

# INTRODUCTION

## **Goals of the Project**

This project has the following goals:

- To identify those areas of opportunity for reducing the State's greenhouse gas emissions which use the best available information and are cost-effective for Delaware;
- To educate communities and raise their awareness of climate change and practical opportunities to reduce the State's greenhouse gas emissions;
- To establish a Delaware Climate Change Consortium representing a wide range of ideas and providing advice on the design and details of an Action Plan that serves Delaware's long-term economic, social and environmental interests; and
- To publish and disseminate an Action Plan that provides Delawareans with a practical, analytically-based strategy to contribute to regional, national and international efforts to reduce greenhouse gas emissions.

## **Structure of the Report**

The Delaware Climate Change Project has followed a six-step process of development:

- Develop criteria via a consensus-building process among DCCC members for evaluating options, including greenhouse gas reduction potential, ecological sustainability needs, costs, and equity considerations;
- Conduct in-depth analyses of the potential greenhouse gas reduction options for each economic sector and analyze the potential for carbon sink preservation and waste minimization;
- Review, revise and refine sectoral options through workshops with Consortium members;
- Prepare an education and outreach strategy to complement GHG reduction, sink preservation, and waste minimization actions; and
- Produce a Delaware Climate Change Action incorporating the Consortium's results and findings.

The outcomes of this six-step process are captured in this report which includes an Executive Summary, an Introduction and 10 chapters. The Executive Summary highlights the major findings and recommendations of the Action Plan. The Introduction outlines the project's goal and aims, describes its background and rationale, provides a broad description of climate change science and impacts, including the potential impacts on Delaware, and outlines the link between national greenhouse gas emission reduction and that within Delaware. Chapter 1 describes the forecast model used to project

economic activity, energy demand and GHG emissions under a business-as-usual scenario. The Economic, Energy and CO<sub>2</sub> (EECO<sub>2</sub>) Forecast, developed for the Action Plan, utilizes the Delaware Econometric Model, maintained by the University of Delaware's College of Business and Economics, to develop an equation structure for projecting major economic, energy and environmental trends to 2010. Chapters 2 through 7 describe the databases and findings of in-depth analyses conducted for each sector examined for DCCAP. These sectors are: Industrial, Residential, Commercial, Transportation, Utility, and Wastes/Forests. Each of these chapters provides an overview of the greenhouse gas emission projections, the methodology used, an evaluation of the emission reduction options, and estimates of probable greenhouse gas emission effects of different state and federal policy strategies. Chapter 8 describes the education and outreach activities that would assist in emission reduction policy formulation and implementation. Chapter 9 provides the policy recommendations drawn from the sector analyses. In the final chapter, the report summarizes the major conclusions of DCCAP and suggests a course of action to refine and implement the Plan. A series of appendices provide summaries of data sources and methods used in an analysis conducted for the Plan.

## **Background to the Action Plan**

### **Origins of the Delaware Climate Change Project**

This project builds on policy analyses being conducted at the national level with support of the U.S. Environmental Protection Agency (USEPA), and parallel efforts at the state and local levels, including those supported by Delaware's State Energy Office (DSEO) in the Division of Facilities Management. This report comprises the second phase of climate change policy research jointly sponsored by the USEPA and DSEO, and was prepared by the Center for Energy and Environmental Policy (CEEP) at the University of Delaware in coordination with the Delaware Climate Change Consortium, a 36-member stakeholder group organized in the first phase of the project.

Under the first phase of the USEPA's State and Local Outreach Program, states compiled inventories of their greenhouse gas (GHG) emissions and sinks. These inventories mark the initial stage in building a strategic approach for a comprehensive and long-range State Action Plan to reduce emissions. Delaware's inventory, conducted by CEEP under this program, was completed in 1997 (see below).

In the second phase of the USEPA program, states formulate Action Plans for GHG emissions reduction. Funded by the USEPA and DSEO, this report is designed to assist policymakers, industry and citizen's organizations in Delaware to identify cost-effective options to mitigate GHG emissions identified in the 1997 state inventory.

