STATES GUIDANCE DOCUMENT

POLICY PLANNING
TO REDUCE GREENHOUSE GAS EMISSIONS

Second Edition

U.S. Environmental Protection Agency
Office of Policy, Planning and Evaluation
State and Local Climate Change Program
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CHAPTER 1
INTRODUCTION

1.1 PURPOSE

State-level policies to control greenhouse gas emissions are essential for mitigating the economic, health, and environmental threats posed by global climate change. States play a crucial role in helping the US as a whole to meet the national pledge to reduce greenhouse gas emissions. However, the circumstances surrounding climate change creates a complicated and politically volatile situation for policy-makers who must deal with complex and uncertain scientific issues and develop policies that potentially affect multiple economic sectors, including energy, transportation, agriculture, industry, and forestry. This guidance document is intended to help states evaluate these complex issue and develop response strategies that address their distinct situations. EPA's objective is to assist each state in formulating a realistic State Action Plan for addressing greenhouse gas emissions.

This document represents the second phase in EPA's State and Local Outreach Program. The first phase produced the *State Workbook: Methodologies for Estimating Greenhouse Gas Emissions*, which contains a set of guidelines and methodologies for states to use to compile an inventory of their greenhouse gas emissions and sinks. Identifying emission sources and sinks and compiling an inventory is a critical first step in building a comprehensive and long range state action plan. The *State Workbook* is available through EPA's Office of Policy, Planning and Evaluation, Office of Economy and Environment.[1]

As follow-on to the Phase I materials, the *States Guidance Document: Policy Options for Reducing Greenhouse Gas Emissions* provides a framework and supporting information to assist policy-makers in further understanding the issues associated with climate change and in identifying and evaluating options to mitigate emissions identified during the inventory process. The document presents background information particularly relevant at the state level and examines emissions forecasting, setting goals and policy criteria, policy evaluation, and organizational and political issues. It also offers suggestions on how climate change mitigation programs can concentrate on reducing emissions where the greatest opportunities exist within each individual state. To support this, a comprehensive survey of technical approaches and policy options for addressing each greenhouse gas source is provided.

The information presented here should help states compile a practical and comprehensive State Action Plan for addressing greenhouse gas emissions. This State Action Plan will lay out the institutional and policy structure, including specific policy proposals or planning processes, that each state will use to develop and implement its climate change mitigation program.

While providing extensive guidance for program development, this document is not intended to lead states explicitly through the detailed steps of climate change policy formulation. Such policy formulation is a process that depends critically on local economic, social, technical, and political circumstances. States may also wish to consider potential adaptive responses to the probable effects of climate change. This

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[1] The Phase I *State Workbook* provides worksheets for calculating greenhouse gas emissions by source category, accompanied by detailed explanations of the formulas and methodologies used, alternative approaches states may consider, data on regional emissions characteristics, and references to additional information.

document is, however, intended to supplement state efforts in a complex field by providing information, resources, and references that highlight and help clarify the most crucial policy and organizational issues.

1.2 ORGANIZATION OF THE DOCUMENT

This document is divided into three parts, which are structured in the form of sequential stages that states may pursue in developing State Action Plans. Each part reflects a different aspect of climate change program design. Part I presents an overview of information and procedures that policy-makers should consider *before* developing explicit programs in this field. Part II describes technical and policy approaches for reducing the concentration of greenhouse gases in the atmosphere. Part III discusses the structuring and administration of climate change programs.

Each of these three parts of the document, which are summarized in more detail below, is subdivided into chapters. The chapters address more discrete components of climate change policy formulation and are designed to be referenced independently. Consistent with the general theme that policy formulation in this field is a dynamic process that incorporates various interconnected issues, each chapter cross-references information in other sections of the document where appropriate. All the chapters maintain a common focus on how states can plan greenhouse gas policies around distinct local environmental, economic, and political situations.

Part I: Initiation of Climate Change Programs

Part I, which includes Chapters 2 through 4, presents information to help state policy-makers establish a focal point the initiation of climate change programs. As discussed throughout the document, climate change and greenhouse gas emissions and sequestration span many sectors of society and extend far into the future. Furthermore, policy measures to address greenhouse gases overlap with many other public policy objectives, often in a complementary way. The chapters in Part I present background information and planning mechanisms for sorting through this complex policy arena and developing a clear focus for policy formulation.

Chapter 2, *Background on Climate Change Science and Policy*, provides scientific and policy background information on climate change issues as they affect states. It includes an introduction to greenhouse gases and to the probable impacts of climate change at the state and local level, summarizes climate change policy initiatives around the world, and highlights the importance of state level action. To help states envision their role in confronting this complicated issue, this chapter integrates these scientific and policy issues, along with important time frame concerns, into a general framework for climate change policy analysis that serves as a basis for State Action Plan formulation.

Chapter 3, *Measuring and Forecasting Greenhouse Gas Emissions,* summarizes the methodologies for estimating emissions that were presented in EPA's Phase I greenhouse gas inventory document, described above. This chapter also explains how these methodologies can serve as a base for forecasting the impact of various alternative policy options throughout future time periods.

Chapter 4, *Establishing Emission Reduction Program Goals and Evaluative Criteria*, examines goal setting in climate change program development. It highlights the practical and political differences between setting quantitative and qualitative emission reduction targets and emphasizes the importance of establishing specific criteria for evaluating policy options over a range of time frames.

Part II: Technical Approaches and Policy Options for Reducing Greenhouse Gas Emissions

Part II, which includes Chapters 5 and 6, describes the specific sources and sinks of greenhouse gases across all sectors of society and highlights numerous emission reduction policy options. The chapters in Part II should be used as a reference tool for learning about how greenhouse gases are generated and for compiling a portfolio of policy options that can be further investigated and, potentially, implemented.

Chapter 5, *Technical Approaches and Source-Specific Policy Options*, contains a separate section on seventeen greenhouse gas sources and sinks. Each section describes how the source generates gases or the sink sequesters them, and discusses the technical approaches that government agencies can use to reduce source-emissions or increase sequestration. The sections also elaborate on potential policy options that states might use to implement those technical approaches, and how these options may interact with other state policy objectives. This chapter emphasizes the range of policy options that are unique to a particular source or sink.

Chapter 6, *Cross Cutting Policy Options*, describes policy approaches that offer promise for reducing emissions from various sources simultaneously. These approaches highlight how innovative government action tailored to particular situations can substantially affect greenhouse gas emissions and can potentially promote other public sector goals as well. In presenting policy ideas, this chapter references the technical information in Chapter 5 extensively.

Part III: Program Development and State Action Plan Preparation

Part III, which includes Chapters 7 through 9, addresses organizational and analytical topics relating to climate change program design and offers guidance in preparing the State Action Plan. Programs that are structured to support flexible selection and evolution of policies will maintain a stronger and more dynamic link with overall state policy objectives. This flexibility is especially relevant because of the diversity of political circumstances surrounding climate change and the changing state of scientific and technical knowledge in this field. The chapters in Part III draw on state experiences and current research to present mechanisms states can use to evaluate options and to structure flexible and responsive programs in an uncertain policy environment.

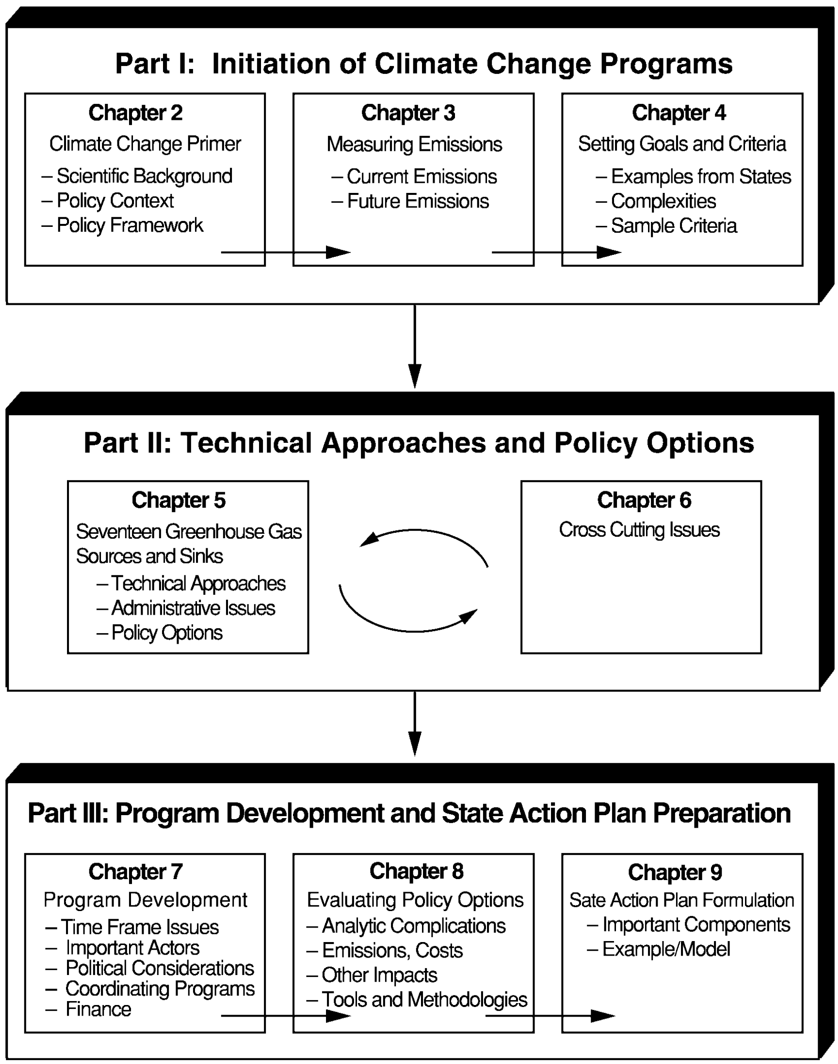
Chapter 7, *Climate Change Program Development*, addresses institutional, administrative, and political issues that can affect the success of climate change mitigation efforts. This information highlights how states can anticipate issues that may arise during the process of program design and presents ideas on how programs might be structured to deal with these concerns. Specific topics include time frame perspectives in policy planning, understanding the important public and private sector actors in this field, political issues in program development, program finance, and interaction between agencies within the state and at the local and national level. The topic of partnerships between state agencies is extremely important within the context of this chapter.

Chapter 8, *Evaluating Policy Options*, examines alternative approaches to balancing emissions, costs, and other policy impacts. It summarizes the methodologies states might use to evaluate emission control policies, and introduces models for analyzing the complicated interactions between various factors. This chapter also discusses analytic constraints, such as uncertainty and multiple time-frames for planning. This information illustrates the range of issues states should consider when evaluating policies and is not intended to suggest any specific approach.

Chapter 9, *Guidance on State Action Plan Formulation*, offers a framework and model for developing the State Action Plan on climate change mitigation.

Exhibit 1-1 illustrates the structure of the document and the primary contents of each chapter. While the document presents policy formulation as a sequential process, the information and concepts presented in each of the chapters may need to be referenced at different times throughout program development.

Exhibit 1-1
Structure of Document



PART I

INITIATION OF CLIMATE CHANGE PROGRAMS

The following three chapters address issues that policy-makers should consider and understand at the outset of climate change program development. These chapters advocate formulation of a strong and deliberate program focus. They are intended to help states gather information, envision the climate change policy context, and anticipate and prepare for critical issues that are likely to arise during program development.

- Chapter 2, *Background on Climate Change Science and Policy*, presents background information on climate change science, international, national and state responses to climate change, and a general framework for policy analysis and program development.

- Chapter 3, *Measuring and Forecasting Greenhouse Gas Emissions*, highlights how states can measure greenhouse gas emissions and anticipate the probable impact of various policy options.

- Chapter 4, *Establishing Emission Reduction Program Goals and Evaluative Criteria*, discusses the importance of setting clear and feasible program goals, and offers examples of specific policy evaluation criteria that states can use.

This information sets the context for Part II, which discusses specific technical approaches and policy options for reducing greenhouse gas emissions, and Part III, which elaborates on organizational, political, and analytic complexities surrounding climate change policy selection and program development.

CHAPTER 2
BACKGROUND ON CLIMATE CHANGE SCIENCE AND POLICY

Initiating climate change response programs requires a basic understanding of the underlying scientific, technical, organizational, and political issues. The purpose of this chapter is to familiarize policy-makers with the current scientific understanding of global climate change and to set the broader policy context for greenhouse gas reduction measures. The first section of this chapter introduces the greenhouse effect and the changes in climate expected to result from increasing atmospheric concentrations of greenhouse gases. The second section describes international and national responses to climate change and identifies the role of states in mitigating this threat. The third section presents a framework for climate change policy analysis that provides the structure for the remainder of this document and the basis for climate change program development. The final section uses an example of comprehensive policy planning to illustrate many of the points made throughout this chapter.

2.1 INTRODUCTION TO CLIMATE CHANGE

The Earth's climate is the result of a complex system driven by many factors, including radiant energy from the sun, volcanic activity, and other natural phenomena. Human activities, specifically those that result in emissions of greenhouse gases, may affect this complex system and alter the Earth's climate. While the atmosphere's natural greenhouse effect is relatively well understood, uncertainties surrounding the effects of increased concentrations of greenhouse gases still exist. This section describes the scientific and technical aspects of climate change and the impacts which may result at both global and regional levels.

2.1.1 Scientific and Technical Aspects of Global Climate Change

The climate of the Earth is affected by changes in radiative forcing attributable to several sources including the concentrations of radiatively active (greenhouse) gases, solar radiation, aerosols, and albedo.[1] Greenhouse gases in the atmosphere are virtually transparent to sunlight (shortwave radiation), allowing it to pass through the air and to heat the Earth's surface. The Earth's surface absorbs the sunlight and emits thermal radiation (longwave radiation) back to the atmosphere. Because some gases, such as carbon dioxide (CO_2), are not transparent to the outgoing thermal radiation, some of the radiation is absorbed, and heats the atmosphere. In turn, the atmosphere emits thermal radiation both outward into space and downward to the Earth, further warming the surface. This process enables the Earth to maintain enough warmth to support life: without this natural "greenhouse effect," the Earth would be approximately 55^{o} F colder than it is today. However, increasing concentrations of these greenhouse gases are projected to result in increased average temperatures, with the potential to warm the planet to a level that could disrupt the activities of today's natural systems and human societies.

