization goal of even 400 ppm might not be sufficient. One 2006 study concludes, for example, that "while very rapid reductions can greatly reduce the level of risk, it nevertheless remains the case that, even with the strictest measures we model, the risk of exceeding the 2ºC threshold is in the order of 10 to 25 per cent."[43] Similarly, a 2009 analysis estimates that if global emissions in 2050 are half 1990 levels, there is a 12–45% probability of exceeding $2^oC$.[44] Further, the 2ºC threshold may not be sufficient to avoid severe impacts.[45] Nevertheless, the goal of policymakers seems to be coalescing around maintaining global temperatures increases at or below 2°C above pre-industrial levels.

**What is the Cost of Stabilizing $CO_2$ Emissions at this Target Level?**
There have been several efforts to estimate the costs of achieving a variety of atmospheric concentration targets. The IPCC has undertaken the most comprehensive effort in this area, as DOE recognizes. In its fourth Assessment Report, the IPCC indicates that annual reductions on the order of 34 metric gigatonnes (Gt) would be necessary to achieve an 80% reduction below current emission levels. [46] That report estimates that up to 31 Gt in reductions are available for $97 per short ton of $CO_2$ in 2009$ or less (Working Group III Summary for Policy Makers).[47] Other recent studies on the costs of achieving stabilization targets include the following:

- The International Energy Agency (IEA) has modeled the implications and results of two international policy framework scenarios: (1) achieving 550 ppm (to limit temperature increases to 3oC), and (2) achieving 450 ppm (to limit temperature increase to $2^oC$).[48] IEA projects that a cap and trade program would result in

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[43] Bauer and Mastrandrea; *High Stakes: Designing emissions pathways to reduce the risk of dangerous climate change;* Institute for Public Policy Research, U.K.; November 2006.
[44] Meinshausen et. al.; *Greenhouse-gas emission targets for limiting global warming to $2^oC$*; Nature, Volume 458, April 30, 2009.
[45] See recent research by James Hansen, Goddard Space Flight Institute – NASA's top climate scientist.
[46] 2000 emissions levels were 43Gt $CO_2$-eq. IPCC AR4, WGIII, Summary for Policy Makers, 2007, at p. 11.
[47] Original value of $100 per metric ton of $CO_{2\text{-eq}}$ in 2006 dollars.
[48] IEA *World Energy* Outlook 2008. WEO 2008 demonstrates how an energy revolution, to achieve a low carbon efficient and environmentally benign system of energy supply, can be achieved through decisive policy action and at what cost. The choice of appropriate global emissions trajectory will have to take into account technological requirements and costs in the energy sector. The WEO-2008 provides analysis to help policy makers around the world assess and address the challenges posed by worsening oil supply prospects, higher energy prices and rising emissions of greenhouse gases. WEO-2008 takes a detailed look at the prospects for oil and gas production. It also analyzes policy options for tackling climate change after 2012 when a new global agreement – to be negotiated at the U.N. Conference of the Parties in Copenhagen next year – is due to take effect. The analysis assumes a hybrid policy approach, comprising a plausible combination of cap-and-trade systems, sectoral agreements and national measures.

carbon prices of \$85 per short ton $CO_2$ in 2030 under the 550 ppm scenario, and \$170 per short ton $CO_2$ in 2030 under the 450 ppm scenario.[49]

- The IEA has also performed an intensive analysis of technologies available to achieve significant greenhouse gas emissions reductions. In its Technology Perspectives 2008, IEA projects that the marginal cost of technologies necessary to reduce emissions in 2050 to current levels (the ACT Map Scenario) would be \$50.10 per short ton $CO_2$ in 2009\$.[50] The marginal cost of technologies necessary to reduce emissions in 2050 to 50% below current levels (the Blue Map Scenario, and the low end of what IPCC projects is necessary for a 2°C temperature increase) would be up to \$200 (2009\$) per short ton $CO_2$ when fully commercialized. If technological progress fails to meet expectations, marginal costs could be as high as \$501 (2009\$) per short ton of $CO_2$.[51] IEA notes that its marginal cost figure for the ACT Map Scenario is nearly twice that in the *Energy Technology Perspective* 2006, primarily due to accelerated trends in $CO_2$ emissions and an approximate doubling of engineering costs.[52]