This project has been conducted in a manner consistent with the USEPA's *State Guidance Document: Policy Planning to Reduce Greenhouse Gas Emissions* (USEPA 1998). Project assistance was provided by the State and Local Climate Change Program under the USEPA's Office of Policy, and by the DSEO. Several state agencies, local governments, industries and citizen's organizations throughout Delaware supported the project through the participation of their representatives over the 30 months it has taken to prepare the State's Greenhouse Gas Inventory and Climate Change Action Plan.

## **Delaware's Greenhouse Gas Inventory**

In the first phase of the project, CEEP produced a report on Delaware's greenhouse gas sources and sinks for the Delaware State Energy Office entitled the *Delaware Greenhouse Gas Inventory* (CEEP 1995).

This analysis revealed the levels of major greenhouse gases produced by each economic sector within the state. Using a number of techniques, a set of estimates was produced by end-use sector. Inventory results established the benchmark for the modeling and analysis conducted in this study.

## **Rationale for the Project**

Greenhouse gas emissions are associated with virtually every social and economic activity in contemporary society. As the *Delaware Greenhouse Gas Inventory* report indicates, all sectors of Delaware's economy and society are contributors to the State's emission stream. Thus, efforts to reduce greenhouse gas emissions require policy initiatives across a wide spectrum of the economy and involve communities, business and government in cooperative and innovative partnerships. Effective policy formulation to address this complex issue has significant information and analysis requirements and for policymakers to have the fullest array of options available for consideration, an extensive analytical effort is needed. In recognition of this fact, the USEPA and DSEO, have cooperated over the past two years to ensure that Delaware's citizens and organizations (private, public and non-profit) have the best information available to them on policy alternatives and their effectiveness.

Climate change represents a significant policy challenge not only because it would involve all sectors of society and would require substantial changes (especially in the way that energy and land use are used) but because decision makers must embrace long-term strategies of 20 years or more to contribute to a climate-stable future. Providing information appropriate to states facing these challenges is the primary goal of the USEPA's State and Local Outreach Program. Despite the obvious difficulties in formulating and operationalizing these policies, there are a number of inherent advantages for policy initiatives in this field.

A clear incentive for state action is to make timely decisions in the present that prevent the escalation of costs and difficulties in the future resulting from deferred decisions. Additionally, many emissions-reduction measures can be justified in their own right, such as the savings brought by increased energy efficiency and energy conservation. For example, as a result of increased efficiency and lowered costs, the competitiveness of Delaware's economy is strengthened, while other environmental and social advantages accrue, such as reducing other pollutants as well as carbon dioxide that benefit both human and ecological environmental health.

States can have the lead role in producing many policies to respond to the challenge of climate change, but effective long-term responses of state initiatives will depend on support and commitment of an informed and involved community. Energy production, transfer and consumption are the primary sources of greenhouse gas emissions. In addition, the reduction in forested land and growth in the volume of society's wastes contribute to the problem. Governments can only directly influence a proportion of the community's and industry's energy-, land-, and waste-related activities. For this reason, the scope of greenhouse gas reduction efforts needs to include all relevant sectors of Delaware's society and economy. Accordingly, this report has as its strategic focus the identification of those greenhouse gas reduction options offering the greatest potential from across the entire State—residential, commercial, industrial, transport, utilities, land use, forests and waste minimization. Because of the importance of involvement by all Delawareans in policy initiatives, this report includes an outreach and education agenda to attract actions by citizens, businesses and organizations throughout the State to meet the goals of the Action Plan.

## **Delaware Climate Change Consortium**

In order that the diverse government, community, and business interests involved in climate change policy could be taken into account during this project, the Delaware Climate Change Consortium (DCCC) was established. In addition to workshops conducted for the full membership of the Consortium, a number of sector-specific working groups were established comprising Consortium members and CEEP project team specialists in these fields.

With the guidance and assistance of the Consortium, CEEP's project team was able to obtain access to information sources that would have been unavailable without the Consortium's assistance. Perspectives varied widely within the Consortium and this added to the scope of the issues addressed by the project. A great number of pragmatic concerns were addressed by the Consortium, in an effort to strengthen the Action Plan's relevance to policy-making and implementation.