Naturally occurring greenhouse gases include water vapor, carbon dioxide, methane (CH_4), nitrous oxide (N_2O), and ozone (O_3).[2] Some human-made compounds — including chlorofluorocarbons (CFCs),

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[1] Albedo is the fraction of light or radiation that is reflected by a surface or a body. For example, polar ice and cloud cover increase the Earth's albedo. "Radiative forcing" refers to changes in the radiative balance of the Earth, *i.e.*, a change in the existing balance between incoming and outgoing radiation. This balance can be upset by natural causes, *e.g.*, volcanic eruptions, as well as by anthropogenic activities, *e.g.*, greenhouse gas emissions.
[2] Ozone exists in the stratosphere and troposphere. In the stratosphere (which starts about 8.4 miles above the Earth's surface), ozone provides a protective layer shielding the Earth from ultraviolet radiation and subsequent harmful health effects on humans and the environment. In the

partially halogenated fluorocarbons (HCFCs), hydrofluorocarbons (HFCs), and perfluorinated carbons (PFCs) — are also greenhouse gases. In addition, there are photochemically important gases such as oxides of nitrogen (NO_x) and nonmethane volatile organic compounds (NMVOCs) that, although not greenhouse gases, contribute indirectly to the greenhouse effect by influencing the rate at which ozone and other greenhouse gases are created and destroyed in the atmosphere.

Greenhouse gases are emitted by virtually all economic sectors, including residential and commercial energy use, industrial processes, electricity generation, agriculture, and forestry. Exhibit 2-1 contains a brief description of these gases, their sources, and their roles in the atmosphere.[3] Exhibit 2-2 discusses how the potential warming effects of these gases are usually expressed using a common scale, viz., global warming potential. Figure 2-1 presents a summary of U.S. greenhouse gas emissions, by gas, weighted by global warming potential. Later in this document, Chapter 3 provides a complete list of emission sources and Chapter 5 elaborates on the emission characteristics and options for addressing emissions from each source.

2.1.2 Potential Impacts of Global Climate Change

Although CO_2, CH_4, and N_2O occur naturally in the atmosphere, rising levels of these gases in the atmosphere are attributed mainly to anthropogenic activities. This buildup has altered the composition of the earth's atmosphere, and possibly will affect the future global climate. Since about 1750, atmospheric concentrations of carbon dioxide have increased by about 30 percent, methane concentrations haveincreased by 145 percent, and nitrous oxide concentrations have risen approximately 15 percent (IPCC, 1996). And, from the 1950s until the mid-1980s, when international concern over CFCs grew, the use of these gases increased nearly 10 percent per year. The consumption of CFCs is declining quickly, however, as these gases are phased out under the *Montreal Protocol on Substances that Deplete the Ozone Layer*.[4] Use of CFC substitutes, in contrast, is expected to grow significantly.

Estimating the potential impact of increasing greenhouse gas concentrations on global climate has been a focus of research within the atmospheric science community for more than a decade. While there is considerable agreement within the scientific community that "climate has changed over the past century," and that "the balance of evidence suggests a discernible human influence on global climate," (IPCC, 1996), there is much less agreement about the timing, magnitude, or regional distribution of any climatic change. Uncertainties about the climatic roles of oceans and clouds as well as the feedback effects of oceans, clouds, vegetation, and other factors make it difficult to predict with certainty the amount of warming that rising levels of greenhouse gases will cause. Current evidence from climate model studies, however, suggests that by 2100, global average surface temperature will increase by 1.8

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troposphere (from the Earth's surface to about 8.4 miles above), ozone is a chemical oxidant and major component of photochemical smog. Most ozone is found in the stratosphere, with some transport occurring to the troposphere through the tropopause (the transition zone separating the stratosphere and the troposphere) (IPCC, 1992).

[3] For convenience, all gases discussed in this document are generically referred to as "greenhouse gases," although the reader should keep in mind the distinction between actual greenhouse gases and photochemically important trace gases.

[4] Recognizing the harmful effects of chlorofluorocarbons (CFCs), halons, and other compounds on the stratospheric ozone layer, many governments signed the Montreal Protocol on Substances that Deplete the Ozone Layer in 1987. This agreement limits the production and consumption of a number of these damaging compounds. As of June 1997, more than 160 nations are Parties to the Montreal Protocol. The US expanded its commitment to phase out these substances by signing and ratifying the Copenhagen Amendments to the Montreal Protocol in 1992. Under these amendments, the US committed to eliminating the production of all halons by January 1, 1994, all CFCs by January 1, 1996, and all HCFCs by January 1, 2030.

Exhibit 2-1. Greenhouse Gases and Photochemically Important Gases

The Greenhouse Gases

Carbon Dioxide (CO_2). The combustion of liquid, solid, and gaseous fossil fuels is the major anthropogenic source of carbon dioxide emissions. Some other non-energy production processes (*e.g.*, cement production) also emit notable quantities of carbon dioxide. CO_2 emissions are also produced by forest clearing and biomass burning. Atmospheric concentrations of carbon dioxide have been increasing at a rate of approximately 0.5 percent per year (IPCC, 1996).

In nature, carbon dioxide cycles between various atmospheric, oceanic, land biotic, and marine biotic reservoirs. The largest fluxes occur between the atmosphere and terrestrial biota, and between the atmosphere and surface water of the oceans. While there is a small net addition of CO_2 to the atmosphere from equatorial regions, oceanic and terrestrial biota in the Northern Hemisphere, and to a lesser extent in the Southern Hemisphere, act as a net sink of CO_2 (*i.e.*, remove more CO_2 from the atmosphere than they release) (IPCC, 1996).

Methane (CH_4). Methane is produced through anaerobic decomposition of organic matter in biological systems. Agricultural processes, such as wetland rice cultivation, enteric fermentation in animals, and the decomposition of animal wastes, emit methane, as does the decomposition of municipal solid wastes. Methane is also emitted during the production and distribution of natural gas and oil, and is released as a by-product of coal production and incomplete fuel combustion. The atmospheric concentration of methane is increasing, although the rate of increase in the 1990s is lower than the rate observed in the 1970s and 1980s (IPCC 1996).

The major sink for methane is its interaction with the hydroxyl radical (OH) in the troposphere. This interaction results in the chemical destruction of the methane compound, as the hydrogen molecules in methane combine with the oxygen in OH to form water vapor (H_2O) and CH_3. After a number of other chemical interactions, the remaining CH_3 turns into CO which itself reacts with OH to produce carbon dioxide (CO_2) and hydrogen (H).

Halogenated Fluorocarbons, HFCs, and PFCs. Halogenated fluorocarbons are human-made compounds that include: chlorofluorocarbons (CFCs), halons, methyl chloroform, carbon tetrachloride, methyl bromide, and hydrochlorofluorocarbons (HCFCs). These compounds not only enhance the greenhouse effect, but also contribute to stratospheric ozone depletion. Under the *Montreal Protocol* and the *Copenhagen Amendments*, which controls the production and consumption of these chemicals, the U.S. phased out the production and use of all halons by January 1, 1994 and phased out CFCs, HCFCs, and other ozone-depleting substances (ODSs) by January 1, 1996. Perfluorinated carbons (PFCs) and hydrofluorocarbons (HFCs), a family of CFC and HCFC replacements not covered under the *Montreal Protocol*, are also powerful greenhouse gases.

Nitrous Oxide (N_2O). Anthropogenic sources of N_2O emissions include soil cultivation practices, especially the use of commercial and organic fertilizers, fossil fuel combustion, adipic and nitric acid production, and biomass burning.

Ozone (O_3). Normal processes in the atmosphere both produce and destroy ozone. Approximately 90 percent of atmospheric ozone resides in the stratosphere, where it regulates the absorption of solar ultraviolet radiation; the remaining 10 percent is found in the troposphere and could play a significant greenhouse role. While ozone is not emitted directly by human activity, anthropogenic emissions of several gases influence its concentration in the stratosphere and troposphere. For example, chlorine and bromine-containing chemicals, such as CFCs, deplete stratospheric ozone.

Emissions of carbon monoxide, nonmethane volatile organic compounds, and oxides of nitrogen contribute to the increased production of tropospheric ozone (otherwise known as urban smog). Emissions of these gases, known as criteria pollutants, are regulated under the *Clean Air Act of 1970* and subsequent amendments.

Photochemically Important Gases

Carbon Monoxide (CO). Carbon monoxide is created when carbon-containing fuels are burned incompletely. Carbon monoxide elevates concentrations of methane and tropospheric ozone through chemical reactions with atmospheric constituents (*e.g.*, the hydroxyl radical) that would otherwise assist in destroying methane and ozone. It eventually oxidizes to CO_2.

Oxides of Nitrogen (NO_x). Oxides of nitrogen — NO and NO_2 — are created from lightning, biomass burning (both natural and anthropogenic fires), fossil fuel combustion, and in the stratosphere from nitrous oxide. They play an important role in climate change processes because they contribute to the formation of tropospheric ozone.

Nonmethane Volatile Organic Compounds (NMVOCs). Nonmethane VOCs include compounds such as propane, butane, and ethane. Volatile organic compounds participate along with nitrogen oxides in the formation of ground-level ozone and other photochemical oxidants. VOCs are emitted primarily from transportation, industrial processes, forest wildfires, and non-industrial consumption of organic solvents. (U.S. EPA, 1991).

Source: U.S. EPA, 1994.

Exhibit 2-2: Global Warming Potential (GWP)

The potential contribution to radiative forcing of the various greenhouse gases differ dramatically. Accurately calculating the amount of radiative forcing attributable to given levels of emissions of these gases, over some future time horizon, requires a complex and time-consuming task of calculating and integrating changes in atmospheric composition over the period. For policy purposes, the need is for an index that translates the level of emissions of various gases into a common metric in order to compare the climate forcing effects without directly calculating the changes in atmospheric concentrations (Lashof and Tirpak, 1990). This information can be used to calculate the cost-effectiveness of alternative reductions, *e.g.*, to compare reductions in CO_2 emissions with reductions in CH_4 emissions.

A number of approaches, called Global Warming Potential (GWP) indices, have been developed in recent years. These indices account for the direct effects of carbon dioxide (CO_2), methane (CH_4), chlorofluorocarbons (CFCs), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), and perfluorinated carbons (PFCs). They also estimate indirect effects on radiative forcing due to emissions of gases which are not themselves greenhouse gases, but lead to chemical reactions that create or alter greenhouse gases.

The concept of global warming potential, which was developed by the Intergovernmental Panel on Climate Change (IPCC), compares the radiative forcing effect of the concurrent emission into the atmosphere of an equal quantity of CO_2 and another greenhouse gas. Each gas has a different instantaneous radiative forcing effect. In addition, emissions of different gases decay at different rates over time, which affects the atmospheric concentration. In general, CO_2 has a much weaker instantaneous radiative effect than other greenhouse gases; it decays more slowly, however, and hence has a longer atmospheric lifetime than most other greenhouse gases. While there is relative agreement on how to account for these direct effects of greenhouse gas emissions, accounting for indirect effects is more problematic

GWPs are used to convert all greenhouse gases to a CO_2-equivalent basis so that the relative magnitudes of different quantities of different greenhouse gases can be readily compared. The GWP potential will be an important concept for states in determining the relative importance of each of the major emissions sources and in developing appropriate mitigation strategies. A more detailed discussion on the development of GWPs can be found in the Phase I document, *States Workbook: Methodologies for Estimating Greenhouse Gas Emissions.*

to 6.3 ^{o} F, with a best estimate of 3.6^{o} F (IPCC, 1996). Global warming of just a few degrees would represent an enormous change in climate. For example, at the height of the last ice age, when glaciers covered the Great Lakes and reached as far south as New York, the global average temperature was only 5 to 9^{o} F colder than today (Hodges-Copple, 1990).

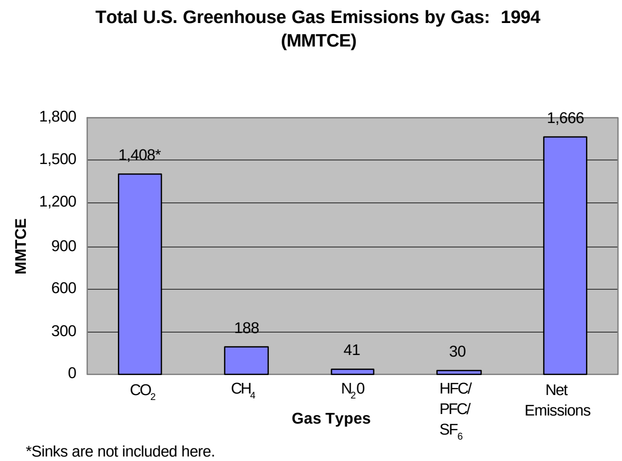
The impact of global climate change in various geographic areas and on various sectors of the world economy could be significant. Coastal areas are especially vulnerable. A recent EPA study (Titus and Narayanan 1995) projects that, in response to climate change, global *sea level* is most likely to rise 15 centimeters by the year 2050 and 34 centimeters by the year 2100. As global sea level rises, coastal areas in the US (particularly wetlands and lowlands along the Gulf and Atlantic coasts) are being inundated. Adverse impacts in these areas include loss of dryland and associated structures, loss of wetland and wildlife habitat, accelerated coastal erosion, exacerbated flooding, and increased salinity of rivers, bays, and aquifers (USEPA 1997).

Higher sea levels could also contaminate fresh water aquifers, which would increase the costs of fresh water supply either through deeper well drilling or importation of water from inland supplies. Sea level rise could also raise water tables in low lying coastal areas, which would increase flood damage, impede drainage, and reduce the effectiveness of sewage disposal facilities (Lesser et al., 1989). This impact could also place additional stress on infrastructure such as roads and bridges.

[5] Storm surges refer to the flooding induced by wind stresses and the barometric pressure reduction associated with major storms.