- McKinsey has produced a second version of its Global Greenhouse Gas Abatement Cost Curve.[53] In this analysis, McKinsey determines that only what it defines as the "Global Action" and "Green World" scenarios are consistent with a sustainability goal of avoiding more than a 2°C temperature increase. In the most aggressive scenario, the "Green World" scenario, all countries would capture one hundred percent of abatement options that cost approximately \$75 per short ton or less, all technical potential options costing up to approximately \$125 per short ton $CO_2$, and all behavioral change potential would be captured. McKinsey states that transaction and program costs, that are not part of the abatement cost curve, are often estimated at an average between one and eight percent per ton of $CO_2$ abated.

Prior to these most recent studies, the IPCC Working Group III Summary for Policy Makers states that "An effective carbon-price signal could realize significant mitigation

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[49] The WEO-2008 values are reported in \$2007 per metric ton. Original values of \$90 per metric ton for the 500 ppm scenario and \$180 per metric ton for the 450 ppm scenario.
[50] Original costs are in real 2005 US dollars of \$50 per metric ton of $CO_2$.
[51] Original values of \$200 and \$500 per metric ton in 2005\$.
[52] IEA *Technology Perspectives 2008*. The introduction to the ETP states that its purpose is to explain how the global energy economy can be transformed over the coming decades to avoid "unsustainable pressure on natural resources and on the environment." ETP 2008 presents "an in depth review of the status and outlook for existing and advanced clean energy technologies, offering scenario analysis of how a mix of these technologies can make the difference."
[53] McKinsey & Company; *Pathways to a Low-Carbon Economy- Version 2 of the Global Greenhouse Gas Abatement Cost Curve*; 2009. McKinsey has developed a global greenhouse gas abatement database to provide a quantitative basis for international discussions of greenhouse gas emissions reduction targets. The current version builds on an earlier version published in 2007 and incorporates updated and more sophisticated assessment of low-carbon technologies, regional and industry-specific abatement opportunities, and investment and financing needs, as well as review of implementation scenarios and how abatement could develop.

potential in all sectors."[54] IPCC explains that modeling studies show that, to achieve stabilization at around 550 ppm $CO_2$-eq by 2100, carbon prices would rise to between $19-$78 per short ton of $CO_2$-eq by 2030 and $29-$151 per short ton of $CO_2$-eq by 2050.ppm $CO_2$-eq by 2100.[55] IPCC notes for the same stabilization level, studies since the Third Assessment Report, that take into account induced technological change, lower these price ranges to between $5-$63 per short ton of $CO_2$-eq in 2030 and $15-$126 per short ton of $CO_2$-eq in 2050.

IPCC finds that most top-down, as well as some 2050 bottom-up assessments, suggest that real or implicit carbon prices of $19 to $49 per short ton of $CO_2$-eq, sustained or increased over decades, could lead to a power generation sector with low-greenhouse gas emissions by 2050 and make many mitigation options in the end-use sectors economically attractive.

A summary of the aforementioned study findings are presented in the table below, in both their original values and units and converted to 2009$ per short ton of $CO_2$ values.

| Study Source | Study | Analysis End Year | Scenario | Value | Units | Value (2009$/short ton CO2) |
|---|---|---|---|---|---|---|
| McKinsey & Company | Version 2 of the Global Greenhouse Gas Abatement Cost Curve | 2030 | Global Action | € 60.00 | 2005 Euro/metric ton CO2 | $74.87 |
| | | 2030 | Greenworld | € 100.00 | 2005 Euro/metric ton CO2 | $124.78 |
| Internation Energy Administration | World Energy Outlook 2008 | 2030 | 550 ppm | $90.00 | $2007/metric ton CO2 | $85.07 |
| | | 2030 | 450 ppm | $180.00 | $2007/metric ton CO2 | $170.14 |
| Internation Energy Administration | Energy Technology Perspective 2008 | 2050 | ACT Map | $50.00 | $2005/metric ton CO2 | $50.10 |
| | | 2050 | Blue Map | $200.00 | $2005/metric ton CO2 | $200.38 |
| | | | **Average** | | | $117.56 |