## **Climate Change: Science and Impacts Issues**

### **The Science of Global Warming and Climate Change**

Evidence that weather patterns may be changing is provided by science. This century's 12 hottest years have all occurred since 1980. NOAA announced that 1998 was the hottest on record (kept for 119 years) surpassing 1997 - the next warmest year on record (NOAA 1999). Global temperatures have risen about 1.0°F this century, mostly in the last 25 years.

Measurement of atmospheric gases and modeling of ocean-atmosphere systems in complex climate models have revealed that the rising global temperatures are the result of human activity. Direct atmospheric measurement, ice-core gas analysis, and tree-ring analysis have all provided the data on rising atmospheric gas concentrations. The United Nations-sponsored scientific advisory body, the Intergovernmental Panel on Climate Change (IPCC), concluded in its Second Assessment Report that the balance of evidence suggests that global warming and other changes in climate patterns are traceable to a discernible human influence on global climate (IPCC 1996a).

Coal, oil, and natural gas combustion have combined with land clearing practices and recent use of halogenated compounds to increase atmospheric concentrations of the so-called greenhouse gases of carbon dioxide, methane, nitrous oxide, ozone, chlorofluorocarbons (CFCs) and other trace gases. Changes in the gaseous composition of the atmosphere alter its radiative forcing capacity and these effects can be estimated with some precision. Rising atmospheric levels of greenhouse gases have intensified the greenhouse effect, increasing the amount of heat retained by the earth. Consequently, global temperatures have increased, leading to a change in global climate. Atmospheric carbon dioxide is now 30% greater than in pre-industrial times, methane has doubled, and nitrous oxide has risen by 15%.

Greenhouse gases released to the atmosphere have long residence times. For example, a molecule of carbon dioxide (CO<sub>2</sub>) - the major greenhouse gas - can reside in the atmosphere for 100 - 200 years. As a result, achieving stabilization of the concentrations of these gases in the atmosphere requires a prolonged period of reduced emissions. Today's greenhouse gas releases will be influencing climate well into the next century. Some indication of the magnitude of the problem is shown by the IPCC calculation

that stabilization of atmospheric carbon levels at twice the pre-industrial era level would require a 60% reduction in global emissions (IPCC 1996a). In this context, the popular goal of reducing carbon emissions to their 1990 levels is a modest, but important, step toward a much higher target.

Because industrialized nations are the source of most GHG emissions, current international negotiations have focused attention on reductions by these countries. In 1996, industrialized nations released almost 60% of the global CO<sub>2</sub> emissions (USDOE 1999). As population growth continues in developing nations, their greenhouse gas emissions are likely to increase in the future. IPCC has projected that by 2025 the developing nations will account for 45% of the forecast global emissions of 38.5 billion mtCO<sub>2</sub> (IPCC 1992). Their share will continue to increase, but industrialized nations will still account for the bulk of global emissions through mid-century.<sup>1</sup>

Modeling of climate change, using a range of greenhouse gas emission forecasts in general circulation models, suggests that global average surface temperature increases could be 1.8° to 6.3°F by the year 2100 if existing trends continue (IPCC 1996a). Such a rate of temperature increase exceeds that of at least the last 10,000 years. In comparison to daily temperature fluctuations, small changes in global average temperature can be mistakenly regarded as constituting only minor change, but the public should be aware that global changes of a few degrees have been associated with significant effects—the last Ice Age was only 5.0° to 10.0°F cooler than today.

## **Impacts of Climate Change**

Aspects of human health and welfare, and the viability of a range of socio-economic and ecosystems, will be influenced by climate change. Agriculture, water resources, forestry and fisheries are considered vulnerable to climate change (IPCC 1996b). Climate change will pose additional stresses to ecosystems, such as tropical rainforests, that are already deleteriously influenced by human activity. Similarly, those nations and regions suffering from socioeconomic disadvantage will exhibit greater sensitivity to climate-induced disruptions. Certain ecological systems may suffer significant disruptions, with a corresponding increase in the rate of extinctions and loss of natural habitat for many terrestrial and coastal species.