Climate change could have other impacts on *water resources*, as well. Changing climate is expected to increase both evaporation and precipitation in most areas of the United States (USEPA 1997). In those areas where the increase in evaporation is greater, there will generally be a decline in the availability of fresh water; where the increase in rainfall is greater, water may become more available. Climate models also suggest that seasonal changes are likely, with generally wetter winters and drier summers. Both climate models and empirical evidence suggest an increase in the frequency of intense rainstorms. The direct effects of a decline in water availability include declines in river flows, lake levels, and groundwater availability. The resulting impacts on society could include insufficient water for navigation; lower production of hydroelectric power; impaired recreational opportunities along rivers and lakes; poorer water quality; and decreased availability of water for agriculture, residential, and industrial uses. At the same time, warmer temperatures are likely to reduce soil moisture, which would increase the need for irrigation water. Increased water availability would generally have the opposite effects (USEPA 1997).

Figure 2-1
U.S. Greenhouse Gas Emissions and Sinks: 1994



Source: U.S. EPA, 1995
Note: MMTCE stands for million metric tons of carbon equivalent.

Climate change may also affect ecosystems, with impacts on commercial forestry, agriculture, and recreational and other uses of natural systems. *Forests* are likely to be affected in terms of their geographic distribution, species composition, and growth. Some areas that currently support forests may no longer be able to do so, while other areas that are not now forested could potentially support forests in the future. As with other predictions of climate change effects, there is considerable uncertainty in the impact estimates for forests, and results vary depending on assumptions made regarding forest type, region, climate projections, water availability, and the effect of higher carbon dioxide concentrations (USEPA 1997). Estimates also differ depending upon whether they address the transient period during which forests adjust to a change in climate or an equilibrium period after adjustments are completed. During a transient phase of adjustment to climate change, forests (particularly softwood forests in the southeast US) may suffer diminished productivity and dieback. The transformation of forests is a slow process during which current trees and other vegetation die and are succeeded by new vegetation, species migrate to sites with newly suitable climates, and soils develop. This transient or adjustment phase is expected to last decades to centuries after the climate ceases to change and has reached a new steady state. After forests are fully transformed and in equilibrium with a new and stable climate, forests in many areas of the US may be more productive than current forests and may expand in area (USEPA 1997).

Agriculture, always sensitive to climatic changes, is expected to be affected by global climate changes. Yields of many crops are likely to be affected by changes in average temperatures and precipitation as well as by changes in climate variability and the frequency of droughts and floods (USEPA 1997). Climate change may also affect availability of irrigation water, the prevalence of pests, and soil erosion. Increased CO_2 levels may increase yields (the “CO_2 fertilization effect”). Most projected impacts in the agriculture sector involve considerable uncertainty; different assumptions generate very different results that range from net benefits to net losses for US agriculture.

Existing studies suggest that the impacts on US agriculture will be modest in aggregate. Studies indicate that a doubling of CO_2 would change US agricultural production by a few percent. Total economic welfare changes are estimated to be within a range of plus or minus two percent. Projected nationwide impacts range from annual benefits of $10 billion to annual losses of $18 billion (USEPA 1997). Regional consequences could be greater in relative terms; there will be winners and losers. Climate change will increase production and economic welfare in some locations and decrease it in others. Under some scenarios, some regions could see losses of more than 10 percent while other see gains of more than 25 percent. When aggregated across regions, the gains and losses offset each other to produce a relatively small net impact.

One of the key regional-scale predictions is that production of some crops may migrate. As climate changes, some crops may expand into new regions and decline or disappear in some parts of their current range. The southern agricultural regions may be more vulnerable to adverse impacts.

Finally, regardless of a state's landscape or geological features, increased summer temperatures are expected to affect *human health*. In a warmer world, the frequency and intensity of extremely hot days are expected to increase, and would likely result in significant increases in annual weather-related mortality in US cities (USEPA 1997). Increased warmth and moisture may enhance the transmission of diseases by mosquitoes, ticks, and other insects. Climatic impacts on marine ecosystems may lead to increases in toxic algae species, contaminated seafood, and cases of seafood poisoning. Furthermore, increases in the persistence and level of air pollution episodes associated with climate change may have adverse health effects (Smith & Tirpak, 1989).

While scientists cannot predict the magnitude of climate effects from greenhouse gas emissions with absolute precision, the decision to limit emissions cannot wait until the full impacts are evident. Because greenhouse gases, once emitted, remain in the atmosphere for decades to centuries, stabilizing emissions at current levels would still allow the greenhouse effect to intensify for more than a century (Lashof and Tirpak, 1990). Thus, our emissions today have committed the planet to climate change well into the 21st century. Delaying control measures will increase this "global warming commitment" still further.[6]

2.2 POLICY CONTEXT FOR CLIMATE CHANGE MITIGATION

The scientific evidence indicates that continuing emissions of greenhouse gases are altering global climate. In response, governments at the international and national levels are taking action to reduce emissions of greenhouse gases. Many individual states have also recognized the potential dangers that global climate change presents to both current and future generations. This section first describes international and national responses to climate change and then discusses the role of states in addressing this global concern.

2.2.1 Introduction to International and National Responses to Climate Change

[6] While this document concentrates on policy formulation to reduce or stabilize greenhouse gas emissions in order to mitigate climate change, other EPA and state research focuses on state-level adaptation to the significant impacts described above should the greenhouse effect intensify.

The international community has coordinated efforts to address the potential impacts of climate change, particularly within the last decade. Some of the more important events are described below.

- *Villach and Bellagio Workshops*: The Villach workshop assessed the role of carbon dioxide and radiatively active constituents under various climate scenarios and assessed the potential impacts under each. The goal of this workshop was to provide a technical basis for a subsequent policy workshop in Bellagio, Italy.

- *The Montreal Protocol on Substances That Deplete the Ozone Layer:* In response to growing international concern about the role of CFCs in destroying stratospheric ozone, 47 nations reached agreement on a set of CFC control measures in September 1987. The control measures, known as the Montreal Protocol on Substances that Deplete the Ozone Layer, laid out a schedule of production and consumption reductions for many CFCs. In June 1990 the Parties to the Protocol agreed to a complete phaseout of CFCs and other ozone-depleting substances (ODSs) (this agreement is known as the London Amendments). In November 1992 Parties accelerated the phaseout schedule for ODSs and agreed to phaseout dates for HCFCs, which are CFC substitutes in many current applications (this agreement is known as the Copenhagen Amendments). As of June 1997, over 160 countries had ratified the agreement.

- *Toronto Conference:* This international conference focused on the implications of climate change for world security and established a goal for industrialized countries to reduce carbon dioxide emissions by 20 percent of 1988 levels by 2005. It was attended by more than 300 policy-makers and scientists from 48 countries.

- *The Intergovernmental Panel on Climate Change:* Under the auspices of the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO), the Intergovernmental Panel on Climate Change (IPCC) was formed in 1988 to conduct studies on global warming. Efforts undertaken include identifying emission sources, assessing possible consequences, and developing mitigation strategies.

- *The International Geosphere/Biosphere Program:* This program was established through the International Council of Scientific Unions in 1988 to facilitate understanding the present state of the earth and the potential impacts of global climate change. This extensive program maps recent global deforestation, produces documents on climate and atmospheric changes, and combines space-based scrutiny of climate change with extensive surveys of land and sea.

- *Noordwijk Conference on Atmospheric Pollution and Climate Change:* The final declaration at this conference encouraged the IPCC to include in its First Assessment Report an analysis of quantitative targets to limit or reduce CO2 emissions, and urged all industrialized countries to investigate the feasibility of achieving such targets, including, for example, a 20 percent reduction of carbon dioxide emissions by the year 2005. The Conference also called for assessing the feasibility of increasing net global forest growth by 12 million hectares per year. During its Third Plenary, the IPCC accepted the mandate.

- *Hague Declaration:* This conference and Declaration (signed by 23 nations) established support for new principles of international law. These principles promote the creation of standards to guarantee protection of the world's atmosphere and combat global warming. The U.S. and Soviet Union were not invited to the conference to avoid potential East-West policy conflict.

- *Cairo Compact:* The compact calls on affluent nations to provide developing countries with the technical and financial assistance to address global climate change.

- *United Nations World Climate Conference:* The IPCC reported the findings of the IPCC Working Groups to the United Nations (Scientific Assessment, Impacts Assessment, and Response). The IPCC report, adopted by the General Assembly, set the stage for future international negotiations on a framework convention on climate change.

- *Intergovernmental Negotiating Committee (INC):* On December 21, 1990, the U.N. General Assembly established the INC to prepare an effective framework convention on climate change, containing appropriate commitments and any related legal instruments as might be agreed upon. The INC, supported by the WMO and UNEP, has convened for ten sessions since its formation. The INC serves as the international mechanism to monitor and enforce the provisions of the United Nations Framework Convention of Climate Change (FCCC). The INC is also currently negotiating to adopt a framework to implement a joint implementation regime.[7]

- *United Nations Conference on Environment and Development (UNCED):* On June 12, 1992, at UNCED (the Earth Summit) in Rio de Janeiro, 154 nations, including the U.S., signed the U.N. Framework Convention on Climate Change. The Convention contains a legal framework that commits the world's governments to voluntary reductions of greenhouse gases, or other actions such as enhancing greenhouse gas sinks, aimed at stabilizing atmospheric concentrations of greenhouse gases at 1990 levels. To facilitate this, Article 4-1 requires that all parties to the FCCC develop, periodically update, and make available to the Conference of the Parties, national inventories of all anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies. In October 1992, the U.S. became the first industrialized nation to ratify the Treaty, which came into force on March 21, 1994. The Convention also contains other binding agreements related to its establishment, support, and administration.[8]

- *Bilateral Sustainable Development Accord Between Costa Rica and the U.S.:* On September 30, 1994, the U.S. and Costa Rica signed a bilateral accord intended to facilitate developing joint implementation projects. These projects are intended to encourage the use of greenhouse gas-reducing technologies (including energy efficiency and renewable energy technologies); develop educational and training programs; diversify energy sources; conserve, restore, and enhance forest carbon sinks (especially in areas that promote biodiversity conservation and ecosystem protection); reduce greenhouse gas emissions and other pollution; and promote the exchange of information regarding sustainable forestry and energy technologies. This accord should provide the basis for future similar arrangements between countries and contribute to establishing an international joint implementation regime that is sensitive to environmental, developmental, social and economic priorities. The accord is intended to encourage partnerships involving the federal government, private sector, non-governmental organizations, and other interested entities.

- *1995 First Conference of the Parties:* The INC was dissolved in February 1995, and the Conference of the Parties (COP) became the new ultimate authority of the FCCC. During the first

[7] The concept of "joint implementation" (JI) was introduced early in the negotiations leading up to the 1992 Earth Summit in Rio, and was formally adopted into the text of the FCCC. The term "JI" has been used subsequently to describe a wide range of possible arrangements between interests in two or more countries, leading to the implementation of cooperative development projects that seek to reduce or sequester greenhouse gas emissions.
[8] To fulfill its obligation under the FCCC Article 4-1, the U.S. government published the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-1993* (U.S. EPA, 1994). The U.S. also published the *Climate Action Report* (U.S. Government, 1994), in accordance with Article 4-2 and 12. The *Climate Action Report* provides a description of the U.S. climate change program.

Conference of the Parties in Berlin from March 28 - April 7, 1995 (COP-1), delegates agreed on a mandate to establish appropriate action for the period beyond the year 2000, including stronger commitments from developed countries. They formed an Ad hoc Group on the Berlin Mandate (AGBM) to begin work on this process.

- *Ad hoc Group on the Berlin Mandate*: At its first session in Geneva, held from August 21 - 25, 1995, delegates to AGBM -1 began the process of drafting a protocol on new commitments for the post-2000 period. The AGBM has met 3 times since then, and has begun making specific proposals for new reduction targets and strategies for both industrialized and developing countries.

- *1996 Second Conference of the Parties*: COP-2 met in Geneva from July 8 - 19, 1996 and endorsed the "Geneva Declaration," which calls for legally binding objectives and significant reductions in greenhouse gas emissions. For the first time, the US agreed to support a legally binding agreement to fulfill the Berlin Mandate being developed by AGBM.

- *1997 Third Conference of the Parties*: COP-3 met in Kyoto, Japan in December 1997, where the parties agreed to an historic protocol to reduce global greenhouse gas emissions and set binding targets for developed nations. (For example, the binding emissions target for the U.S. is 7% below 1990 emissions levels.) The Kyoto Protocol seeks to achieve targets on all six major greenhouse gases by 2008-2012; international emissions trading is included as a compliance option. The parties will meet again at Buenos Aires in November 1998, where the U.S. will attempt to secure meaningful participation by developing countries.

In the negotiations that led to the FCCC, the United States "supported an approach to global action that focused on the development of national policies and measures to mitigate and adapt to climate change, recognizing that only concrete actions will enable the world community to effectively address climate change, and that measures and policies must be rooted in specific national circumstances and fashioned from a comprehensive set of options addressing all sectors, sources, and sinks of greenhouse gases" (U.S. DOS, 1992). To fulfill this goal, the United States has undertaken actions to address climate change, including scientific and economic research, policy analysis, and program development. These actions culminated in the release of the *Climate Change Action Plan* (CCAP) by the Clinton Administration in October, 1993 . The CCAP presents the U.S. strategy for reducing greenhouse gas emissions to 1990 levels by the year 2000. Neither the measures initiated in 1993 nor the additional actions developed since then will likely be adequate to meet the emissions goal enunciated by the President, but they have significantly reduced emissions below growth rates that otherwise would have occurred. The analysis used to develop CCAP significantly underestimated the reductions that would be needed to return emissions to 1990 levels by the year 2000. Lower-than-expected fuel prices, strong economic growth, improved information on emissions of some potent greenhouse gases, and diminished levels of funding by Congress are among the factors responsible for the need to revise the CCAP goals. Based on current funding levels, the revised action plan is expected to reduce emissions by 76 million metric tons of carbon equivalent (MMTCE) in the year 2000, or 70 percent of the reduction projected in the CCAP. Annual energy cost savings to businesses and consumers from CCAP actions are anticipated to be $10 billion (1995 dollars) by the year 2000. Even greater reductions are estimated from these measures in the post-2000 period: reductions are projected to be 169 MMTCE in 2010, and 230 MMTCE in 2020. Annual energy savings are projected to grow to $50 billion (1995 dollars) by the year 2010.

