The Global Warming Pollution Reduction Act: The Science Behind S. 309

Workshop in Applied Earth Systems Management: Summer 2007

Columbia University:
School of International and Public Affairs
The Earth Institute

The Global Warming Pollution Reduction Act:

The Science Behind S. 309

ENVP U9229 The Workshop in Applied Earth Systems Management
Summer 2007

Master of Public Administration in Environmental Science and Policy

Columbia University:
School of International and Public Affairs
& The Earth Institute

Group Members: Noura Bakkour, John Battaglia, Kelsey Bennett, Connie Chao, Tara Jordan, Heather Matheson, Samantha Miller, Erin Morey, Will Murray, Harmony Patricio, Kyle Smith, Sofia Trevino

Advisor: Professor Steve Cohen

Table of Contents

Executive Summary

The Problem: Global Warming

Global warming poses a real and significant threat to the quality of life on this planet. The greenhouse effect is the primary driver of global warming, and is a natural process that regulates temperature on the earth's surface. Shortwave radiation emitted by the sun enters the earth's atmosphere and is absorbed by the earth. The earth emits approximately 70% of this radiation in the form of longwave, infrared radiation. Greenhouse gasses in the earth's atmosphere such as water vapor, carbon dioxide, and methane, absorb this radiation and warm the earth's surface. This process regulates temperature on earth and is required to sustain life; however, an increase concentration of anthropogenic greenhouses gasses in the atmosphere, namely carbon dioxide, absorb more infrared radiation and cause the earth to warm further.

A wealth of scientific evidence indicates that greenhouse gas concentrations have increased exponentially following the industrial revolution. This evidence is extrapolated from the field, such as sample of air bubble trapped in ancient ice cores, and mathematical modeling. The 2007 IPCC report states with a high degree of confidence that global warming is occurring, and that its effects are myriad. These effects include, but are not limited to, sea level rise, biodiversity loss, increased intensity of weather patterns, shifts in seasons, and the resurgence of disease.

While global warming is a global problem, the United States currently contributes to 23% of the greenhouse gas emissions worldwide. Of these emissions, 84% come from carbon dioxide, which is released through the combustion of fossil fuels. Methane emissions, which have steadily declined since 1990, result primarily from decomposition of wastes in landfills, natural gas systems and activities associated with domestic livestock. Agricultural soil management and mobile source fossil fuel combustion are the major sources of nitrous oxide emissions. The emissions of hydrofluorocarbons, which are substitutes for ozone depleting substances, are the primary component of fluorinated gas emissions.

The Proposed Solution: Senate Bill 309

The Global Warming Pollution Reduction Act S.309 amends the Clean Air Act of 1970, and would regulate CO_2 as a pollutant. It charges Environmental Protection Agency (EPA) with setting milestones to reach the standards, which are proposed as follows:

- 1/3 of 80 percent of the aggregate net level of 1990 emissions by 2030
- 2/3 of 80 percent of the aggregate net level of 1990 emissions by 2040
- 80 percent of the aggregate net level of 1990 emissions by 2050

To do so, the bill proposes a number of provisions that to reduce carbon dioxide emissions through a series of programs, regulations and market-based incentives. These programs include the following:

Vehicle Emissions Standards: The bill charges the EPA Administrator with establishing regulations to increase the stringency of emission standards, with which U.S. motor vehicle manufacturers must comply by 2016. The principal requirements are that both vehicle class emissions standards shall not exceed certain carbon dioxide (CO_2) equivalents per grams per mile (g/m) depending on the vehicle weight (205 g/m and 332 g/m for automobiles and 405 g/m for

vehicles over 8,501 pounds). The effectiveness of this method has been proven in the past with previous emissions standards, and thus is an effective method of reducing CO2 emissions. However, the regulations may increase costs for the automobile industry, and some economists argue that a command and control approach to regulation does not utilize market efficiencies.

Emissions Standards for Electric Generation Units: The United States derives 52% of its energy from coal, a fossil fuel composed primarily of carbon and is one of the largest sources of carbon dioxide emissions. The act outlines an approach for standards compliance that phases out the use of coal and other polluting fuels. Electric generation units must meet emission standards for new combined cycle natural gas generating units by 2030. This provision of the Act requires the development of new technology and may generate political opposition.

Low Carbon Generation Requirement: Low carbon generation requires specified electricity generators to produce a certain amount of low-carbon energy. Generators with a rated capacity of 25 megawatts, and annual energy inputs of 50% or more from coal, petroleum coke, lignite or any combination of these fuels, must produce for sale 5% low carbon electricity by 2020. To achieve emission reduction targets the EPA is given the right to increase the requirement by up to 2% each year from 2021-2025 and 3% each year from 2026-2030. Compliance with low-carbon requirements can be achieved two ways: 1) generating or purchasing low-carbon electric energy, or 2) purchasing credits pursuant to the Low-Carbon Generation Credit Trading Program. The carbon trading program utilizes market efficiency to reduce emissions, and provides a viable incentive. However, there exists the potential to undervalue or over-issue credits a la the European Union's Emissions Trading Scheme (ETS). Such an error might also be exacerbated by the fact that penalties for non-compliance are monetary.