**Notes**

2005 Euros converted to 2005 US dollars based on average exchange rate of 1:1.245 Euro to Dollars from www.oanda.com

2007$ converted to 2009$ based on GDP chain type values for 2007(119.82) and 2009 (124.86) from http://www.bea.gov/national/nipaweb/TableView.asp?SelectedTable=13&FirstYear=2002&LastYear=2004&Freq=Qtr
One metric ton equals 1.102 short tons

**Table 2 Carbon Emission Studies Summary**

### A Recent Meta-analysis of Marginal Abatement Costs - Kuik et al.

A recent meta-study authored by Onno Kuik, Luke Brander, and Richard Tol takes a slightly different approach to develop (through regression modeling) a marginal

[54] IPCC, 2007: Summary for Policymakers. In: Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
[55] Data originally presented as 20 to 80 US$/tCO2-eq by 2030 and 30 to 155 US$/tCO2-eq by 2050 in 2006$.

abatement cost for greenhouse gas emissions.[56] This paper investigates the marginal abatement costs derived from 26 studies necessary to achieve long-term stabilization of greenhouse gases in the atmosphere. The "control cost" methods generally look at the *marginal* cost of control; i.e., the cost of control valuations look at the last (or most expensive) unit of emissions reduction required to comply with regulations. The cost of control approach can be based upon a "regulators' revealed preference" concept. In other words, if "air regulators" are requiring a particular technology with a certain cost per ton to be installed at power plants, then this can be taken as an indication that the value of those reductions is perceived to be at or above the cost of the controls.

To be clear, unlike the studies at issue in Tol 2005, these studies do not look at the cost of damages, but instead focus on the control cost (marginal abatement cost) associated with meeting a specific target concentration. Kuik et al. investigated a range of atmospheric concentration targets of 450 to 650 parts per million of $CO_{2\ eq}$. This approach sidesteps some of the issues associated with the damage-based valuation, in that it is not necessary to estimate the cost of damages resulting from climate change in each study.

In our analysis we present the marginal abatement costs for 2050 summarized by Kuik et al. in their analysis. A frequency distribution of the 2050 marginal abatement costs converted to 2009$ per short ton of $CO_2$ is presented in Figure 3.[57]

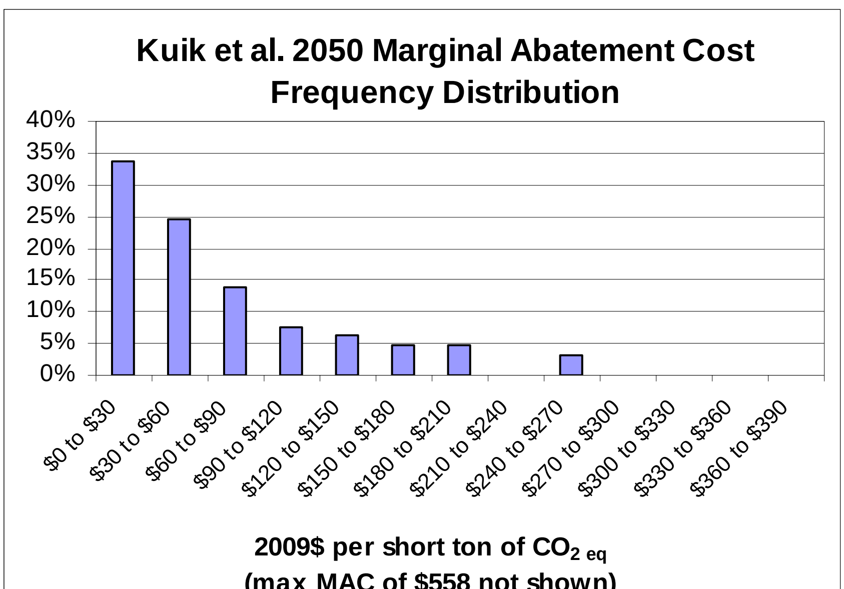


**Figure 3 2050 MAC Frequency Distribution**

[56] Kuik, O., Brander, L., Tol, R.S.J. 2009. Marginal abatement costs of greenhouse gas emissions: A meta-analysis. *Energy Policy,* **37:**1395-1403.

[57] Raw data provided in $ per metric ton of carbon via personal correspondence with Onno Kuik. Data converted to 2009$ and short tons by Synapse Energy Economics.