Climate change is likely to bring greater precipitation extremes and induce extreme weather events, such as heat waves, floods, and droughts. Some researchers believe that these changes are already occurring. That recent increases in temperature and other associated climate changes, such as increased

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<sup>1</sup> Because developing countries currently contribute less than one-fifth of global emissions of greenhouse emissions at this time, and will be the source of only one-third of global emissions well into the next century, international negotiations to avert climate change have centered initially on activities to be undertaken by the industrialized countries of North America, Europe, Japan, Australia and New Zealand.

extreme weather events, are entirely due to natural climate fluctuations is now considered extremely unlikely.

Climate change effects on natural systems are potentially damaging, with high environmental costs forecast for coastal areas and islands. Sea-level rise is expected to be 15 to 94 cm. (6 to 37 inches) higher by 2100, with serious implications for flooding, inundation and storm surge. Shoreward erosion, saltwater intrusions, altered tidal ranges, nutrient transport disruption, and losses of coastal habitat exemplify potential coastal damage.

Agriculture may benefit from yields boosted by the atmospheric carbon fertilization effect, with regional changes in production patterns; however, changes in pests and diseases may counter these gains. Water supply may be affected by alterations to the availability and distribution of surface and ground waters. For example, flooding and drought frequency may alter water supplies and quality throughout coastal areas. Areas already vulnerable to quality or quantity problems in water supply systems are vulnerable to diminution of supplies.

Finally, human health is likely to be affected, although developing nations will suffer more extensively than the United States. Vector-borne diseases (such as malaria, dengue fever, and viral encephalitides) will probably have their ranges extended. Urban respiratory illness, heat stress, and allergenic disorders are likely to increase.

## **Delaware and Climate Change: Vulnerabilities and Potential Impacts**

Delaware is vulnerable to climate change in several ways. A USEPA fact sheet entitled "Climate Change and Delaware" (USEPA 1997), together with IPCC reports and other research literature, can be used to develop a general profile of possible vulnerabilities and impacts of climate change on Delaware and the mid-Atlantic region. IPCC climate modeling of future temperature change for Delaware indicates that by 2100, temperatures in spring could be 3.0°F higher and temperatures in other seasons could be 4.0°F higher (USEPA 1997). Precipitation could increase by 15 to 40% in all seasons (USEPA 1997). There would be an increase in the number of high rain and snow days and the number of extremely hot days in summer would also likely increase.

Currently, ground-level ozone concentrations across Delaware exceed national standards for human health set by the USEPA. Wilmington and the northern region are classified as non-attainment areas, due to the frequent exceedance of USEPA ozone standards. An increase in air temperature associated with climate change would increase ozone in the region.

Climate change research has directed attention to potential impacts on human health. Insects that carry disease may respond to climate change with extended ranges and increased infectivity, spreading the incidence of malaria, dengue fever, and Lyme disease. Mosquitoes in the Delaware area can carry malaria and equine encephalitis, while Lyme disease already occurs in the state. In the marine environment where people are in contact with fresh and salt water bodies, primarily through recreation, there might also be climate-related health impacts. Warmer seas could create the conditions for an increase in the spread and duration of algal blooms; brown algal tides and toxic algal blooms are already a feature of the Atlantic waters.

Sea level rise is one of the major impacts of global warming and can be forecast with greater certainty than many other aspects of climate change. Obviously, it is a prospect of some concern to the State of Delaware. With some 381 miles of coastline, Delaware has a variety of inland bays, wetlands and estuaries, barrier beaches and islands, as well as marshlands. These resources provide considerable value through residential and commercial land uses, recreation and tourism, and resource-based activities, such as fishing. Many of these activities could be disrupted by climate change-induced increases in sea level. Inundation of low-elevation coastal areas, beach erosion, contamination of drinking water and damage to roads, causeways and bridges could occur as a result of sea level rise. During the last century, sea level rise has been measured at about 31 cm (12 inches) at Lewes, and could rise by a further 59 cm (23 inches) by the year 2100 (USEPA 1997). Delaware's inland bays are already eroding, and sea level rise would extend this process. Salinity levels in the Delaware River and Bay could be altered by these rises as well.