Also at the national level, the Department of Energy has released a set of draft guidelines for entities to voluntarily report their reductions of greenhouse gas emissions and fixation of carbon, achieved through any measure. The purpose of these guidelines is (1) to provide a database of information for entities seeking to reduce their own greenhouse gas emissions; (2) to establish a formal record of emissions and emission reductions and carbon sequestration achievements; and (3) to inform the public debate in future discussions on national greenhouse gas policy.

The CCAP and other U.S. actions are the outgrowth of more than $2.7 billion in global change research conducted since 1990 (U.S. DOS, 1992). This research includes a variety of multinational scientific projects. For example, the U.S. Global Change Research Program coordinates research of the EPA, the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration, the National Science Foundation, and the Departments of Energy, Agriculture, Interior, and Defense. The objectives of the Research Program are to evaluate and further current research activities in the U.S. that address scientific questions concerning global climate change, to define future research needs, and to establish federal agency roles. The Research Program is also intended to develop national and international partnerships between governmental bodies, the academic science community, and the private research sector to achieve long-term scientific goals. Much of this research has focused on steps to strengthen the ability of economic, social, and ecological systems to adapt to adverse change; concrete measures to mitigate the risk of future climate change through greenhouse gas reduction measures; aggressive research to improve understanding of climate, climate change, and potential responses; and international cooperation to broaden the global effort in each of these areas.

To foster international cooperation, the *Climate Change Action Plan* makes provisions for reducing emissions internationally through the U.S. Initiative on Joint Implementation (U.S. IJI). U.S. IJI is a voluntary pilot program that contributes to the international knowledge base regarding joint implementation, through projects demonstrating a range of approaches for reducing or sequestering greenhouse gas emissions in different geographic regions. U.S. IJI provides public recognition and selected technical assistance to approved projects. These projects contribute to emissions reductions by promoting technology cooperation with and sustainable development in developing countries and countries with economies in transition. As of July 1997, 26 project proposals have been accepted by USIJI.

Many individual states and localities have also initiated independent climate change responses. At the state level, 29 states have developed a state-level GHG inventory, and 20 states have developed or committed to develop a state-level action plan to reduce GHG emissions. More than 20 states and more than 80 cities and counties have joined Rebuild America, a program which emphasizes energy efficiency improvements, thus reducing greenhouse gas emissions. Over 30 state government agencies and more than 120 local governments have joined EPA's Green Lights program, making a commitment to replace old lighting fixtures and bulbs with energy efficient lighting, thus reducing greenhouse gas emissions. Portland, Oregon proposes to reduce carbon dioxide emissions from the Portland metropolitan area to 20 percent below the 1988 level by the year 2010 (PEO, 1993). The Urban CO_2 Reduction Project, which is a joint effort between cities, highlights both the international collaboration needed to combat global climate change as well as the key role local governments can take in implementing solutions.

In addition to those deliberate efforts to address climate change, many other recent state and local actions have helped to reduce greenhouse gas emissions. These include initiatives in energy efficiency, urban planning, transportation planning, forest management, agricultural management, and other areas. For example, the Iowa State Energy Bureau's Building Energy Management Program promotes cost-effective energy management improvements in state buildings, schools, hospitals non-profit organizations, and local government facilities. The program covers measures designed to reduce energy consumption, including replacing lights and ballasts; replacing boilers and controls; improving heating and ventilation controls; and improving insulation of roofs, walls, and pipes. By reducing the demand for electricity, much of which is generated from fossil fuel combustion, these measures reduce emissions of both greenhouse gases and other air pollutants. The program also provides financial savings to a state that imports 98 percent of its energy and creates jobs (Wells, 1991). In Minnesota, more stringent energy standards have been adopted for the new construction of residential dwellings and government offices. Oregon has increased the weatherization standards in the construction of low income homes. New York has recently established a public-private partnership to encourage and support schools in making their facilities more energy efficient (*Energy Smart Schools*), and Colorado has established the *Colorado Green Program*, which assists builders and honors residents who construct homes that conserve natural resources and increase energy efficiency. As in Iowa, these programs reduce greenhouse gas emissions and other air pollutants (by lowering electricity demand), while simultaneously providing financial savings and promoting energy security.

States are also increasing the use of compressed natural gas (CNG) in state and municipal vehicles, primarily school buses and buses used for public transportation. For example, in Mecklenberg County, North Carolina all school buses have been converted to CNG vehicles, and in Maryland, the Department of Transportation has replaced its fleet of diesel fuel shuttle buses at BWI with 20 new CNG vehicles. Also in Maryland, the governor signed an executive order which formally expressed Maryland State Government's commitment to improve air quality and to comply with the clean fuel provisions of the *Clean Air Act Amendments of 1990* (CAAA of 1990) and the Energy Policy Act of 1992 (EPAct). The order established an interagency "Alternative Fuels Work Group" which is to evaluate and recommend alternative fuels for use in state fleets. These types of programs provide economic and environmental benefits beyond climate change mitigation. Similar activities are highlighted throughout this document.

2.2.2 Importance of State Action

On both a total and per capita basis, many states emit carbon dioxide in amounts comparable to some of the highest emitting countries in the world. Although problems such as global warming need to be addressed through cooperative national and international efforts, many of the critical responses can be initiated locally. If the adverse effects of climate change are to be avoided, states will need to take an active and immediate role in addressing greenhouse gas emissions. The section below presents several of the foremost reasons that states may wish to take definitive action to reduce greenhouse gas emissions.

States retain much of the policy jurisdiction over emission sources.

States have the power to alter greenhouse gas emission patterns significantly through their influence and authority over energy use, land use, transportation, taxation, environmental programs, and other relevant policy areas. Although some states have started to deregulate some aspects of the utility sector, many state governments still hold direct regulatory authority over electric and gas utilities, which are responsible for one third of the current carbon dioxide emissions (US EPA, 1995). In addition, state public utility commissions (PUCs) oversee decisions regarding the need for new generating capacity and the choice of fuel mix. Many PUCs are now requiring utilities to include environmental considerations explicitly in their decision making. The federal government does not have jurisdiction over many of these areas.

States can also encourage local governments to revise or establish building codes and land use regulations. Some local governments have implemented stringent energy efficiency requirements for new housing. For example, two California cities, Davis and Berkeley, require compliance with minimum residential energy standards as a condition for the sale of a home (Randolph, 1988). The state's authority to conduct land use planning can also have a dramatic impact on emissions from the residential, commercial, and transportation sectors. For example, several cities have undertaken large-scale tree-planting programs to improve air quality and lower summer temperatures, thereby reducing summer energy needs for air conditioning.

Other opportunities for state and local action to reduce greenhouse gas emissions include management of landfills and regulation of existing stationary sources of air pollution. For example, state and local programs to increase recycling and source reduction of municipal solid waste management promote industrial energy savings from secondary materials manufacturing, reduce landfill methane emissions, and promote forest carbon sequestration(USEPA 1997b)).

The Climate Change Action Plan creates new opportunities for states.

The *Climate Change Action Plan* offers both opportunities and support to state action in a number of sectors. For example, the federal government has made a commitment to promote integrated resource planning (IRP) by utilities, specifically including technical and financial assistance to states. Similar opportunities are being fostered in the transportation, agriculture, and other sectors. The CCAP also commits federal agencies to further link their programs to state and local initiatives.

States have the capacity for enacting "low risk" policies to address climate change.

States can implement many climate change mitigation measures that have immediate, non-climate related benefits. This opportunity enables states to supplement existing policy goals with climate change policies. For example, in addition to reducing greenhouse gas emissions, investments in energy efficiency will lower energy bills of state residents and reduce emissions of local air pollutants. Promoting energy efficiency not only benefits the consumer, but may also provide for a stronger and more efficient economy. By saving energy costs in the production of goods, energy efficiency can improve the competitive position of states in both national and international markets. Energy efficiency provides increased energy and economic security by lessening dependence on foreign oil and other fuel supplies (Schmandt et al., 1992). Reforestation and urban tree programs not only sequester carbon but can also reduce cooling energy requirements and aesthetically improve the urban and rural environment. Movement away from certain fertilizers in agricultural practices may reduce problems of groundwater contamination from their residues.Composting agricultural crop wastes enhances soil fertility while reducing particulate emissions and smoke. All these actions reduce greenhouse gas emissions.

These types of measures often present little economic or political risk to policy-makers. Many policies provide states with economic benefits regardless of any future changes in climate. For example, the EPA's Green Lights Program encourages the use of energy efficient lighting. Energy efficient measures result in lower energy bills and the overall benefits that society gains from such programs often outweigh the total costs incurred. In addition, in most instances these policies carry little political risk because they complement existing programs. For example, policies on greenhouse gas emission reductions in New York are generally framed in the context of state energy planning. New York's State Energy Plan was developed jointly by the State Energy Office, the Department of Environmental Conservation, and the Public Service Commission. Together, these agencies developed energy policies to achieve environmental, energy, and economic policy objectives. Thus, adopting low risk measures can not only result in multiple benefits, but also enhance economic and political feasibility.

Many other "low risk" programs are already in place. For example:

- *The Connecticut Department of Transportation* has pioneered programs to increase the use of car pools, van pools, and public transportation. By assisting commuters to find alternatives to driving alone, these programs reduce traffic congestion, pollution, and greenhouse gas emissions.

- *The Georgia Governor's Office of Energy Resources* is increasing energy and agricultural efficiency by facilitating six programs targeted to crop, poultry, and livestock producers. These programs conserve energy and save money in addition to reducing greenhouse gas emissions.

- *The Missouri Department of Natural Resources* has created a reforestation program designed to reduce heating and cooling needs with strategic landscaping, to arrest soil erosion, enhance natural water filtration, and remove carbon dioxide from the atmosphere. The program coordinator of this multifaceted project, called Operation TREE, must work to involve every division of the Department of Resources and encourage cooperation among other state agencies (Wells, 1991).

- *The Alabama Broiler Litter Program*, co-sponsored by the Science, Technology and Energy Division of the Alabama Department of Economic and Community Affairs and the USDA's Tennessee Valley Resource Conservation and Development Council, addresses energy conservation, reduces the landfill waste stream, promotes recycling, and improves agricultural productivity. In this program newspaper is shredded and blown over the poultry house floor, where it becomes matted and slick from droppings and moisture content. When the litter and paper is gathered from the floor, it is spread on crops as fertilizer, or is mixed with feed and is fed to livestock. The paper also acts as an insulator for the poultry house, thereby reducing energy needs (*Conservation Update*, September 1993).

- *The Minnesota Department of Public Service, Energy Division* has adopted new standards to achieve higher levels of energy efficiency in new construction. These regulations will not only decrease energy demands of consumers, but will also reduce consumers' overall energy bills while simultaneously reducing CO_2 emissions through decreased electricity demand (*Conservation Update*, July 1994).

- *The Governor of Wisconsin* signed a major energy policy directive that mandates state agencies and local governments to implement the following priorities when making energy decisions: (1) energy efficiency; (2) non-combustible renewable energy resources; (3) combustible renewable energy resources; and (4) non-renewable combustible energy resources (natural gas first, then oil, then coal with low sulfur content, and then other carbon-based fuels) (*Conservation Update*, June 1994).

These measures demonstrate how states have already implemented programs that address climate change, and that action in this area does not place policy-makers on entirely new ground. Further, the existence of such programs highlights coalition building as an important part of addressing climate-related problems, since the responsibility for solving many environmental problems is often widely spread among diverse state agencies (this issue is discussed in greater detail in Chapter 7).

States will feel the impacts of climate change and will likely be called upon to address them.

Although climate is a growing concern, climate-related problems will ultimately affect local and state economic sources. Further, recent surveys indicate that public opinion supports a greater environmental consciousness. A growing number of Americans are becoming "green consumers" and "green voters," *i.e.*, they incorporate environmental considerations into their buying habits and political choices (Cale et al., 1992). Thus, state governments may face public and political pressure to respond to climate change.

Because state governments are often more attuned to local public sentiment than are their federal counterparts, the state planning process can incorporate localized public input and priorities. Federal agencies, however, must craft programs that cover larger regions of the country. As a result, state and regional priorities may be overwhelmed by national interests during federal planning. By initiating their own programs, states can make adjustments according to their own needs, allocate resources as they see appropriate, and complement other state policy goals in ways that the federal government may not consider.

As greenhouse gas emissions continue to emerge as an international and national priority, federal policies and programs will also continue to develop. States that have already started to plan accordingly will experience the least social and economic disruption. By delaying the transition to a more energy efficient economy, for example, a state risks having to make rapid and disruptive adjustments in the future. In addition, by acting now, states will influence future decisions at the national level.

Further, states have the opportunity to assume a leadership role in the global climate change arena. The ten states with the highest carbon dioxide emissions each produce more than the Netherlands, which has taken a key role in promoting international agreements to curb climate change. Denmark would rank 31^{st} among the states with respect to CO_2 emissions (Lashof and Washburn, 1990). Even states with relatively small contributions to climate change can demonstrate to the U.S. and to the world that emission levels can be reduced while economic growth is sustained. As summarized in Exhibit 2-3, a number of states are already arguing for the key role that states can play in this critical area.

State agencies do not shoulder this burden alone. As EPA notes, "no single activity is the dominant source of greenhouse gases; therefore, no single measure can stabilize global climate. Many individual components, each having a modest impact on greenhouse emissions, can have a dramatic impact on the rate of climate change when combined" (Smith and Tirpak, 1989). The state role in solving this global problem can be significant. Although national and international effort is essential for an overall solution, states are uniquely positioned to reduce emissions and, in doing so, to encourage the appropriate national and international responses. The United States and other nations have already recognized the threat that climate change poses and the need for action. States, armed with the same understanding, now face the same decision.