Renewable Portfolio Standard: By 2008**,** all electricity suppliers must provide a percentage of electricity (determined by the EPA) from renewable sources (i.e., solar, wind, biomass, landfill gas, ocean (including tidal, wave, current, and thermal), geothermal, municipal solid waste, or new hydroelectric generation). In addition, to subsidize renewable energy, the EPA will be given a mandate to establish a renewable energy credit program one year after the enactment of the title. A key benefit in this approach is development of renewable energy technology and a market force for clean energy generation. However, monitoring the standard may prove difficult, and states that rely more heavily on traditional fossil fuel production might distort the market.

Research and Development: The bill will establish a global climate change standards and processes research competitive grant program with the following Federal agencies: National Oceanic and Atmospheric Administration (NOAA), National Aeronautics and Space Administration (NASA) and the Department of Energy (DOE). The objective of this program is to 1.) Develop enhanced ways to monitor global warming pollution; 2.) Establish a baseline reference point for future global warming pollutants, and 3.) Begin an international exchange of information in an effort to develop mutually-recognized measurements. Furthermore, a program aimed at researching abrupt climate change is a priority under this Act. Research and development is a key component of the bill, as it will increase the current state of knowledge technology of clean energy programs. However, the international aspect lacks a concrete timeline and plan for implementation.

Carbon Sequestration: Carbon sequestration involves the capture and long-term storage of carbon dioxide in geologic repositories and the terrestrial biosphere. Carbon dioxide generated by point sources such as power plants is separated from other byproducts of energy production, captured and pressurized, and then pumped into geologic formations such as oil and gas reservoirs, coal beds,

saline reservoirs, and basalt formations. While there is evidence that carbon sequestration is effective, the impact of a potential leak would have disastrous consequences. Also, sequestration cannot remove existing CO2 from the atmosphere, as many people believe.

Are There Uncertainties?

While science always has some degree of uncertainty, the methods for reducing emissions outlined in the bill are, by ad large, scientifically sound. There are a number of uncertainties associated with the political ad economic ramifications of some of the proposed solutions, but those uncertainties will not be discussed in further detail here. The source of greatest scientific uncertainty, as mentioned above, is carbon sequestration. While evidence and experience suggests that geological sequestration could provide a viable solution for storing CO2, the consequences of a potential leak are unknown and unstudied. Additionally, scientists cannot predict the probability that a leak will occur.

The Outcome: Measuring Success

Currently, the United States estimates its CO2 emissions by the amount of fossil fuel consumed, which is an indirect measurement. Thus, the measure of the program's success will also be somewhat indirect. In order to measure the long-term effectiveness and success of the bill, the most representative and useful mechanism is to calculate the reduction of GHG emissions from each carbon-intensive sector, including the transportation and energy sector, for example. However, as mentioned above, all emission inventories have inherent limitations in their accuracy and comparability and again, there is an absence of any directly measured or reported information on global warming pollution emissions.

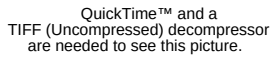
While the United States constitutes significantly to global warming, it does not act alone. Thus, there is an inherent disparity in measuring the bill's success: does success mean adhering to the proposed standards, or reducing global warming? Naturally, policy makers can only monitor specified and discrete measurements, such as fossil fuel consumption, number of permits issued, etc, and thus the success of the bill may not imply a reduction in global warming. However, the proposed reductions are significant, and if successful, are likely to have a large impact on global CO2 concentrations.

What Is Global Warming?

What is the Greenhouse Effect?

The Greenhouse Effect is a natural process where solar radiation reaches the earth and radiation is either reflected into the atmosphere or absorbed by the earth. Some of the radiation that reflects back into the atmosphere is absorbed by heat trapping gases called greenhouse gases and some radiation is emitted back into space. This process maintains the earth's warmth by keeping a blanket of heat at the earth's surface. The Enhanced Greenhouse Effect occurs when greenhouse gas concentrations increase, absorbing more solar radiation emitted by the earth. With more greenhouse gas, more heat is trapped, warming up the earth to higher temperatures.

Figure 1: The Greenhouse Effect



Source: Pew Center on Global Climate Change.

All greenhouse gases are alike in that they allow light from the sun to come into the atmosphere but trap a portion of the outward-bound infrared radiation and thus keep the Earth's average temperature of 59 degrees F. Without them, Earth's surface would be right around 0 degrees F. Different greenhouse gases have different absorption efficiencies (also known as absorptivity) as a function of wavelength, with CO2 and water vapor being the most effective absorbers. The CO2 absorption band overlaps a gap in the water vapor band, creating a "window". By closing the window, CO2 increases the absorptive power of the atmosphere, ultimately affecting the climate. CO2, methane, nitrous oxide and water vapor are the major greenhouse gases that are enhanced by human activities. CO2 accounts for 80% of total greenhouse gas emissions from the burning of fossil fuels (oil, natural gas and coal), deforestation and land use changes. 60% of methane is currently produced by humans, from landfills, livestock farming, fossil-fuel burning, wastewater treatment, and other

industry. 17% of current nitrous oxide (N2O) emissions come from fertilizers, fossil fuels and the burning of forests and crop residues. Sulfur hexafluoride (SF6), PFCs and HFCs are solely anthropogenic greenhouse gases, they are not produced naturally. They are released into the atmosphere by industrial activities like aluminum smelting. Water vapor is a natural greenhouse gas that increases in volume with warmer temperatures, thereby magnifying the impact of all artificial greenhouse gases.