Like the damage-based studies at issue in Tol 2005, the studies analyzed by Kuik et al. show a right skewed distribution, meaning that there is a high cost associated with uncertainty. However, the uncertainty associated with the approach applied by Kuik et al. results from the uncertainty of costs in addressing climate change (e.g., effectiveness of carbon capture and sequestration is still unknown), not with the uncertainty of the cost of damages associated with the damage-based approach..

Based on a review of these different sources, we recommend that DOE adopt an estimated marginal abatement cost of \$80/t$CO_2$-eq (\$88/metric ton $CO_2$) in evaluating its proposed energy conservation standards. This value is comfortably within the range of current estimates of the marginal abatement costs for achieving a stabilization target that is likely to avoid temperature increases higher than 2$^{o}$C above pre-industrial levels. We believe that applying this number is a practical and conservative approach to incorporating the Societal Cost of Carbon in benefit/cost analysis. Nevertheless, we recognize that there is a wide range of uncertainty and there are numerous unresolved matters including an appropriate atmospheric concentration, and emissions reduction target. Nevertheless, our recommended value provides a reasonable method for taking the benefits of GHG emission reductions into account in evaluating energy efficiency measures. Clearly, some estimates are lower, and some estimates are much higher, reflecting a variety of effects including assumptions about technological innovation, emission reduction targets, technical potential of certain technologies, international and national policy initiatives, and the list goes on. Of course, selection of this value requires multiple assumptions and cannot be definitive given the quickly evolving combination of scientific understanding of the causes, effects and scale of climate change, international policy initiatives, and technological advances. It will be necessary to continuously review available information, and determine what value is reasonable given information available at the time of reviews.

# 6. Conclusion

Based on our analysis of DOE NOPR and research, Synapse concludes the following:

- DOE's effort to take into account a monetary benefit of $CO_2$ emissions reductions associated with its proposed conservation standards is both timely and essential.

- DOE's monetary value of $CO_2$ emissions reductions should not incorporate a damage-based estimate of a social cost of carbon. The range of the damage-based values in the papers collected and summarized by Tol 2005 is tremendous, and is in our view more important than the specific "mean of peer reviewed studies" that DOE relies upon. Additionally, the studies that are analyzed by Tol, and relied upon indirectly by DOE, are highly dependant upon not just scientific uncertainties (e.g., the climate models) but also upon a number of ethical assumptions, most importantly the assumed discount rate and the equity weighting.

- Using a damage-based estimate of the social cost of carbon reduces all of the species impact, health impacts and societal impacts of climate change into a single number. While easy to comprehend, this number oversimplifies the complex policy and societal choices that need to be made to address the climate change issue.

- DOE's proposal to restrict its consideration to U.S. damages only is inappropriate. DOE puts considerable emphasis on its intention to count only the US portion of the global cost of $CO_2$ emissions, and points out that this is likely to be a small fraction of the total damages from $CO_2$ emissions. This becomes the justification given for using a low value of zero and for picking a high value of $20 per ton based on the "mean" values estimated from damage-based models.

- A long-run international marginal abatement cost of carbon is a practical and conservative measure of social costs of carbon, and should be incorporated into DOE's conservation standard analyses. We recommend that DOE use a marginal abatement cost (2009$) of $80 per short ton of $CO_2$ ($88 per metric ton $CO_2$) that incorporates findings from a recent meta-analysis of marginal abatement costs and from recent abatement cost analyses published by both international agencies and multinational consultancies. These studies all find marginal abatement cost values that are much higher than the $20 per metric ton of $CO_2$ currently proposed by DOE.

# Appendix I Allowance Pricing for $CO_2$ in DOE's Electricity Price Projections

We note that the NEMS-BT model used to estimate $CO_2$ emission benefits resulting from the proposed TSLs does not include a $CO_2$ price in determining electricity usage and impacts of $CO_2$ regulation upon the energy markets. This practice is consistent with DOE's treatment of policies in its Annual Energy Outlook reference case where it only models existing policies in an effort to remain policy neutral, However given the current status of actions taken by corporations, states, and regions, and the likelihood of federal carbon constraints; we believe it is warranted for DOE to incorporate some level of $CO_2$ pricing in its electricity consumption model in evaluating energy efficiency standards.