2.3 GENERAL FRAMEWORKS FOR CLIMATE CHANGE POLICY ANALYSIS

Policy formulation can be a complex undertaking that involves understanding the issues at hand, envisioning the range of actions that governments can take to address those issues, and selecting from within this range the approaches that offer the most potential for achieving multiple public goals. The policy formulation process must respond to local circumstances and must fit within institutional, fiscal, political, and other constraints. The presence of uncertainties, diverse economic sectors, and long lag times between emissions and affects, as well as the political sensitivity associated with the climate change issue, further complicates actions to reduce greenhouse gas emissions.

To help clarify this complex issue, this document develops an analytic framework that suggests, first, establishing strong and well-founded focal points for program development and then structuring programs around these focal points. This approach recognizes that states face impediments in effectively reducing greenhouse gas emissions. These impediments take three forms: barriers that inhibit actions to reduce greenhouse gases, perverse incentives that actually encourage greenhouse gas production, and time frame issues that complicate the whole process.

This section addresses each of these three factors. First, it presents the types of barriers that may inhibit effective policy implementation. Next, in order to provide a general orientation and organizing principle for various policy options, it reviews the general structure used to present ideasfor policy solutions in Part II of this document. Finally, this discusses timing issues in climate change policy development.

2.3.1 Barriers to Emission Reductions

Designing climate change mitigation strategies is not a straightforward task. A number of barriers to emission reductions confound the policy design process and may inhibit implementing mitigation programs. These barriers may include technological capacity, information flow constraints, price structures and other market related elements, legal or regulatory issues, organizational or institutional considerations, political considerations, and analytic constraints. These barriers, in particular situations, can either inhibit emission reductions or can actually create incentives that lead directly or indirectly to emissions.

Technological Capacity

Greenhouse gases are produced through the fundamental processes that help our economy and our society function, including food production, commerce, and generation of other goods and services on which we depend in our everyday lives. Improving the technologies critical to these necessary and desirable processes could result in lower greenhouse gas emissions as well as decrease the undesirable activities. Frequently, technologies that can achieve specific greenhouse gas reduction goals are available but not widely disseminated, while in other situations technological improvements or new ways of approaching these fundamental tasks in our society have not yet been developed.

Information Flow Constraints

Information barriers can take three forms. First, in the climate change field, incomplete understanding of the atmospheric science as well as to the probable effects of various policy options on greenhouse gas concentrations impedes developing effective policies. Second, those who emit greenhouse gases, including the general public, may not fully appreciate their role and responsibility. Third, the information that would empower members of society to reduce greenhouse gas emissions is frequently not available or understandable to them. This is often the case when technological improvements to various processes have been developed but are not known to the actors who use those processes in the field.

Price Structures and Related Market Elements

Three distinct factors relating to prices and costs of goods and services can contribute to greenhouse gas production and emissions. First, government subsidies and taxes, which are designed to promote goals unrelated to climate change, can conflict with climate change mitigation policies. Second, prices and costs often do not account for the environmental damage being caused by consumption of the

Exhibit 2-3

State Reasons for Climate Change Response

Motivation (as published in state documents)	State (Source)
. . . it's a powerful concept, to think we can adjust the way we live and could have a powerful effect on our global climate. It's a challenge we should take seriously and should accept.	Louisiana (Hodges-Copple, 1990)
Americans, Iowans included, have become both more informed and more concerned about the environment in the last two years to three years. Public consciousness has absorbed the positive message of Earth Day as well as the horror of environmental disasters.	Iowa (Cale et al., 1992)
Vermont has a strong incentive to lead the way in developing energy policies which properly account for environmental risks. . . . Two problems stand out as demanding special attention: global warming, which threatens all of the planet's people and ecosystems and to which Americans make a disproportionate contribution; and acid deposition, which poses a particular threat to Vermont's environment and way of life.	Vermont (Vermont Dept. of Public Service, 1991)
. . . the limited nature of federal leadership means that California's efforts to reduce greenhouse gas emissions will influence, rather than be directed by, federal leadership. . . . In any event, while unilateral California action to reduce emissions will not solve the problem, California leadership could help facilitate greater cooperation between the States, the federal government, other countries to begin reducing greenhouse gas emissions.	California (California Energy Commission, 1991)
Everyone is familiar with the need to pay insurance today for risks that may occur in the future. Actions to slow global warming are the insurance paid to accommodate the risks from global warming. The insurance proposed in this report would also pay a dividend in a more efficient and resilient economy, cleaner air, and less dependence on foreign oil supplies. Responding to global warming is another reason to manage resources wisely. While this is a global problem, everyone must be part of the solution.	Oregon (Oregon Task Force on Global Warming, 1990)
. . . good environmental stewardship and energy efficiency will make Missouri stronger economically, improve our flexibility in the face of uncertain international markets, and fulfill our environmental responsibilities. These benefits prevail regardless of whether Missouri experiences substantial or subtle climate change. If we fail to be accountable for our role in climate change and ozone depletion, we will pay with diminished quality of life for ourselves and our children. Missouri, as a responsible global citizen, has an important opportunity to create environmental and economic benefits from this challenge.	Missouri (Missouri Commission on Global Climate Change & Ozone Depletion, 1991)
The legislature recognizes that waste carbon dioxide emissions, primarily from transportation and industrial sources, may be a primary component of the global greenhouse gas effect that warms the earth's atmosphere and may result in damage to the agricultural, forest, and wildlife resources of the state.	Minnesota (Minnesota Statutes 116.86)
. . . although Washington's contribution to the greenhouse effect is small, the state can demonstrate to U.S. and world policy-makers that CO_2 emissions can be reduced while sustaining economic growth.	Washington (Lesser et al., 1989)
Because Texas has a lot at stake in preserving and protecting its water and coastal resources, it is incumbent upon state officials to start to develop the most cost-effective strategies now. ... Texas does have a role in solving this problem. Indeed, with so much of the structure in place to correct this problem to which we so heavily contribute, it can be asserted that we have an obligation. The next question is: Do we have the political will?	Texas (Schmandt et al., 1992)

goods or services in question; thus, greenhouse gas emissions are an "externality" not reflected in prices. Third, "transaction costs" for obtaining information about, or converting to, more environmentally friendly processes are often high.

Legal or Regulatory Issues

Legal issues affect greenhouse gas emissions in several ways. First, many of the informational and market distortions presented above originate in previous regulatory or other legal action. In these cases, the law itself inhibits reduction of greenhouse gases or even encourages their production. Sometimes this may be to society's benefit because of higher priorities, while in other cases the law inappropriately or inefficiently pursues its objectives, some of which may be outdated. An example of this type of barrier occurs in the regulations that require flaring of methane at landfills, which may exclude its recovery and sale as a fuel source. Second, the absence of regulations or legislation may itself serve as a barrier, as when the absence of certain consumer protection measures inhibits new environmentally friendly technology or product acceptance. Third, ill-defined or vague property rights governing commercially valuable greenhouse gases, such as methane produced from coal mines, can inhibit recovery efforts and thus increase emissions.

Organizational and Institutional Considerations

Institutional factors also may constrain implementing emission reduction policies. Public agencies responsible for developing, analyzing, implementing, and enforcing policies must maintain the skills, resources, and motivation necessary to do this job; without sufficient institutional support, many programs cannot be implemented. In addition, designing emission reduction programs and formulating policy may require distinct institutional mechanisms for coordinating action between public agencies and with many diverse private sector actors. If these channels do not exist, programs can be difficult to develop and administer.

Political Considerations

Greenhouse gas emission reduction policies can affect many actors across all sectors of society. Competing and conflicting interests across these individuals, groups, and organizations can generate significant political tension. In this context, politics may become either an impediment or an asset to climate change policy formulation. Political viability in the climate change arena, thus, depends on the coordination of affected interests, popular or legislative familiarity with the policy instruments being pursued, the perceived fairness of policy ideas, and consistency with other major political agendas.

Analytic Constraints

Several analytic factors may inhibit climate change policy formulation. These revolve around the difficulty and costs of acting when the magnitude and timing of policy impacts are highly uncertain. Chapter 8 discusses many of the issues that create such uncertainty, such as intertemporal comparisons of costs and benefits and issues of interaction between different emission reduction policies.

2.3.2 Structure of Policy Approaches

Because climate change responses must address the wide variety of barriers and constraints presented above, arranging a similarly varied portfolio of policy approaches can enhance program effectiveness. The specific options available for greenhouse gas reduction programs, which are detailed in Chapters 5 and 6, are grouped into four categories:

- Providing information and education;
- Restructuring legal and institutional barriers;
- Providing (and correcting distorted) financial incentives; and
- Implementing direct regulations.

Each of these policy approaches is elaborated on below.

Providing Information and Education

Information provision generally takes three forms: identifying informational needs, generating new information, and disseminating information. Such efforts are usually intended to change the behavior of some target audience (*e.g.*, consumers, corporations, managers, or school children) in order to reduce emissions. Doing so generally requires that policy-makers understand the target audience's current level of knowledge as well as the links between that knowledge and how the audience behaves. For example, energy consumers may not know the most effective ways to save energy, the time and costs involved, or even the linkage to greenhouse gas emissions. By identifying what consumers do generally understand, policy-makers can take action to fill gaps in understanding and knowledge, with the intent to change consumer behavior.

Information dissemination programs may include public advertising or educational campaigns, the provision of information through technical reports, publicity around voluntary standards, public service announcements, media coverage of government activities, support for research and development, technology or process demonstration projects, and direct technical assistance.

Restructuring Legal and Institutional Barriers

Certain legal and institutional barriers not only constrain but prevent effective implementation of greenhouse gas reduction measures. These can include: laws with alternative purposes, such as economic stimulation or public safety, that inadvertently and unnecessarily inhibit greenhouse gas reductions; existing and long-standing operating procedures in public and private organizations that interfere with how policies are implemented; and a lack of institutional or regulatory support capacity for greenhouse gas reduction policy action.

Policy approaches to addressing these barriers frequently include changing existing laws, formulating new laws, and developing new institutional procedures for administering these activities. For example, resolving legal issues concerning the ownership of coalbed methane resources would establish incentives for investment in methane recovery projects (U.S. EPA, 1993b). Similarly, revising outdated laws governing fat content ratings for milk and beef production to reflect modern consumer preferences could result in methane reductions in the livestock sector, by requiring less food intake and digestion per animal for the same quantity of usable food output.

Providing Financial Incentives

Financial incentives involve stimulating private and public sector transactions in order to induce actions that reduce greenhouse gas emissions. This can include changing how current transactions take place, like subsidizing or taxing certain fuel prices to induce choice of cleaner home-heating or transportation fuels, or it can involve fostering new actions all together, like subsidizing or rewarding research on technology development.

Three main categories of action can provide financial incentives to promote public sector goals: 1) direct government expenditures; 2) taxes, fees, loans, or subsidies that alter the consumption of a good or service by changing its price relative to other items consumers might freely choose; and 3) market structures established by governments that stimulate transactions without further direct government action.

Financial incentives are often chosen as a least-cost mechanism for inducing a certain level of production or consumption.[9] For example, by allocating tradeable pollution permits, the federal government is attempting to achieve a pre-determined level of emissions through market interactions, avoiding the rigidity of direct regulation and achieving emission reduction goals at the least cost to society. Similarly, the gasoline tax serves to decrease carbon emissions by reducing gasoline consumption. The four predominant systems through which governments provide financial incentives are tradable emission rights, emission charges, deposit-refund systems, and basic consumption taxes.

Implementing Direct Regulations

Governments can also promulgate direct regulations to address the barriers to greenhouse gas reductions. This may include any legislation or rule that directly limits the action of private and public sector actors. In the climate change field, regulations may force private firms to incorporate social costs of global warming into their decision making process, although financial incentives or other approaches may be more economically efficient and possibly more effective. Direct regulations generally can take two forms: performance standards and technology controls. Performance standards set a limit on a firm's emissions (*e.g.*, 20 lbs./day of a specific pollutant) and allow a firm to choose how to meet the standards. Technology controls, in contrast, define specific design and operating requirements, often specifying required emission control technologies by name.

2.3.3 Timing Issues in Policy Development

A final consideration when developing options for addressing climate change is the issue of timing. Because of the dynamic and complex nature of climate change processes, policies for addressing immediately controllable emissions in the short-term might be entirely distinct from long- term policies necessary for tackling other types or levels of emissions. Given that scientific understanding and the state of technology are evolving rapidly in this field, policy approaches should maintain flexibility. Flexibility is also necessary to respond to changing economic and political circumstances.

The general policy context surrounding climate change roughly spans three time frames -- the immediate- to near-term, the mid-term, and the long-term future. These are relative time frames that help provide focus for programs and that should not constrain programs in any way. Near-term policy responses can usually be initiated quickly, within one to four years, with direct emission reduction or other important benefits. Ideally, they should be incorporated into larger, comprehensive programs. For

[9] See Chapter 8 for more information on least-cost planning.

example, a technical assistance program to help farmers improve fertilizer application placement, timing, and rate will help reduce N_2O emissions immediately and may be the first step in a mid- to long-term program to reduce emissions from the agricultural sector.

Mid-term policies, typically set within five to twenty year periods, frequently depend on issues such as the development and introduction of new technologies and institutional capacity for administering new programs, and are often constrained by the time frames used in economic and energy forecasts. A ten to twenty year span frequently represents the longest periods with which analysts and policy-makers can anticipate the outcomes of their actions. For example, states may not be able to implement programs to support large scale methane recovery and use immediately because of lack of institutional support, but this constraint may be overcome within a few years of program implementation. These policies should be flexible to react to changes in the scientific, technical, economic, and political arenas.

Finally, long-term policies may take several decades to enact. Modifying land use and transportation systems in major cities, for example, can take twenty to fifty years. It is expected that dramatic changes in technology and lifestyles will occur and will have a substantial effect on the climate change problem within this time frame. Thus, research and development and public education are critical components of long-term policy planning.

The policy implications of these three relative time frames are defined in greater detail in Chapter 7. It is important to note at the outset, however, that specific policies may address only one time frame or they can be integrated across time frames. Current policies, for example, can be designed to maximize emission reductions now using available technologies and set the stage simultaneously for future reductions through research and development, education, institutional strengthening, or other actions. Comprehensive state programs should integrate all three time frames in order to maximize the benefits from climate change response strategies. More specifically, effective policy design should ensure that emission reduction goals set in the near-term allow for scientific, technological, economic, and political changes in the mid-term and set the groundwork and the context for addressing long-range objectives.