In the U.S. the primary greenhouse gas emitted by human activities is CO2, representing approximately 84 percent of total greenhouse gas emissions. The largest source of CO2 is from the combustion of fossil fuels. Methane emissions, which have steadily declined since 1990, result primarily from decomposition of wastes in landfills, natural gas systems and activities associated with domestic livestock. Agricultural soil management and mobile source fossil fuel combustion are the major sources of nitrous oxide emissions. The emissions of hydrofluorocarbons, which are substitutes for ozone depleting substances, are the primary component of fluorinated gas emissions.

In 2007, the Intergovernmental Panel on Climate Change (IPCC) summarized its assessment of global climate change and reached several conclusions regarding temperature increase and it effects. These conclusions were formed by the planet's most distinguished environmental scientists, and were based on a most comprehensive set of integrated data. The IPCC summary for policy makers described "high confidence" that snow and ice stores are melting, and hydrological systems are being affected worldwide. Additionally, the IPCC had "very high confidence" that temperature warming is affecting terrestrial and aquatic ecosystems (IPCC2007).

What Evidence Supports Global Warming?

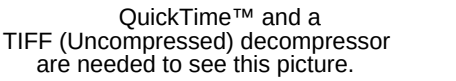
Years of research have shown that carbon dioxide levels and global average temperatures have been increasing since the Industrial Revolution. There have been extreme weather patterns such as droughts, flooding, and severe hurricanes. The second largest land-based ice sheet located in Greenland is melting more noticeably than ever and in the South Pole, the glaciers in Antarctica are melting at a faster rate than expected, changing the terrain and affecting wildlife habitat.

Scientists drill out ice core samples of ice caps and glaciers to collect information about carbon dioxide levels and historical temperatures. Since each layer that forms in the ice caps is one of freezing and melting, the layers together tell a story of what the air quality in that time period was like. By studying each layer, one understands the makeup of the air quality during that time. The air bubbles trapped in each layer also can reveal what the temperatures were like. Combining carbon dioxide levels with temperature in that time period gleans light because when the data are graphed, there is a direct correlation between carbon dioxide concentration and temperature. During the 600,000 years of ice core samples studied, as carbon dioxide levels decrease, temperature decreases, and as carbon dioxide levels increase, temperature increase too.

Even though climate change and fluctuations in environmental chemistry are at least as old as the geologic record, the human impact upon environmental chemical processes in the

atmosphere for example, is clearly unique. Air bubbles trapped in ice-core samples from Polar Regions indicate atmospheric concentrations of carbon dioxide were around 230 parts per million (ppm) in pre-industrial times. By 2007, CO_2 has increased to approximately 378 ppm (Baird & Cann 2005). For perspective, concentrations had not reached beyond about 290 ppm between the years 1000 and 1800. The current carbon dioxide concentration levels in the atmosphere are unprecedented.

Figure 2: Increasing Concentrations of GHGs over Time



Source: IPCC 2007.

Splitting of the ice shelf in the Arctic is another piece of evidence supporting global warming. In addition, parts of the Larsen B ice shelf in Antarctica broke off in 2002. The number of hurricanes have been unusual and severe. Flooding events are worldwide and have been devastating as Hurricane Katrina powerfully destroyed New Orleans, Louisiana. Droughts have been long-drawn and severe. These climatic events are natural in themselves but the extremity of these natural events is due to higher concentrations of carbon dioxide in the atmosphere. As large amounts of carbon dioxide and other greenhouse gases get trapped in the atmosphere, heat is trapped and the earth's temperature-rise, affecting wind and ocean currents.

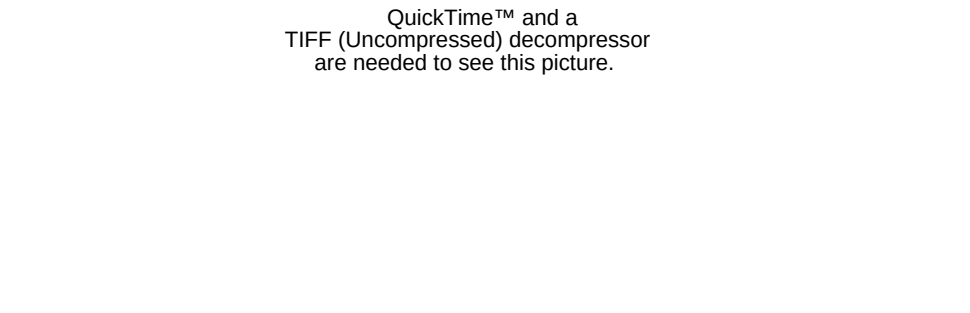
What are the major effects of global warming?

Sea Level Rise

There are two major factors regarding sources of sea level rises. The first is an increasing rate of glacial melt, especially at the Poles. The second is thermal expansion of the ocean itself as it warms. The estimates of expected increase in temperature due to global warming are generally given as a global average. However, due to thermal circulation in the ocean and

atmosphere, the expected temperature increases at the poles are much higher than the estimates for the global average. Ice sheets in the Antarctic and North Pole are already melting at rapid rates, and these rates will increase with progressively higher temperatures. Additionally, as water is heated it expands because the molecules are more active. As rising surface temperatures heat the ocean to higher temperatures, the same mass of water will increase in volume, causing a further rise in sea levels.

Figure 3: Changes in Sea Level Associated with Global Warming



Source: IPCC 2007

Biodiversity Loss

Many species thrive only in a particular range of temperatures and depend on the system functions which are influenced by temperature. Coral reefs, for example, have been observed to experience bleaching (loss of the photosynthetic organisms which build coral) at high temperatures. Coral reefs are one of the most biologically diverse systems, providing habitat, food and nurseries for many species. As coral reef systems and functions decline, so too will the various species which depend upon them.