From a technical standpoint, the value of $CO_2$ emissions could easily be included as part of the electricity modeling. We recognize that the AEO 2009 reference case does incorporate some acknowledgement of a cost associated with greenhouse gas emissions., *AEO* 2009 states that the reference case includes "a 3-percentage-point cost of capital penalty has been added when evaluating investments in GHG intensive technologies. "[58] However, we believe this approach is inadequate. A three percentage point change translates to approximately $10 to 15 per MWh or $10 to $15 per ton of $CO_2$, based on capital cost estimate of $4,000/kW for a coal-fired plant.[59] The risk premium is added "to GHG-intensive projects to account for the risk that they may have to purchase allowances or make other investments in the future to offset GHG emissions."[60]

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We believe a preferable approach would be for DOE, for its benefits calculation, to use an electricity price forecast that includes the reasonably expected emission allowance prices for $CO_2$[61] or, alternatively, add this price in at the end recognizing that it is an expected market cost for emitting $CO_2$.

We recommend that DOE use as a starting point a NEMS model case that includes either some estimate of federal $CO_2$ regulation or some allowance price for $CO_2$ emissions.

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[58] http://www.eia.doe.gov/oiaf/aeo/pdf/aeo2009_presentation.pdf (p. 22)

[59] EIA *AEO 2008* estimates for overnight capital costs are $1,534/kw as noted in http://www.eia.doe.gov/oiaf/aeo/assumption/pdf/tbl38.pdf. Rationale for higher coal capital costs are documented in "Coal Fired Construction Costs" July 30, 2008. http://www.synapse-energy.com/Downloads/SynapsePaper.2008-07.0.Coal-Plant-Construction-Costs.A0021.pdf

[60] http://www.eia.doe.gov/oiaf/aeo/pdf/aeo2009_presentation.pdf (p. 22)

[61] We use the term "allowance price" here, but this could also be a carbon tax or other form of internalized market cost. This is different from the "societal cost of carbon," which gets to the external costs, or "externalities." These include the damages from $CO_2$ emissions that are not "internalized" in the costs borne by entities in the energy markets.

# Appendix II Review of Tol 2008 Paper on the Societal Cost of Carbon

Of the 47 separate studies cited in the Tol (2008) metastudy, less than half have an "independent estimate" of the cost according to Tol's criteria, and half of those are by three prolific authors (including Tol). A majority of these were published before the year 2000. Many of the studies that publish damage figures are derivations and theoretical exercises, exploring different discount rates, damage functions, or interesting scenarios, and cannot be considered independently derived datasets. While the studies all raise important questions there is a nearly universal acknowledgement that "a cost-benefit analysis cannot be the whole argument for abatement. Uncertainty, equity, and responsibility are other, perhaps better reasons to act."[62]

**Reasons for and Implications of the Wide Range in SCC Estimates**

The distribution of SCC estimates has many causes. These include methodological variations, and differences in what is excluded from the analysis. They also include differences in the underlying models for what the quantitative physical impacts of climate change are. Perhaps most importantly, however, the differences in SCC result from differences in how the various impacts are aggregated across individuals in different parts of the world (this includes the "equity weighting" issue) and differences in how the impacts are valued over time.

The published values for the social costs of climate change range from negative values (a net benefit) to $2,400 per ton of carbon in 1995$. According to the Tol (2008) meta-study, the average value of all studies ranges from $88 to $127 per ton carbon in 1995$, but the standard deviation (indicating the range of values proposed by researchers) is much greater than the average, suggesting significant uncertainty even among researchers. Further, the combined metastudy indicates that an unusually large number of studies estimate very high damage costs.[63] As noted in Guo et al. (2006), "the enormous range of estimates in the damage-based estimates reflects both the sheer size of the uncertainties in our understanding of future climate change, future socioeconomic variables, and also the particular ethical parameters adopted in each model."[64] The Stern Review on the Economics of Climate Change (2006), a report commissioned by the British government, derived a cost of approximately $314 per ton of $CO_2$ eq.[65]