Each chapter in this document addresses time frame issues. Chapter 3 considers time frames in the context of measuring and forecasting greenhouse gas emissions. Chapter 4 discusses the process of setting and adhering to short-, mid-, and long-term emission reduction targets and goals. Chapters 5 and 6 describe approaches for greenhouse gas emission reductions within the context of what is currently feasible and what scientists and others anticipate being feasible in the future. Chapter 7 discusses how time frames can be used strategically to build political and institutional support in the present and for the future, and provides examples and potential models of policy formulation across time frames. Chapter 8 explains how time frame issues can be incorporated in the policy evaluation process.

Exhibit 2-4 presents a model of public planning that illustrates many of the points made in this chapter. It describes the Air Quality Management Plan for the South Coast Air Basin, an effort organized by multiple agencies that provides a wide variety of social benefits. This plan establishes long-term program goals and then employs different policy approaches set within three distinct time frames, highlighting land use changes that fall under state and local jurisdictions. The policies described here include information and education projects, institutional restructuring and strengthening, and implementation of financial incentives and direct regulations.

Exhibit 2-4: The South Coast Air Quality Management Plan

In July 1991, the South Coast Air Quality Management District and the Southern California Association of Governments adopted a revised, comprehensive Air Quality Management Plan (AQMP or Plan) designed to achieve national and state ambient air quality standards. The 1991 AQMP continues the aggressive emission control program established by previous plans, but also addresses requirements of the California Clean Air Act (CCAA). In addition, the AQMP has been expanded to address global climate change, stratospheric ozone depletion, and air toxics. The 1991 AQMP sets forth programs which require the cooperation of all levels of government: local, regional, state, and federal. The AQMP can serve as a substantive and organizational model for state and local governments in their emission reduction efforts. The Plan is organized into three tiers, each distinguished by its readiness for implementation:

Tier I

Tier I calls for full implementation of known technological applications and effective management practices within the next five years. This phase of the AQMP is action-oriented. It identifies specific control measures for which control technology currently exists.

Tier II

Unlike Tier I, the second phase of the AQMP will require significant advances in current applications of existing technology and strong regulatory action for successful implementation within the next ten to fifteen years. The proposed Tier II control strategy is composed mostly of extensions or more stringent applications of Tier I control measures.

Tier III

The final tier of the AQMP depends on the development, adoption, and implementation of new technologies within the next twenty years. Achievement of Tier III goals depends on substantial technological advancement and breakthroughs that are expected to occur throughout the next two decades. This requires an aggressive expansion of Tier II research and development efforts.

Since the adoption of the 1991 AQMP, the District has been studying the feasibility of implementing a market-based regulatory program for the Basin. Recommendations and findings from this study were presented as the Regional Clean Air Incentives Market (RECLAIM). An amendment to the 1991 AQMP incorporates the concepts of RECLAIM into the existing Marketable Permits Program control measure originally proposed in 1991. RECLAIM calls for declining mass emission limits on the total emissions from all sources within a facility and requires facilities to meet prescribed annual emission reduction targets. Facilities under RECLAIM will be given a facility-wide permit that will detail all emission sources in their facility. Allowing sources to "bubble" facility emissions to meet annual reduction targets increases compliance flexibility at each facility.

CHAPTER 3
MEASURING AND FORECASTING GREENHOUSE GAS EMISSIONS

A state inventory of greenhouse gas (GHG) emissions and sinks is a useful tool both for establishing a baseline level of GHG emissions, and for identifying options for GHG reductions. In addition to preparing an inventory of current GHG emissions, a state may wish to forecast *future* levels of GHG emissions in the absence of state policies to reduce emissions. Such a forecast could serve as a benchmark against which future emission reductions could be measured. The purpose of this chapter is to discuss the usefulness of calculating current and future greenhouse gas emissions, and the methods for doing so.

3.1 MEASURING CURRENT EMISSIONS

The first step in a state's effort to address climate change is to identify all source categories in the state that emit greenhouse gases, and determine their current emission levels. By developing an inventory of greenhouse gas emissions, states can identify those source categories that contribute the most to global warming. The inventory can also be useful for identifying options for greenhouse gas mitigation policies. To assist states in developing GHG inventories, EPA's State and Local Climate Change Program developed a workbook that describes how to prepare greenhouse gas emissions inventories. The *State Workbook: Methodologies for Estimating Greenhouse Gas Emissions* offers relatively simple approaches to preparing an emissions inventory, as well as more sophisticated approaches that generally require more detailed data and a greater level of effort. Several states have used the *State Workbook* to develop a state-level GHG emissions inventory as the first step in developing policies and strategies to reduce greenhouse gas emissions.[1] Exhibit 3-1 presents the emissions sources included in the *State Workbook,* along with a list of the independent variables that are used in the emissions calculations.[2]

3.2 PROJECTING FUTURE EMISSIONS AND EMISSION REDUCTIONS

This section discusses (1) the concept of baseline (or reference case) GHG emissions, (2) methods for forecasting reference case emissions and policy-induced emission reductions, and (3) the potential for "leakage" of GHG emissions (i.e., GHG emissions increases in one sector that result from GHG reductions in another sector).

A state may project the level of GHG emission reductions it will achieve through state-level policies in one of two ways: (1) relative to a static baseline (i.e., the level of GHG emissions estimated in the state's GHG inventory) or (2) relative to a forecasted level of emissions.

Projecting emission reductions relative to a static baseline has the advantage of simplicity -- once the state GHG inventory is developed, no further work is needed to estimate the static baseline. However, to the extent GHG emissions are likely to grow in the absence of state policy, use of a static baseline will understate future emission levels. Moreover, if static data are used to estimate GHG *reductions* due to state policy, the GHG reductions may be understated as well. For example, if a state plans to implement a carpooling program

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[1] See Chapter 1 for more information on the *State Workbook*.

[2] The results of equations used in the *State Workbook* to calculate emissions from each greenhouse gas source are determined by the values assigned to a set of independent variables. These variables reflect the measurable quantities or intensities of various factors that produce greenhouse gases, such as fossil fuel consumption, area of city landfills, or the amount of fertilizer used in a year.

Exhibit 3-1
Independent Variables Used in Emission Calculations in the *State Workbook*:
Data Required to Estimate Current Greenhouse Gas Emissions

Source Category*	Required Data
Greenhouse Gases from the Residential Sector	State Residential Energy Consumption for the following fuel types: · Gasoline · LPG · Distillate Fuel Oils · Naphtha · Kerosene · Other Solid Fuels · Petroleum Coke · Asphalt & Road Oils · Distillate Fuel · Other Liquid Fuels · Natural Gas · Residual Oil · Coal (by type)
Greenhouse Gases from the Commercial Sector	State Commercial Energy Consumption for the following fuel types: · Gasoline · LPG · Distillate Fuel Oils · Naphtha · Kerosene · Other Solid Fuels · Petroleum Coke · Asphalt & Road Oils · Distillate Fuel · Other Liquid Fuels · Natural Gas · Residual Oil · Coal (by type)
Greenhouse Gases from the Industrial Sector	State Industrial Energy Consumption for the following fuel types (list may not be inclusive): · Gasoline · Other Liquid Fuels · Other Solid Fuels · Distillate Fuel · Bituminous Coal · Natural Gas · Residual Oil · Sub-Bituminous Coal · LPG · Lignite
Greenhouse Gases from the Electric Utility Sector	State Energy Consumption from the Electric Utility Sector for the following fuel types: · Gasoline · Other Liquid Fuels · Other Solid Fuels · Distillate Fuel · Bituminous Coal · Natural Gas · Residual Oil · Sub-Bituminous Coal · Anthracite · LPG · Lignite
Greenhouse Gases from the Transportation Sector	State Transportation Energy Consumption for the following fuel types: · Gasoline (by type) · LPG · Other Solid Fuels · Jet Fuel (by type) · Distillate Fuel · Other Liquid Fuels · Natural Gas · Residual Oil · Bituminous Coal
Greenhouse Gases from Production Processes (e.g., CO_2 from Cement Production)	· Annual Cement Production · Annual Soda Ash Production · Annual Lime Use · Annual Adipic Acid Production · Annual Soda Ash Consumption · Annual Aluminum Production · Annual Nitric Acid Production · Annual Lime Production · Annual HCFC-22 Production · Annual CO_2 Manufacture
Methane from Oil & Natural Gas Systems	· Amount of Oil Produced · Amount of Oil Transported · Amount of Gas Produced · Amount of Oil Refined · Amount of Oil Stored · Amount of Gas Processed · Amount of Gas Distributed
Methane from Coal Mining	· Annual Coal Production from Surface Mines · Annual Coal Production from Underground Mines · Amount of CH_4 Recovered

Exhibit 3-1 (Continued)
Independent Variables Used in Emission Calculations in the *State Workbook*:
Data Required to Estimate Current Greenhouse Gas Emissions

Source Category*	Required Data
Methane from Landfills	· Amount of Waste in Place · Fraction of Waste in Place at Small vs. Large Landfills · Average Annual Rainfall · Amount of Landfill Gas that is Flared · Amount of Landfill Gas that is Recovered as an Energy Source
Methane from Domesticated Animals	Populations of: · Dairy Cattle · Horses · Sheep · Buffalo · Beef Cattle · Mules · Goat · Range Cattle · Asses · Swine
Methane from Animal Manure	Populations of: Feedlot Beef Cattle: · Steers · Heifers · Cows/Other Other Beef Cattle: · Calves · Heifers · Steers · Cows · Bulls Dairy Cattle: · Heifers · Cows Swine: · Market · Breeding Poultry: · Layers · Broilers · Ducks · Turkeys Other: · Sheep · Goats · Donkeys · Horses/Mules · Percentage of Animal Manure Handled in Each Manure Management System
Methane from Rice Fields	· Total Area Harvested (Not including Upland or Deepwater Rice Fields) · Length of Growing Season
Nitrous Oxide from Fertilizer Use	· Annual Fertilizer Consumption
Forest Sector Carbon Sequestration	· Forested Area · Species Composition · Forest Ages
Greenhouse Gases from Burning of Agricultural Wastes	· Annual Production of Crops with Residues that are Commonly Burned, *e.g.*: Wheat, Barley, Corn, Oats, Lentils Rye, Rice, Millet, Sorghum, Sugarcane Pea, Beans, Soybeans, Potatoes FeedbeetSugarbeet, Artichoke, Peanut
Methane Emissions from Wastewater Treatment	· State Population Data · Pounds of Biochemical Oxygen Demand (BOD) Per Capita · Percentage Wastewater Treated Anaerobically · Amount of CH_4 Recovered

* Note: The source categories presented in this table do not make an exact match with the categories addressed in Chapter 5. The source categories in Chapter 5 are based on the categories listed above, but have been modified somewhat to facilitate presentation of available policy options.

Exhibit 3-1 (Continued)
Independent Variables Used in Emission Calculations in the *State Workbook*:
Data Required to Estimate Current Greenhouse Gas Emissions

that will reach a certain percentage of all commuters, and assumes the same number of commuters in 2010 as in 1990, the GHG reductions due to the program are likely to be underestimated.

An alternative approach is to project emission reductions relative to a forecasted reference case which accounts for projected changes in the state's population, economic activity, and other factors. This approach has the advantage of greater realism and thus greater accuracy. Another advantage is that if a state plans to achieve GHG emission levels equal to some percentage of baseline (e.g., 1990) levels, use of a forecasted reference case would allow the state to project whether its policies will achieve the target level of emissions. For example, suppose a state had 1990 GHG emissions of 20 million metric tons of carbon equivalent (MTCE), and forecasted a 2010 reference case of 23 million MTCE in the absence of state policy to reduce GHGs. If the state wanted to reach a goal of achieving 2010 GHG emissions equal to 1990 levels, the state would need to reduce GHGs by 3 million MTCE per year by 2010, relative to the forecasted reference case.

A hybrid approach would be to forecast future emissions only for those sectors in which the state plans to implement GHG reduction policies. This hybrid approach would enable the state to project with relative accuracy the GHG reductions its policies would achieve, in relation to future emission levels in the absence of policy. However, forecasting emissions for only some sectors would not enable the state to estimate total statewide GHG emissions in the absence of policy; thus the state would not know the total GHG reductions needed to achieve some target level of GHG emissions.

One relatively simple method for forecasting future emissions in the absence of GHG reduction policies is to extrapolate the *State Workbook* inventory methodologies using forecasted data (e.g., forecasts of population and economic activity). Under this approach, a state would predict changes in the independent variables (and perhaps some changes in the coefficients in the emission equations), and then recalculate emissions from each affected source category using the *State Workbook* methodologies. Exhibit 3-2 illustrates how changes in the independent variables can be used to forecast (1) emissions in the absence of policy, and (2) emission reductions relative to a forecasted reference case.

Alternatively, an analyst might need to change the coefficients in the emissions equations, or the structure of the equations themselves, in cases where policy alternatives are expected to alter the level of greenhouse gases emitted per unit of activity. For example, technology improvements may increase the amount of electricity produced per unit of fuel consumed, or may reduce the amount of methane that escapes into the atmosphere per ton of municipal solid waste placed in landfills. Exhibit 3-3 illustrates how changes in coefficients can alter emission forecasts.

Note that uncertainty is a significant concern when forecasting greenhouse gas emissions. To prepare reliable forecasts, states should extend emission forecasts only into the near future. Given the degree of uncertainty already associated with existing methodologies and available data, carrying projections beyond this point can undermine the usefulness of forecasts. The maximum time frame for projecting emissions in most situations is likely to be 15 to 20 years -- the typical time frame for energy use projections. Beyond that, uncertainties in technological changes alone will likely call into question the accuracy of forecasts.