Threats to Human Health

Increasing temperatures are expanding the range of tropical disease vectors. Organisms such as mosquitoes that carry malaria and dengue fever will be able to thrive in a greater range of latitudes and altitudes as temperatures in these areas rise. An increase in the range of disease vectors will expose a greater number of humans to these diseases, posing a serious risk to human health.

Water Shortages

Many arid regions depend on the melting of winter snow packs to provide water throughout the drier parts of the year. Southern California, for example, gets the bulk of its drinkable water supply from the gradual seasonal melting of the Sierra snow pack. As global temperatures rise, there has already been an observed reduction in winter snow pack. A

greater percentage of winter precipitation now comes from rain as opposed to snow. This leads to a decreased supply of snow melt as a water source during the dry parts of the year.

Increase in Severity of Extreme Weather Patterns
Rising temperatures cause interactions within the climate system that may cause an increase in the severity of extreme weather events such as hurricanes. The strength and frequency of hurricanes appear to have increased over recent years. Rising temperatures cause increased evaporation from the ocean around the equator as well as steeper temperature gradients. These factors may contribute to the development of tropical storms such as hurricanes.

Shift in Seasons
As global temperatures rise, the timing of flowering, migration, and other spring activities may be altered. For example, there have been observations of many trees and plants flowering days or weeks earlier than were seen in the past. This shift could influence species interactions and system functions. If the timing of flower blooms and the emergence of insects do not correspond, the process of pollination could be hindered.

Invasive Species
Many species that thrive in the tropics are less competitive in cooler climates. However, rising temperatures could allow these species to migrate to higher elevations and latitudes. The higher temperatures may have limiting effects on native species, while enabling the influx of invasive species that prefer warmer climates. These invasive species could out-compete native species, causing cascading effects within the system. Native fauna may not be able to adapt to the new composition of species and communities could be extirpated.

Why is global warming a problem for the United States?

Public Health and Welfare
Some scientists have speculated that increased surface temperature may increase heat wave mortality (particularly in the summer months), especially in more vulnerable populations such as infants and the elderly. More hot days may cause elevated smog levels, leading to increased respiratory problems and incidence of asthma, especially in urban areas. Climate change can also increase levels of pollutants and pollens in the air affecting those with allergies. Higher temperatures lead to more severe storms, such as hurricanes, and to more flooding. More deaths, injuries, and population relocation, particularly along the coastal areas, would be expected. Flooding and drought would also be expected in other regions, such as the western U.S. Higher temperatures could also bring more tropical diseases by expanding the range in which insects can survive to spread infection.

Biological Environment
Global warming affects all of the Earth's natural systems, with the potential for catastrophic results. Some effects are already apparent today. Rising ocean levels could displace coastal communities, introduce saltwater into freshwater, and disrupt estuarine ecosystems that filter wastes and provide other benefits. The melting of the polar ice caps and thawing of permafrost and sub-polar and mountain glacier regions are already evident and will contribute to the rise in sea levels, which in turn will enhance global warming. For example, in the United States it is estimated that the current rate of global warming will leave no

glaciers in Glacier National Park by 2030. The ice-covered regions reflect incoming sunlight. If they are melted, the oceans absorb more heat. Sensitive ecosystems are already feeling effects of global warming. Increased temperatures in the oceans have hurt coral reefs. Diminished ice in the arctic region has damaged polar bear habitats. Global warming will contribute to a loss of species that are sensitive to temperature and are forced to relocate to a different habitat.

National Security
Global warming could increase instability in vulnerable and economically fragile parts of the world. Climate change can exacerbate drought conditions, reduce food production, increase disease, cause water shortages, and simulate involuntary migration of large populations. These disastrous situations can be beyond the capacity of weak and fragile governments and could lead to extremist politics. The resulting geopolitical destabilization makes the world less safe and implicates U.S. national security interests.

Economy
Global warming may have negative impacts on the United States economy. Significantly affected sectors will include agriculture, water supply, energy needs, and protection of costal regions. Severe weather such as hurricanes, flooding, and drought can impose significant costs as the recent experience with Katrina demonstrates. Displacement of large numbers people could mean the overcrowding of inland cities and higher unemployment rates. Loss of productivity in critical economic sectors could lead to supply shortages, increased unemployment, and decreases in national GDP.

Why is government action needed?

Government action is needed to reduce the U.S. contribution of greenhouse gas emissions. The current Clean Air Act is not sufficient to reduce CO2 emissions.. Emissions continue to increase, which will further increase the Earth's surface temperature.

The economic marketplace, including consumer conduct and industry performance, is not producing sufficiently aggressive steps to reduce CO2 emissions. Although many individuals and businesses have made voluntary efforts, the majority of them have not. While some entities have implemented programs since 1992 to respond to the UN Framework Convention on Climate Change they have yet to show success in reducing or even stabilizing total U.S. emissions. While technologies have improved, even greater efficiency has been outpaced by higher demand caused by population growth, economic expansion and changing consumer preferences. Government action is needed to stimulate the broad engagement that will be necessary to achieve the level of emissions reductions that will ultimately be required. The government has the capacity to regulate industry generally to reduce CO_2 emissions and to set standards reaching all sectors.