Water supplies for municipal and industrial purposes in Delaware draw heavily on groundwater sources. Increases in summer evaporation under climate change could reduce aquifer recharge, although such losses may be offset by any increases in winter precipitation. Increased migration of pollutants in groundwater as a result of altered infiltration may result from increased inflows into aquifers. Although agriculture is influenced by climatic conditions and water supply, a range of studies of U.S. agriculture suggest that while there may be regional shifts in production, it is likely that aggregate production levels would not fall as a result of climate change. Grain yields in Delaware could be improved by up to 24% or fall by up to 32%, depending upon the particular consequences of climate change in the region (USEPA 1997). Such variability in impact may adversely affect the economies of agriculture in Delaware.

Forecasts of future impacts of climate change on the State's forests indicate that the extent and density of forests could decline by up to 10 to 20% (USEPA 1997). Changes in species composition are likely; the northern hardwood-dominated forests would be replaced by mixed forests, with southern pines and oaks. Maritime forests are vulnerable to increased storm damage; estuarine environments are vulnerable to changes in hydrology that would be associated with changes to upland forest hydrology. Many of the State's rare species of flora and fauna are associated with wetland habitats, as well as many of

its largest populations of shorebirds. These species are vulnerable to the potential coastal changes described above.

## **International and national policy responses**

### **UN Framework Convention on Climate Change**

Having been opened for signature at the 1992 Conference of the Parties in Rio de Janeiro (the so-called 'Earth Summit'), the UN Framework Convention on Climate Change (FCCC) entered into force in March 1994. There are now over 160 nations that have signed the FCCC, including the United States. It is the FCCC's objective to stabilize atmospheric greenhouse gas concentrations at levels that would prevent dangerous anthropogenic interference with the climate system. There were no binding requirements to reduce greenhouse gas emissions in the original Convention. Developed nations were asked to voluntarily limit emissions by formulating policies that would stabilize them by the year 2000 at 1990 levels. However, voluntary agreements have not succeeded in reducing emissions.

A protocol to the FCCC was subsequently developed at the Conference of the Parties meeting held in Kyoto, in December 1997. At this meeting, a set of binding targets and timetables were negotiated. Under the Kyoto Protocol, industrialized nations committed themselves to specific and binding reduction targets for six greenhouse gases. Developed countries under this agreement are required to reduce their collective emissions by an average of 5% below the 1990 baseline by 2008-2012. For the United States, the reduction target is 7% from the 1990 level averaged in the period of 2008-2012. This Protocol was opened for signatures in March 1998.

Under the Kyoto Protocol, countries are able to adopt a comprehensive approach by including all greenhouse gases in their national inventories and also make allowances for sink enhancement activities. Emission trading mechanisms are to be developed and may slow the burden on developed countries, including the United States, in meeting the Kyoto Protocol's targets. Approaches to the emissions trading and joint implementation (which involves project-specific partnerships among industrialized nations to mitigate GHG emissions) were further developed at the FCCC Conferences of the Parties in November 1998 in Buenos Aires and again in November 1999 in Bonn.

Senate opposition to the Kyoto Protocol in its present form has been expressed in a non-binding resolution. Since the U.S. Senate must ratify all treaties for the U.S. to officially be a party to them, the resolution has political significance. The Senate's objection is that large developing countries, such as China and India, are not expected to

limit their GHG emissions during the 2008-2012 budget period. International efforts are underway to address this objection. It should be noted, though, that the average CO<sub>2</sub> emissions per U.S. citizen is over 19 tons per year (by molecular weight), while China is less than 2 tons per citizen, and India averages less than 1 ton per citizen (Byrne et al, 1998). Still, growth in per capita emissions is expected for these countries and high rates of per capita emissions from China and India are expected by the middle of next century. Eventually, emissions from these countries will have to be addressed, if a climate-stable future is to be realized.