Exhibit 3-2: Forecasting Sectoral GHG Emissions Before and After a GHG Reduction Policy

Suppose a state had 1990 gasoline consumption of 200 trillion Btu (such data are reported in U.S. DOE, 1993). Using the *State Workbook* methodology, 1990 CO_2 emissions from gasoline consumption would be calculated as follows:

CO_2 Emissions =Consumption x Carbon Content Coefficient x Percent Oxidized x 44/12

CO_2 Emissions =200,000,000 million Btu x 41.8 lbs C/million Btu x 99% x 44/12

CO_2 Emissions =15.2 million tons CO_2

Suppose the state forecasted that, in the absence of policy, CO_2 emissions from gasoline consumption would be 10 percent higher in 2005 than in 1990 (based on a projected increase in the driving age population, an increase in the vehicle miles traveled per driver, and some assumption about average mileage per gallon for all cars in the state). Then, forecasted 2005 CO_2 emissions from gasoline consumption in the absence of policy would be 10 percent higher than in 1990, or 16.7 million tons of CO_2.

Finally, suppose that the state planned a carpooling program that was expected to reduce annual vehicle miles traveled by two percent by 2005. The CO_2 reductions and net CO_2 emissions would be calculated as follows:

CO_2 Reductions in 2005 = 2% x 16.7 million tons CO_2 = 330,000 tons CO_2.
Net CO_2 Emissions in 2005 = 16.7 million tons CO_2 - 330,000 tons CO_2 = 16.4 million tons CO_2.

Forecasting can be complex because there are many factors that can affect future emissions, including population growth, economic growth, technological improvements, and degree of urbanization. Possible means of accounting for these external factors include the following: [3]

- *Expert judgment* relies on the insights of experts to forecast future values of key variables. This approach can be effective in considering difficult-to-quantify factors, as well as important interrelationships that may be accounted for by quantitative forecasting methods.

- *Content analysis* is a technique sometimes used to forecast broad social and technology trends. This technique involves reviewing and analyzing the content of the information carried through various media with respect to emerging social trends.

- *Trending methods* are simple linear or logarithmic projections of historical trends, and are rarely used as stand-alone forecasting methods. A more sophisticated variant of trending uses statistical time-series techniques to extract more precise information about trends from historical data. Trend and time-series analyses may be most applicable to short-term forecasts where the influence of structural factors is not expected to be great.

[3] The following bullets were taken from "Methods for Assessment of Mitigation Options" written for the *IPCC Second Assessment Report* by IPCC Working Group II.

Exhibit 3-3: Example of a Policy that Affects Methodological Assumptions

Suppose a state had 700,000 head of beef cattle in 1990. (Such data are reported in USDA, 1990). Using the *State Workbook* methodology, methane emissions from this source would be calculated as follows:

CH_4 Emissions = Animal Population x Emission Factor

CH_4 Emissions = 700,000 head x 152 lbs. CH_4/head/year

CH_4 Emissions = 53.2 thousand tons CH_4

One strategy for reducing methane emissions from domesticated animals is to change their diet. For example, certain feed additives can increase feed efficiency by approximately 10 percent. This change will have a direct effect on the emissions factor above, regardless of any changes in animal population. The magnitude of this change can be calculated using equations provided in the discussion section of the *State Workbook*. Suppose a state implements a policy to increase feed efficiency, and this policy decreases the emissions factor by three percent, to 147 lbs. CH_4/head/year. The methane emissions may be forecasted by using the new emissions factor in the *State Workbook* methodology (the following example assumes no change in the number of beef cattle):

CH_4 Emissions = Animal Population x Emission Factor

CH_4 Emissions = 700,000 head x 147 lbs. CH_4/head/year

CH_4 Emissions = 51.6 thousand tons CH_4

Policy Impact = 53.2 thousand tons CH_4 - 51.6 thousand tons CH_4

= 1,200 tons CH_4

- *Economic forecasting* methods use multiple regression techniques to relate behavior to a series of explanatory independent variables. The specific quantitative form of an economic model is estimated using historical, and in some cases, cross-sectoral data pertaining to the model's independent variables. Forecasts of economic activity, the demand for transportation or forestry products, and emissions can be understood in terms of underlying economic behavior, and therefore, have wide application in the assessment of alternative mitigation strategies.

- *End-use forecasting* models primarily provide a finer level of detail to forecast emissions from the energy sector by representing energy demand within sectors. These methods forecast demand as a function of the efficiency characteristics of specific types of end-use equipment, the utilization of the equipment, and the number of pieces of the equipment in use. Total demand for a given fuel is estimated by aggregating over end-uses, at which point carbon content coefficients and emission factors for other gases can be applied to determine the future emissions potential of various options.

Finally, when accounting for emission reductions, forecasts should also take into account the possibility of “leakage” of GHG emissions -- that is, the possibility that as a state policy reduces emissions in one sector, emissions may, as a direct result, increase in another sector. For example, if a state program promotes use of biomass ethanol as a fuel, with no controls on the energy required to produce the ethanol, the GHG emission reductions from displacing gasoline with ethanol might be offset by increased GHG emissions from fossil fuels used in growing the biomass and producing the ethanol. Many other examples of potential “leakage” could be identified; the challenge for state GHG planners is to identify areas where potential leakage may be significant, and to adjust their estimates of GHG reductions accordingly.

CHAPTER 4
ESTABLISHING EMISSIONS REDUCTION PROGRAM GOALS AND EVALUATIVE CRITERIA

An appropriate mitigation strategy must combine individual projects and programs into a coordinated approach that meets both mitigation objectives and the broader set of state economic, industrial, agricultural, environmental, and other goals. The first step, thus, in a mitigation assessment is to define the set of objectives a mitigation program and/or strategy should meet and to develop criteria for evaluating the success or failure of alternative mitigation strategies. This chapter examines the process of setting broad program goals and specific policy evaluation criteria and highlights the complexities that surround these issues (see Exhibit 4-1 for definitions of the terms goals and criteria). States can choose to set priorities and develop strategies in different ways. For example, goals could be oriented around specific time frames rather than infinite time horizons, focused on quantitative targets rather than qualitative objectives, or based on technical or scientific recommendations rather than on perceived emission reduction capabilities. Exhibit 4-2 presents the key questions states may wish to pose when defining and prioritizing emission mitigation goals. After defining program goals and establishing evaluation criteria, analysts can then assess the feasibility and viability of implementing alternative greenhouse gas mitigation options, such as those presented in Chapters 5 and 6, in light of other state policy objectives. The material presented in this chapter also provides the basis for the discussion in Chapter 8 on analyzing state mitigation strategies.

Exhibit 4-1: Goals and Criteria

Goals: Program goals explicitly state the broad aims that every climate change action should support. By doing so, they provide a consistent focal point for use across diverse situations and between state agencies and across sectors.

Criteria: Criteria are the standards that policy makers can use to assess alternative policy options. Criteria are fundamentally rooted in two types of state policy goals: (1) those that support the climate change mitigation program; and (2) those that ensure that climate change mitigation policies do not impede or negate other state policy priorities or objectives. In contrast to program goals, criteria are more specifically defined and are frequently more directly measurable.

Exhibit 4-2: Key Questions Related to Goal Setting

- Should an emission reduction goal be relative measured against a prior, current, or future reference year?
- How do mitigation objectives relate to existing energy, agricultural, and development policies?
- What type of processes can be used to reach a decision on specific mitigation objectives?
- How can objectives be prioritized?

4.1 EXAMPLES OF GREENHOUSE GAS REDUCTION GOALS

For guidance in setting explicit goals, states can draw on the experience of and research conducted by multilateral organizations, such as the IPCC, and other country, state, and local governments. For example, emissions reduction targets established by the Framework Convention on Climate Change (as discussed in Chapter 2) encourage nations to reduce missions of greenhouse gases to 1990 levels by the year 2000.[1] Several individual countries and some U.S. states and cities have also established their own near- and long-term greenhouse gas reduction goals. Exhibit 4-3 provides examples of these explicit local, state, national, and international program objectives.

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[1] This target is for Annex 1 countries only (*i.e.*, developed countries).

Exhibit 4-3: Examples of Climate Change Program Goals

Local Goals

Portland, Oregon, set a target to reduce carbon dioxide emissions from that metropolitan area to a level 20 percent below 1988 levels by the year 2010. This means a reduction of 42 percent from the 2010 level of emissions currently projected.

State Goals

The Wisconsin State Action Plan established a goal to stabilize GHG emissions to 1990 levels by 2010, in large part by cutting CO_2 emissions by 37 million short tons. The Action Plan identifies cost-saving options for reducing CO_2 emissions by 26.2 million short tons, and options for further CO_2 reductions of 36.9 million short tons for under $15 per ton.

Washington set a goal of emissions stabilization by 2010, to be achieved by cutting 18 million short tons of CO_2. Toward this end, the Washington State Action Plan outlines options that could reduce CO_2 emissions by 19 million short tons for less than $5 per ton, or by 44.3 million short tons for about $100 per ton.

The Illinois State Action Plan would stabilize GHG emissions by 2000, through a cut of 10 million short tons of CO_2. Thirty-seven percent of this goal (3.74 million short tons) can be achieved at no cost. The Action Plan describes options which could reduce CO_2 emissions by 28.9 million short tons for about $60 per ton, or by 92 million short tons for about $110 per ton.

Oregon's Action Plan predicts that the state's strategy will reduce GHG emissions by at least 2 million tons (presumably, 2 million short tons of carbon dioxide equivalent) in 2015, compared to a "business as usual" scenario.

National Goals

In the October, 1993, Climate Change Action Plan, the United States set a target of returning U.S. greenhouse gas emissions to 1990 levels by the year 2000 with cost-effective domestic actions. This includes measures in all sectors of the economy targeted at all significant greenhouse gases.

Sweden passed legislation in 1986 to stabilize its carbon dioxide emissions at 1988 levels.

The German cabinet has established a goal of twenty-five percent carbon dioxide emission reductions from 1986 levels by 2005.

International Goals

The objective of the U.N. Framework Convention on Climate Change (UNFCCC), established at the 1992 U.N. Conference on Environment and Development (UNCED) and ratified in March of 1994, is to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system and to do so within a time-frame sufficient to allow ecosystems to adapt naturally to climate change. Signatories to the UNFCCC are currently negotiating binding national climate change goals which may be adopted as early as December 1997 in Kyoto, Japan.

The twelve nation European Union (EU) has agreed, in principle, to stabilize carbon dioxide emissions at 1990 levels. The EU has proposed that developed countries reduce GHG emissions to 7.5 percent below 1990 levels by 2005, and 15 percent below 1990 levels by 2010.

In addition, some national and state level governments have chosen to concentrate on those policy options that promise to reduce greenhouse gas emissions while providing additional non-greenhouse gas-related benefits. For example, measures to increase energy-efficiency in appliances and other technologies not only reduce greenhouse gas emissions, but also increase energy independence and economic competitiveness, and lower emissions of criteria air pollutants. Policy options of this type are referred to as "no-regrets" measures, *i.e*., policies that provide benefits other than those directly related to climate change, such as increased energy security or the creation of jobs. Options that can provide significant additional benefits often encounter less resistance politically and garner more public support than mitigation policies that focus solely on the reduction of greenhouse gas emissions.

Exhibit 4-4: Goal Setting in Oregon

Oregon has been a pioneer in responding to global climate change. The Oregon legislature passed a law requiring the Oregon Department of Energy (ODOE) and other agencies to develop a strategy to reduce greenhouse gas emissions by 20 percent from 1988 levels by the year 2005. ODOE fulfilled this mandate by incorporating a greenhouse gas reduction strategy into its 1991 biennial energy plan, although the strategy did not become a formal state goal. Still, the presence of this strategy in the energy plan helps the state project how it will meet its future energy needs and offers specific policies and actions. In this context, the energy plan calls explicitly for the development of a state action plan to deal with climate change, with a target of stabilizing emissions at 1990 levels. This target was set as a state benchmark through recommendation of a "Progress Board" headed by the Governor. Furthermore, within the context of the energy plan, Oregon's qualitative goal is to achieve reliable, least-cost, and environmentally safe sources of energy. Oregon is able to monitor and update its progress towards achieving these quantitative and qualitative goals through the preparation of energy plans every two years.

4.2 COMPLEXITIES IN EMISSIONS REDUCTION GOAL SETTING

This section addresses the factors that make goal setting an analytically difficult task, such as contending with technological, economic, and political constraints. As a result of these factors, goal setting often becomes an iterative process of gathering technical and economic data, analyzing these data and potential response options in the context of resource constraints, projecting future emissions, and then repeating this process until a realistic program can be developed that meets state objectives. Some state governments have conducted this type of iterative analysis before setting any program goals, in order to determine the most realistic approach. Other analysts, however, have based their goals from the outset on pursuing actions required to meet specific mitigation targets, and then mold their programs to meet competing demands at a later stage. Section 4.2.1 presents four basic variables that, among others, policy-makers may wish to address during the goal setting process. Section 4.2.2 elaborates on the complications that can arise during this process.

4.2.1 Four Variable Aspects of Goal Setting Processes

Policy-makers may find it valuable to consider four primary distinctions in goal setting when formulating the core focal points for their climate change programs. These are discussed below.

Goals oriented around specific time frames versus permanent or perpetual goals

While each state should optimally establish a definitive primary objective for programs, such as no net increase in greenhouse gas emissions or stabilization to some baseline level, more specific goals and program milestones set within distinct time frames can provide critical guidance for policy development and implementation. In the context of a long-term baseline goal, for example, specific near-term reduction targets may provide important motivation to agencies and private sector actors to implement options.

Similarly, certain policy actions are appropriate in the near-term and others in the mid- or long-term. Careful goal structuring that accounts for these time frame differences can significantly strengthen program development. Policies adopted in the near-term may substantially lower the costs and increase the acceptance of future actions by, for example, focusing on the development of technologies that minimize emissions or by demonstrating early the cost-effectiveness of an option.

Quantitative goals versus qualitative goals

Programs may pursue specific numerical targets for emission controls, or they may focus on qualitative issues, such as promoting the use of the most energy-efficient technologies and processes in all economic sectors. Setting quantitative emissions reduction goals, such as Oregon or Missouri's twenty percent target, can be extremely effective in focusing state efforts across sectors. Quantitative goals may also allow analysts to assess more easily the feasibility for alternative policy options to meet specific targets and to monitor with greater accuracy the progress of these options. The Oregon target, for example, seems to provide continuing focus as policies are developed and revised over time. Similarly, the California state directive to evaluate the pros and cons of a CO_2 reduction target, although it has not actually produced a formal quantitative target, has prompted important analysis of how existing and potential new state policies may affect projected greenhouse gas emissions.