The government has a duty to protect its citizens' public heath and welfare. Global warming could threaten their well being The United States contributes more emissions than any other country to the world's global warming problem. In our view, the U.S. government has an ethical obligation to play a leadership role in addressing this global environmental problem. The United States alone cannot solve this problem but we are central to any long term

strategy that will require international agreements and "sustained global action and investment over many decades" (Pew Center on Climate).

What is the Proposed Legislation?

S. 309 amends the Clean Air Act of 1970 to reduce carbon dioxide emissions through a series of programs, regulations and market-based incentives. The bill would regulate CO_2 as a pollutant, and charge the Environmental Protection Agency (EPA with setting milestones to reach the standards, which are proposed as follows:

Goals of Senate Bill 309 are to reduce U.S. emission levels to:

- The aggregate net level of 1990 emissions by 2020
- 1/3 of 80 percent of the aggregate net level of 1990 emissions by 2030
- 2/3 of 80 percent of the aggregate net level of 1990 emissions by 2040
- 80 percent of the aggregate net level of 1990 emissions by 2050

This translates into a requirement for U.S. annual average emissions to not exceed:

- 6,242 megatons CO_2 equivalents starting in 2020
- 4,577 megatons CO_2 equivalents starting in 2030
- 2,913 megatons CO_2 equivalents starting in 2040
- 1,248 megatons CO_2 equivalents starting in 2050

The EPA's Administrator acts as the primary enforcer of all requirements within the bill. The EPA has a contract with the National Academy of Sciences (NAS), which is charged with studying the potential contribution of the non-highway portion of transportation sector emissions. A low-carbon generation trading system will also be implemented, in addition to setting requirements for electric generation units. The proposed bill also includes plans for a biological and geological carbon sequestration program, to be established by the Secretary of Agriculture. Furthermore, the Securities and Exchange Commission (SEC) is charged with requiring securities issuers to inform investors of the risks associated with global warming. The bill will also influence impact statements that evaluate and analyze global warming.

Vehicle Emissions Standards

According to information published by the Energy Information Administration of the Department of Energy (EIA-DOE), in 2004 the United Sates consumed ~7.6 billion barrels of crude oil and petroleum. The U.S. transportation sector registered the second highest primary energy consumption (27.7%) only after electric power (38.9%). According to EIA-DOE data, 67% of US petroleum consumption is destined to the transportation sector. The reliance of this sector on fossil fuels is evident, as 96% of the energy consumed by vehicles comes primarily from petroleum (other sources: natural gas 3%; renewable energy 1%).

The bill acknowledges the importance of reducing global warming emissions from vehicles, and proposes the EPA Administrator establish regulations to increase the stringency of emission standards requiring compliance by both automobiles and highway vehicle models sold by U.S. manufacturers by 2016. The principal requirements are that both vehicle class emissions standards shall not exceed certain carbon dioxide (CO_2) equivalents per grams per mile (g/m) depending on the vehicle weight (205 g/m and 332 g/m for automobiles and 405 g/m for vehicles over 8,501 pounds).

Benefits

- Not only reduction of emissions would be achieved, but cars would burn less gas and consumers would save money.
- Better car engines and less CO2 emissions coming form them would translate to better air quality in large cities.

Limitations

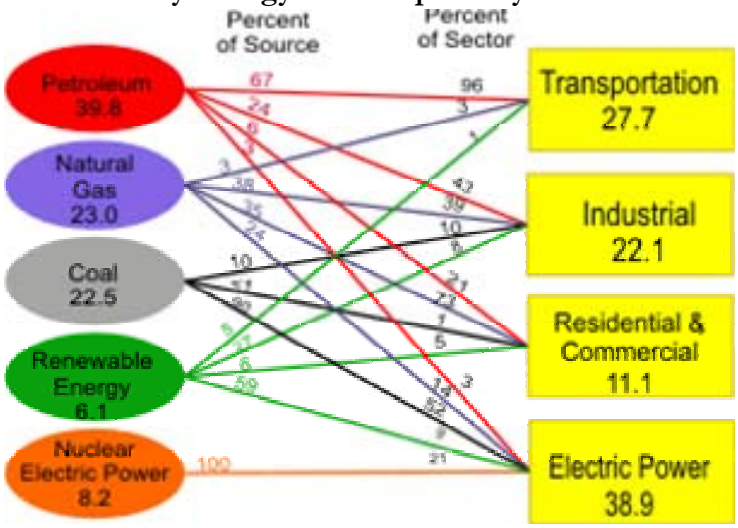
- In order for automobile industry to achieve this goal, they would need to invest in R&D for new technologies that will enable engines to emit less GHG
- Until the results of the required study by NAS are presented, it is not clear if this measure will have the expected impact of emissions reductions and ability to achieve the goals for emission cuts established in section 704.
- Command and Control approach does not fully utilize the efficiencies of the market

Emissions Standards for Electric Generation Units

The United States consumed 3,815,669 million kwh in 2004 (EIA-DOE, October 2006). According to official energy statistics published by the EIA-DOE, electric power registered the highest consumption of U.S. primary energy in 2004 (38.9%). The main sources of electric power generation are coal (52%), nuclear power (21%) and natural gas (14%) (other sources: renewable energy 9%; petroleum 3%).

Considering that coal is a fossil fuel composed primarily of carbon (along with other elements such as sulfur), it is one of the largest sources of carbon dioxide emissions; and acknowledging the need to decrease emissions of GHG as a consequence of electric power generation, this section of the Act outlines a phased approach for standards compliance. Under this proposed statute, EPA regulates electric generation units, requiring them to meet emission standards for new combined cycle natural gas generating units. All units will be required to comply with applicable final standards by 2030, regardless of when the unit began operations.