[62] Tol, R.S.J. and G.W. Yohe. 2007. A Stern Reply to the Reply to the Review of the Stern Review. World Economics. **8**:2:153-159
[63] The distribution in the Tol (2008) meta-study is non-normal and has a "fat-tail", indicating that there are more studies which suggest a high damage cost than would be expected in a normal distribution of the data.
[64] Guo, J., C.J. Hepburn, R.S.J. Tol, D Anthoff. 2006. Discounting and the social cost of carbon: a closer look at uncertainty. *Environmental Science and Policy*. **9**:205-216.
[65] Stern (2006)

## Discount Rate Implications

Global climate damages from a ton of $CO_2$ emissions today will occur over many decades. The economic models used to estimate damages generally contain a "discount rate" assumption which specifies how much future damages are worth relative to near term damages. Figure 4, below shows a scatter plot of the SCC estimates according to the assumed consumer discount rate (CDR).[66] The CDRs range from zero to 10 percent, with many of the estimates in the 2 to 5 percent range. A 3 percent discount rate would imply, for example, that an impact valued at $100 dollars fifty years from now, would be worth only $23 today. Or, looking out further, and impact valued at $100 dollars one hundred years from now would be worth only $5 today. Impacts out beyond 100 years are effectively discounted to insignificance.

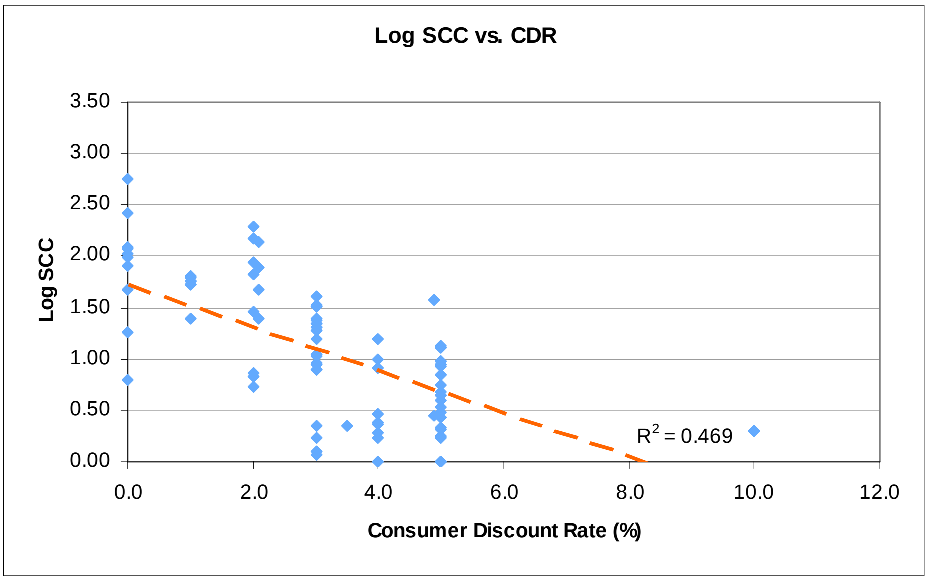


**Figure 4 Scatter plot of Log SCC versus CDR**

As illustrated in Figure 4, there is a wide range of Log SCC values at any given discount rate; however the assumed discount rate is one of the key factors in explaining the variation in the estimates.[67] The r-squared value of 0.469 suggests that about 46.9% of the variability of the Log SCC values may be attributed by changes in the consumer discount rate. There are arguments for discounting, and for evaluating financial investment decisions over reasonably short time periods, even several decades, are compelling. For public policy questions, however, involving very long time periods or

[66] The Tol SCC values have been converted from 1995 dollars per metric tons of Carbon to 2009 dollars per short ton of $CO_2$.
[67] Since the distribution of SCC values is skewed by very high values; transforming the data with a log function normalizes the distribution to assist in the analysis.

very large impacts (such as climate policy) economic discounting becomes a more important topic of discussion.[68]

[68] The Office of Management and Budget has very specific guidelines on the use of discount rates and public policy (http://www.whitehouse.gov/omb/circulars/a094/a094.html). Discussion of appropriate discount rates to assess climate change policy impacts is the subject of much scholarly debate. Participants include many of the authors cited throughout this paper. A detailed discussion of the discounting issue with regards to climate change may be found at Ackerman, F. *Can We Afford the Future?: The Economics of a Warming World.* Zed Books, 2009.