### **Implications for the United States and the National Policy Setting**

There are considerable implications for the United States in the climate change issue. Although its proportion of the world's population is around 5%, its share of the total greenhouse gases emitted annually amounts to 25%. Calculated on a per capita basis, the United States emits twice as much as Japan and Germany, nine times that of China and about nineteen times that of India. Emissions categorized by U.S. economic sector show the problem to be distributed broadly; in 1998 CO<sub>2</sub> emissions for transport and industry accounted for about a third each, with the residential sector contributing a little under twenty per cent and the commercial sector, about 16% (EIA 1999).

National greenhouse emissions have increased since 1991, according to the Energy Information Administration (EIA), which considers the rise to be the consequence of strong national economic performance and the high cost of natural gas (which has discouraged the switch from coal); although 1998 was only slightly above the 1997 level (EIA 1999). At the time of the 1997 Kyoto Conference of Parties, it was estimated that the U.S. was 13% above the FCCC emission target of stabilization at 1990 emission levels. Earlier Presidential pledges to reach the target by the year 2000 had failed to be realized, indicative of the difficulty of achieving changes of this magnitude. However, emissions would have been greater than present levels if the National Climate Plan Action Plan had not been enacted in 1993.

Responding to the problems of climate change, the U.S. has launched an array of policy responses at the national, state and local government levels. National climate change policies have taken several forms, of which the most important is the 1993 National Climate Change Action Plan (NCCAP – see

Office of the President, 1993). This overarching Plan contains 50 programs and 5,000 partners in buildings, energy, forestry, transport, utilities, and several industries.

In June 1997, President Clinton announced four additional climate change-related environment initiatives: the Million Solar Roofs Initiative; a Developing Country Climate Change Initiative; Overseas Private Investment Corporation's Environment Program; and the Technology Challenge. Considerable research and policy development is being devoted to climate change and related issues. Under the U.S. Global Change Research Program in fiscal 1997, total expenditure was \$1.8 billion.

## **References**

- Byrne, John et al. (1998) "An Equity- and Sustainability-Based Policy Response to Global Climate Change." *Energy Policy*. Vol. 26, No. 4 (March): 335-343.
- Center for Energy and Environmental Policy (CEEP). (1995) *Delaware Greenhouse Gas Inventory*. Newark, Delaware: CEEP, University of Delaware.
- Energy Information Administration (EIA). (1999) *Emissions of Greenhouse Gases in the United States 1998*. Washington, DC: National Technical Information Service.
- Intergovernmental Panel on Climate Change (IPCC). (1998) *The Regional Impacts of Climate Change – An Assessment of Vulnerability*. Cambridge, UK: Cambridge University Press.
- . (1996a) *Climate Change 1995: The Science of Climate Change*. Cambridge, UK: Cambridge University Press.
- . (1996b) *Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses*. Cambridge, UK: Cambridge University Press.
- . (1992) *Climate Change 1992: The Supplementary Report to the IPCC Scientific Assessment*. Cambridge, UK: Cambridge University Press.
- National Oceanic and Atmospheric Administration (NOAA). (1999) "1998 Warmest on Record, NOAA Announces." January 11 Press Release. Washington, DC: National Technical Information Service.
- Office of the President (1993). *The National Climate Change Action Plan*. Washington, D.C.: U.S. Government Printing Office.
- U.S. Department of Energy (USDOE). (1999). *Kyoto-Related Fossil-Fuel CO<sub>2</sub> Emission Totals*. Washington, D.C.: National Technical Information Service. Information available at the website: <http://cdiac.esd.ornl.gov/trends/emis/annex.htm>
- U.S. Environmental Protection Agency (USEPA). (1998) *States Guidance Document: Policy Planning to Reduce Greenhouse Gas Emissions*. Washington, DC: National Technical Information Service. Second Edition.
- . (USEPA). (1997) *Climate Change and Delaware*. Washington, DC: National Technical Information Service. Pamphlet 230-F-97-008h 1997.