Figure 4: U.S. Primary Energy Consumption by Source and Sector, 2004



Source: DOE

Benefits

- Any new generation plant would have to comply with the requirements in order to operate, guaranteeing lower emissions.
- If emission reduction is achieved as a consequence of more efficient generation, private individuals would benefit by obtaining better and more efficient service (better distribution).
- Eventually all generation plants would have too comply with the requirement, but the existing ones would have more time (avoiding conflict).

Limitations

- In order for generation plants to comply with the requirements, they would need to invest in R&D for new technologies that will allow a more efficient and clean generation and distribution.
- The measure could be broader and include energy consumption, promoting electric efficiency in industry and the use of efficient electric appliances in US homes.

Low Carbon Generation Requirement

Low carbon generation requires specified electricity generators to produce a certain amount of low carbon energy. The bill stipulates generators with a rated capacity of 25 megawatts, and annual energy inputs of 50% or more from coal, petroleum coke, lignite or any combination of these fuels, must produce for sale 5% low carbon electricity by 2020. To achieve emission reduction targets the EPA is given the right to increase the requirement by up to 2% each year from 2021-2025 and 3% each year from 2026-2030. Compliance with low-carbon requirements can be achieved two ways: 1) generating or purchasing low-carbon electric energy, or 2) purchasing credits pursuant to the Low-Carbon Generation Credit Trading Program. The trading program authorizes the EPA to establish a program whereby generators violating low-carbon generation requirements may purchase credits to achieve compliance. Any generator not compliant with the requirements will be subject to a civil penalty. The bill stipulates that funding for low-carbon energy research and development will be increased 100% each year for 10 years after enactment of the bill.

Benefits

- Requires power generation sector to reduce burning of fossil fuels
- Stimulates market incentive for low carbon electricity generators

Limitations

- Establishes a command-and-control regime using monetary penalties for non-compliance; if the penalties are too low, companies might be willing to absorb them to reduce the cost of complying with the rules,
- May not reduce emissions fast enough to meet targets
- Potential to issue too many credits and undermine system

Renewable Portfolio Standard

To curb this dependence on foreign oil and mitigate the impacts of global warming, the act proposes to require electricity generation suppliers to provide a base quantity percentage of electricity from renewable sources beginning in 2008. The EPA Administrator and Secretary

of Energy are to develop regulations that include renewable sources including solar, wind, biomass, landfill gas, ocean (including tidal, wave, current, and thermal), geothermal, municipal solid waste, or new hydroelectric generation. In addition, to subsidize renewable energy, the EPA will be given a mandate to establish a renewable energy credit program one year after the enactment of the title.

The benefits of a renewable energy program would be subsidization of renewable energy and the promotion of a renewable energy market. Historically, non-renewable energy sources have been heavily subsidized by the government, and their social and environmental externalities have not been accounted for in the market, making these non-renewable energy sources more profitable than renewable sources. A renewable energy credit will offset the additional expense of producing renewable energy for the generator. This program would ensure the legal rights for renewable energy generation units to a credit that can be sold or traded on the open market as an asset. A key benefit in this approach is innovation in renewable energy industries and a market force for clean energy generation. Currently, several states have a renewable energy credit program in which a renewable energy provider (such as a wind farm) is rewarded one credit for every 1,000 kWh of electricity produced. A certifying agency gives each credit an identification number to make sure it doesn't get double-counted; the bill stipulates the prohibition of double counting. The renewable energy is then fed into the electrical grid and the credit can then be sold on the open market.

Benefits

- Increased flexibility for compliance; for a generator who has to comply with the renewable energy requirement, if a source of renewables is not local, they can buy credits to achieve compliance. Likewise, the party generating the renewable can now sell to parties outside of their locale as well thereby increasing flexibility for the renewable generator.
- Capacity building; tradeable credits will help to allow renewable generators to build capacity in more remote locations away from electricity generators where conditions may be more economically favorable, ie more sun or more wind.
- Financing; credits represent a monetized asset for generators; a new source of additional revenue and financing for the development of capacity

Limitations

- Cost of compliance and technical gaps for business
- Equity and interstate issues; ratepayers paying for their utilities to procure renewables may lose the environmental and economic benefits of the renewable energy to out-of-state payers if their utilities purchase credits in other states
- Potential fraud resulting from difficulty of tracking credits; accounting systems across state boundaries will need to be integrated

Research and Development

One of the main goals under the Research and Development portion of this Act is to establish a global climate change standards and processes research program, in consultation with the following Federal agencies: National Oceanic and Atmospheric Administration (NOAA), National Aeronautics and Space Administration (NASA) and the Department of Energy (DOE). The objective of this program is to 1.) Develop enhanced ways to monitor global warming pollution; 2.) Establish a baseline reference point for future global warming

pollutants, and 3.) Begin an international exchange of information in an effort to develop mutually-recognized measurements. Furthermore, a program aimed at researching abrupt climate change is a priority under this Act.

Benefits

- International focus
- The establishment of a national global climate change standards and processes research program
- Anticipated extensive research on climatic limitations and abrupt climate change
- Projected increase in funding for clean energy research and development

Limitations

- International aspect lacks a concrete timeline and plan for implementation
- Abrupt climate change research program lacks a timeline and information on the cost effectiveness of such a program
- Projected increase in spending on clean energy research and development of (100 % for each annually for 10 years) lacks information on the cost effectiveness and economic feasibility of such a program

Energy Efficiency Performance Standards

Electricity savings in the Act are defined as "reductions in end-use electricity consumption relative to consumption by the same customer or at the same new or existing facility in a given year, as defined in regulations promulgated by the Administrator." Reductions can be achieved through the installation of energy-saving technologies and devices and through the use of "combined heat and power systems, fuel cells, or any other technology identified by the Administrator that recaptures or generates energy solely for onsite customer use." In terms of targets, for calendar year 2008 and all subsequent calendar years, the Administrator will require retail electric suppliers to achieve electricity savings annually that coincide with the targets delineated in the Act.

The Act states that no later than one year after the date of enactment of the title, the Administrator will set regulations to implement the stated targets in the Act. In addition, a national credit system that will permit credits to be awarded, bought, sold and traded by and among retail electricity suppliers is one of the most significant portions of this Act. A credit system within the United States has the potential to successfully mitigate the effects of climate change. However, within a credit system exists the opportunity for companies (utilities, etc.) to continue to pollute at the same levels prior to the enactment of the program, and in some cases more, due to the fact that companies have the opportunity to buy more credits. The European Union provides a salient example of this.

Benefits

- Clear and cogent timeline and implementation plan for pollution reductions
- Potential for the establishment of a national carbon credit trading program

Limitations

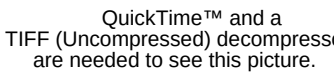
- Lacks information on the economic feasibility of pollution reductions
- Lacks information on how these reductions will help to mitigate national and overall global carbon emissions

- Potential to undervalue or over-issue credits and undermine effectiveness of credit trading scheme

Geological and Biological Sequestration

Carbon sequestration referred to in the Act involves the capture and long-term storage of carbon dioxide in geologic repositories and the terrestrial biosphere. Geological and biological sequestrations are two separate methods of such storage. In geo-sequestration carbon dioxide generated by point sources such as power plants is separated from other byproducts of energy production, namely particulates and other gases, before it is captured and pressurized (DOE, 2007). The CO2 gas is then pumped into geologic formations such as oil and gas reservoirs, coal beds, saline reservoirs, and basalt formations. The gas will flow toward the surface until its path is impeded by impervious rock. Here it is stored as a gas or as a solid if reacting with minerals to form carbonates. Bio-sequestration, also known as terrestrial carbon storage, seeks to enhance and utilize natural processes of the biosphere that remove CO2 from the atmosphere. Such processes include reforestation, growth of dense biomass vegetation, and accumulation of soil organic matter. Currently, research on this method of carbon storage is seeking development of fast growing vegetation and understanding genomes of carbon-storing soil microbes. The Global Warming Pollution Reduction Act includes provisions to create standards to account for such bio-sequestration.

Figure 4:Methods of Geo-Sequestration



Source: IPCC 2007

Benefits of Geo-sequestration:

- Long term storage of CO2 keeps gas out of atmosphere for long periods
- Enhanced oil recovery through immiscible replacement; Longer, more productive use of gas fields
- Enhanced production of methane from coal beds

Limitations of Geo-sequestration:

- High cost of operation, and increased energy requirement of power plants
- Potential for environmental risks to humans, such as rapid release of a large volume or venting of CO2
- Potential for aquifer contamination
- Underground movement of displaced fluids

Benefits of Bio-sequestration:

- Reduce emissions of global warming pollutant
- Relatively low cost
- Environmental and ecological benefits, such as: provide habitat, groundwater retention, reduce erosion, accumulate soil organic matter by reducing tillage

Limitations of Bio-sequestration

- Carbon cycle is complex, measurement is difficult, standards difficult to implement
- Issues of permanence
- Requires arable land that may be used for other purposes

What are the Scientific Uncertainties?

Global Warming

In general, the scientific community agrees on three key points: "the earth is warming; the warming is caused primarily by the build-up of GHGs in the atmosphere; and that the warming will continue if we don't reduce Global Greenhouse Gas emissions" (Pew Climate Center). The vast majority of scientists agree that this change is human-induced (IPCC), though there is some uncertainty as to the rate of warming. Groups that disagree with the idea of global warming are dominated by pro-oil/coal industry groups and some political conservatives who believe that the greenhouse gas studies are inconclusive. Many of them oppose limiting industrial heat-trapping gases, arguing that the gases pose no threat.[1] The uncertainty in the scientific community is not whether warming is happening, but at what rate is it occurring.

Sequestration

The sequestration of Carbon Dioxide is appealing as an option to reduce green house gas emissions due to the fact that it prevents carbon dioxide from entering the atmosphere and it does not impede economic growth and development by capping emissions. However, opponents to this solution—which include a significant portion of the scientific community—contend that this option does not solve the problem of global warming and green house gas emissions but creates a potentially larger problem. The IPCC concluded that CO2 could be sequestered for millions of years if stores are planned and managed properly. Oil and gas companies already inject gas into reservoirs in oil recovery operations, increasing the life and productivity of gas fields. Technology does exist to allow such injection, and furthermore, the value of energy fossil fuels and natural gas yielded by injection might offset cost of storage.

However, there are a number of environmental and safety risks associated with the capture and storage of carbon dioxide. They include concerns about carbon dioxide seepage from underground tanks into our potable drinking water aquifers, or above ground, which can affect human health in to concentrated levels. Also, carbon dioxide disposed of in oceans can affect the pH of the ocean waters thus affecting marine ecosystems and species. There are also some concerns of earthquakes due to underground movement of displaced fluids. Along with these environmental issues are cost issues. The MIT Energy Laboratory estimates that it takes $30-$90 to prevent the release of one ton of carbon dioxide into the atmosphere, and with the United States emitting over seven billion tons of green house gas each year (most of which is carbon dioxide) the use of sequestration could be expensive. It is also estimated that carbon dioxide sequestration increases plant energy needs by 10-40% and the cost of energy from a plant by 30-60% (DOE, 2005).

Currently carbon dioxide sequestration methods are being used more extensively outside of the United States in parts of Europe and Canada. In Norway the world's first sequestration project was undertaken in 1996 by Statoil in which carbon emissions were captured and pumped into a aquifer beneath the sea floor. Presently in the United States there is an initiative entitled FutureGen whose goal is to build the world's first zero emissions fossil fuel plant that utilizes sequestration methods to a large extent.

[1] David Appell, "A claim of nonhuman–induced global warming sparks debate," August 2003.

How Will Success Be Measured?

The scientific indicators of success for this bill are focused on cutting the U.S. contribution of global greenhouse gas emissions (GHG) and decreasing these aggregate emissions incrementally. The specific incremental targets listed in the bill are as follows:

- 1/3 of 80% of 1990 levels by 2030
- 2/3 of 80% of 1990 levels by 2040
- 80% of 1990 levels by 2050

The net aggregate emissions level was approximately 6,242 Mt (Megatonnes) in 1990.[2] Therefore, the net aggregate level to be achieved by 2030 is 4,577 Mt, 2,913 Mt by 2040 and the ultimate goal for 2050 is 1,248 Mt. For reference, the 2005 level of aggregate emissions was 7,262 Mt. Thus, in order to reach the 2030 target of 4,577 Mt, for example, a net reduction of 2,685 Mt over the course of 25 years is needed, which amounts to a 107.4 Mt per year reduction. Similarly, a reduction of 6,014 Mt over the course of 45 years – 2005 to 2050 – is needed in order to reach the desired 2050 target level of 1,248 Mt.

Gauging the success of the bill will be difficult for three reasons: 1.) Emission inventories have inherent limitations in accuracy and comparability, 2.) There exists an absence of any directly measured or reported information on global warming pollution emissions, and 3.) Global warming is a global problem and requires global attention, and not just attention from the U.S.

In order to measure the long-term effectiveness and success of the bill, the most representative and useful mechanism is to calculate the reduction of GHG emissions from each carbon-intensive sector, including the transportation and energy sector, for example. However, as mentioned above, all emission inventories have inherent limitations in their accuracy and comparability and again, there is an absence of any directly measured or reported information on global warming pollution emissions.

Furthermore, global warming is a global problem and requires global attention. The U.S. cannot act alone in curbing GHG emissions. However, even though the U.S. will not be able to solve this global issue alone, the impact of the U.S. reducing its emissions, which account for 23% of the world's energy-related carbon emissions, will be significant.

[2] 1 Megatonne is equal to 1,000,000 metric tons.

Conclusions

While global warming is a global problem, the United States' contribution to greenhouse gas emissions is significant. Thus, any reduction in emissions will provide a necessary step toward mitigating global climate change. The Global Warming Pollution Reduction Act S. 309 represents a significant step toward curbing global warming. That a bill of this nature is on the table at all represents a shift in American political thinking about practical solutions to immense climate problems. While the provisions might be altered through further debate, Americans can expect to see an incarnation of this bill passing in the near future. The provisions set forth are firmly rooted in science, an often-absent feature of environmental policy. The real task begins in operationalizing these provisions and couching them within a viable political framework. As a global leader, the United States has the responsibility to curb its emissions, and to encourage growing nations to follow suit. While U.S. action alone is insufficient to solve the problem, it is necessary; and, it is imminent.

References

Baird C., and Cann M. 2005. Environmental Chemistry. 3rd ed. W.H. Freeman and Co. New York, NY. 166-206.

DOE. Office of Science. 2004. Carbon Sequestration. http://cdiac2.esd.ornl.gov/index.html

_____ 2005. Fossil Energy: Carbon Capture and Separation. http://www.fossil.energy.gov/programs/sequestration/capture/index.html

_____ 2006. http://www.eia.doe.gov/basics/energybasics101.html

Herzog, H.; Drake, E.; Adams, E. *CO_2 Capture, Reuse, and Storage Technologies for Mitigating Global Climate Change;* DE-AF22-96PCO1257; Energy Laboratory, MIT: Cambridge, MA, January 1997.

Intergovernmental Panel on Climate Change (IPCC). 2007. Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability- Summary for Policy Makers. Working Group II Contribution to the IPCC Fourth Assessment Report 1-23.

Jackson R., Jobbagy G., Avissar R., Roy S.B., Barrett D., Cook C., Farley K., Le Maitre D., McCarl B., Murray B. 2005. Trading Water for Carbon with Biological Sequestration. Science, Vol. 310, no. 5756, pp. 1944-1947.

Tufts Climate Initiative. 2007. Carbon Offset. Joint project of the Stockholm Environment Institute. http://www.tufts.edu/tie/tci/index.htm.

United States Environmental Protection Agency (U.S. EPA). 2005. Climate Change-Greenhouse Gas Emissions: Human Related Sources and Sinks. epa.gov/climatechange/emissions. Accessed on June 22, 2007.