Goals based on prescriptive emissions targets versus goals based on perceived emission reduction capabilities

Policy-makers may decide to set goals based on technical or scientific prescription of emission levels necessary for climate change mitigation (*e.g.*, stabilization at 1990 levels), on actual emissions or technological projections (*i.e.*, implement measures that will achieve the maximum amount of emissions reductions possible given the current and projected state of technology), on state administrative and analytical capacity for implementing and supporting certain types of programs (*e.g.*, base emissions reductions targets on the number of climate change projects/programs state agencies can realistically manage over the period being considered), or on a range of other emissions reduction criteria. This choice will often determine how aggressive or conservative program development and policy selection are, and it will also affect the types of demands programs place on state resources.

Broad versus narrow substantive goals

Goals can cover all greenhouse gas emissions or they can emphasize specific greenhouse gases or particular economic sectors. This again will hinge on each state's motivations and institutional structures and will probably vary significantly with greenhouse gas emissions characteristics in different geographic regions. Many domestic and international efforts focus explicitly on carbon dioxide or on fossil fuel consumption in transportation and electricity generation, for example, since these source categories account for the majority of anthropogenic greenhouse gas emissions. Similarly, some areas choose to focus on stationary source emissions rather than mobile source emissions, since stationary sources are often easier to monitor.

4.2.2 Complications that Affect Goal Setting

Distinct economic, environmental, and political circumstances in each state will probably determine the relative importance of the above four issues for the policy formulation process. This section elaborates on specific issues that complicate the analysis of the four aspects of goal setting discussed above including: the scientific uncertainty associated with greenhouse gas emissions estimation and climate change-related impacts; the actual impact of mitigation measures on emissions and on climate change; and questions of measurability. Chapter 7 examines how states might structure programs to take full account of these issues in all aspects of program design. Exhibits 4-4, 4-5, 4-6, and 4-7 present examples of how states have dealt with these complications in setting emissions reductions goals and targets.

Scientific and Technical Uncertainties

Achieving permanent stabilization could require carbon dioxide emission reductions of fifty to eighty percent from currently projected levels, as well as significant reductions in the other greenhouse gases. This stabilization goal would be extremely difficult to achieve at the present time, and few analysts seem sure about what levels of emissions reductions are actually feasible. Scientific uncertainties underlie many aspects of our understanding of climate change processes, such as the uptake of CO_2 by forests and the oceans. Further, uncertainties exist in estimating emissions from various source categories and in assessing the potential greenhouse gas and associated impacts of specific control technologies. Given these uncertainties, the idea of an optimal emission reduction target is subject to considerable controversy and often becomes defined by other criteria.

Uncertain Impacts and Interactions of Policy Approaches

Some policies may be effective in the short-term, while others will take longer to produce desired results. Also, some options have benefits other than those related to greenhouse gases, such as increased energy security or decreased soil erosion. At the same time, however, these options may prove to be politically unpopular and thus perhaps not feasible, as a result of potentially significant sectoral economic impacts or required changes in behavior. As one illustration of these issues, policy measures such as taxes and other economic incentives can be the most effective in modifying consumer behavior, but they also frequently generate the highest levels of political resistance.

Exhibit 4-5: Goal Setting in Missouri

Missouri's 85th General Assembly adopted a resolution in 1989 that created the Missouri Commission on Global Climate Change and Ozone Depletion. The commission consisted of 14 members with various backgrounds and was charged with assessing Missouri's contribution to these global environmental and social problems, and to offer possible policy alternatives. The Commission's report was presented to the Missouri General Assembly, in 1990. This report was well received and has served as a catalyst for discussion throughout the state. As a result of the Commission's recommendation, Missouri's Environmental Improvement and Energy Resources Authority and the Division of Energy of the Department of Natural Resources have initiated a comprehensive state energy study. Furthermore, the Commission's charge was extended in order to study and fully develop options for preparation and mitigation of effects associated with global climate change and ozone depletion. In addition, Missouri established a non-binding goal of reducing greenhouse gas emissions by twenty percent. This goal has apparently provided a valuable focal point and source of motivation for the state legislature, state agencies and other organizations.

Exhibit 4-6: Goal Setting in Vermont

In October 1989, Vermont's governor signed an executive order calling for a comprehensive review of all forms of energy used in the state and for the development of a plan to modify energy usage in order to achieve specific goals relating to environment quality, affordability, and renewability. Goals include a reduction in per-capita non-renewable energy use of twenty percent and a reduction in emissions of greenhouse gases and acid rain precursors by fifteen percent, both by the year 2000. To meet this charge, the Vermont Comprehensive Energy Plan was developed cooperatively by the Vermont Department of Public Service, the Agency of Natural Resources, the Agency of Transportation, and many of Vermont's leading authorities on energy usage. The Plan showed that through actions to modify and adapt the state's energy usage to meet the goals laid out in the executive order, Vermont can reduce greenhouse gases by twelve percent, acid rain precursors by eighteen percent, and the per-capita use of non-renewable energy by twenty-seven percent.

Similarly, broader and more qualitative goals may be effective in addressing these issues, but complications surround them as well. For example, Massachusetts' explicit goal of providing electricity at the lowest possible financial, social, and environmental cost accounts for the social effects of carbon dioxide from energy production in addition to addressing the environmental impacts of energy production. The energy goal thus incorporates a variety of social objectives and may serve as a model for addressing the impacts of greenhouse gas emissions from many sources, including utilities, industries, commercial and residential buildings, and transportation. This approach may be especially valuable in situations where different sectors could be unevenly affected by emission reduction policies if clear groundwork is not laid in advance. However, this broad, qualitative goal may complicate the projections of emission reductions resulting from the policies, and create political controversy over methods and procedures adopted for quantifying benefits.

Measuring Results

The direct effects of important climate change-related policy actions are often extremely difficult to measure or forecast. For example, quantitative goals, while often politically and analytically difficult to set and agree upon, are frequently much easier to assess and communicate than qualitative goals. On the other hand, many qualitative and inherently difficult-to-measure actions, like broad public education on climate change and energy-efficiency issues, may offer some very good opportunities for achieving long-term climate stabilization.

Similarly, the emission impacts of short-term actions are frequently easier to measure than those of longer-term policies, largely because the longer-term actions (especially those with twenty year or longer time horizons) are subject to complications and interactions from many unforeseeable economic, physical, and environmental developments. To address this issue, states can set detailed near-term targets within the context of broader mid- or long-term qualitative or quantitative goals. This structure, elaborated in Chapter 7, provides a way of focusing measurable or monitorable policy formulation in the short-term and fostering momentum for future program development. It also provides a mechanism to ensure that emphasis on the most promising short term policies does not override or exclude consideration of critically important long-term actions.

4.3 ESTABLISHING CRITERIA FOR EVALUATING POLICIES

Clear and consistent policy evaluation criteria can provide a strong base for ensuring that all policies support fundamental program

Exhibit 4-7: Goal Setting in Iowa

The Iowa Department of Natural Resources delivered the state's first Energy Plan to the General Assembly in 1990. The plan "pointed out the way to a future of wise energy use, economic stability, and environmental quality." With the plan, updated in 1992, Iowa aims to achieve two long term qualitative goals: 1) to meet all new energy demand with efficiency rather than new supplies of fossil fuels, and 2) to effectively double, then double again the share of renewable, "homegrown" resources in the state's energy mix. The plan also sets the objective of continuing to explore how to meet these goals. Towards this end, the state has taken and continues to take steps to create innovative utility energy efficiency efforts, to encourage efficient homes through building ratings, to stimulate alternative energy industries, and to promote research and development through university centers.

The DNR is currently conducting a study that looks at the direct, indirect, and induced effects of increased investment in energy efficiency and renewables. The study is focussed more on the economic rather than environmental analysis of options, since utilities and consumers typically focus on the cost-effectiveness of options rather than the direct environmental benefits.

goals. The criteria should not only recognize that some goals may be competing, but should also account for substantive, administrative, and political factors. As opposed to creating strict guidelines to which all policies must adhere, carefully developed criteria establish a framework with which to compare the implications of different policy options. Compiling these criteria carefully at the outset will help ensure that important issues are not overlooked at any time during program and policy development.

Each of the criteria delineated below represents factors that are potentially important to state policy-makers and that, if adopted by an individual state, could be applied to every policy consideration. These should not necessarily serve as constraints that must be met, but rather as guidelines to ensure comprehensive and consistent consideration of all relevant factors during policy selection. At the same time, to evaluate and compare policies effectively, states will probably prioritize among the criteria they adopt. The criteria presented here are drawn from various state experiences and may not be appropriate for all new programs. Each state should develop a set of clear and distinct criteria that reflects their individual priorities and circumstances.

As with the development of quantitative or qualitative program goals, application of specific policy evaluation criteria may vary across time frames. In the immediate-term, for example, existing institutional structures and politics may dominate policy selection. For the mid- or long term, however, policy flexibility and overall economic efficiency may be more important for some states. Some criteria will certainly apply in all time periods. Urban tree planting programs, for example, illustrate these points. While the carbon sequestration value of urban tree planting may be small, this project focuses public attention on the global climate change issue in the near-term, potentially builds political support, and helps alleviate the "urban heat island" phenomenon in the long term. Similarly, some far-reaching and potentially expensive policies may not seem justified if their benefits within the near-, mid-, and long-terms are not all acknowledged. This is especially relevant with regards to climate change, where the impacts and direct mitigation benefits of some actions will probably not be felt for decades.

- *Effectiveness in Reducing Greenhouse Gas Emissions.* This is a key criterion for climate change mitigation policies. Every policy should help reduce current or future greenhouse gas emissions. However, several issues could confound a policy-makers' perceptions of the effectiveness of alternative policy options. These issues include the timing of a policy's effects, the certainty of results from different types of government actions, the degree of control that the public sector seeks to retain, the continuing effectiveness of a policy in the face of economic fluctuations and growth, the responsiveness to technological change, and the degree and impact of interaction among various concurrent policies.

- *Private Sector Costs and Savings*. Most policies will alter the costs recognized by the private sector, including industry and consumers. Policies regulating technology use, industry reporting, or emissions taxes, for example, will impose costs on the private sector and ultimately on the consumers of affected products. At the same time, these or other measures may promote cost savings through energy-efficiency and similar mechanisms. The timing, distribution between affected actors, and magnitudes of costs may all be important to consider.

- *Public Sector Costs*. New policies frequently require implementation, administration, and enforcement support from state agencies. This support costs the agencies, and thus the state government, additional resources in terms of direct financial expenditures, staffing, equipment, and building space. These costs are especially relevant in terms of administering and coordinating programs and maintaining adequate records. For example, all policies will probably require some level of staffing for general administration, and certain non-voluntary emission reduction goals and directives may require additional administrative and field resources for ensuring compliance.

- *Institutional Capacity*. In addition to general public sector resource expenditures for program administration, as noted above, certain types of policies may require distinct institutional capabilities, like the ability to perform specific types of scientific or economic analysis. Similarly, policies may require substantial levels of interagency or public- and private-sector cooperation. An important criterion may be whether states have the existing or foreseeable capacity to meet these types of policy implementation requirements.

- *Enforceability*. In addition to imposing direct enforcement costs, some policies may require new legal powers for state agencies to administer, while some policies may simply be difficult to enforce. This is especially relevant given complications in measuring some greenhouse gas emissions and in measuring the effectiveness of certain policy options. Similarly, regulatory approaches that target large numbers of decentralized emission sources, such as individual consumers who use polluting products or services, may pose especially difficult enforcement problems. For these reasons, the general enforceability of policy options may be an important criterion.

- *Economic Efficiency*. Although many policies can reduce greenhouse gas emissions, policy-makers may want to emphasize options that use resources most efficiently -- *i.e*., achieve emissions reductions using the least amount of private and public resources. Policies that focus first on sources that can provide the lowest cost reductions usually promote these objectives. From a national perspective, cooperation between states and regions may promote least-cost emission reductions.

- *Social Equity*. Both costs and other impacts may be distributed unevenly across certain geographic locations, income groups, or economic sectors. Policies that affect prices of basic consumer goods, such as home heating costs, may have a disproportionate impact on low income individuals. Similarly, some policies may adversely affect one economic sector more than others. For example, policies targeted at nitrous oxide emissions may affect agriculture more than they will affect manufacturing. Additionally, since the impacts and costs relating to climate change extend far into the future, policy-makers may need to grapple with intertemporal inequity between generations.

- *Political Impact and Feasibility*. Public or political acceptability is an essential element of a successful emission control program. Some recommended measures, such as taxes and other economic incentives, for increasing economic efficiency or changing consumer and producer behavior, can generate significant popular resistance. Near- term policies or actions that include public education or that encourage public input and involvement in the climate change decision making process may help build public support.

- *Legal Constraints*. The introduction of some emission reduction policies and goals may be constrained by existing legal barriers. For example, setting land aside for tree planting, requiring utilities to undertake least-cost planning, or addressing environmental "externalities" may all require new or revised laws. Some additional technical approaches for emissions reduction, such as methane recovery from landfills and coal mines, have not been actively pursued before, in part because of legal complications arising from public safety or other concerns.[2] Frequently, these legal constraints can be

[2] As part of the CCAP, methane recovery from landfills and coal mining is being aggressively pursued. These programs focus on recovering methane for use as an energy source. These programs, the *Landfill Methane Outreach Program* and the *Coal Bed Methane Outreach Program*, are federally-sponsored voluntary programs committed to working with state regulators and industry representatives to maintain public safety, revise current state and local regulations and industry standards, and promote a cost-effective alternative to flaring.

overcome by modifying or broadening regulatory guidelines to permit new activities that still promote initial regulatory objectives, such as public safety, without excluding certain approaches to reducing greenhouse gas emissions. For example, changing landfill methane emission laws to permit recovery and sale of methane, as being pursued in the CCAP, rather than requiring methane flaring as the only safe control measure, illustrates this point.

- *Ancillary Benefits and Costs*. Some climate change mitigation actions could affect other state programs and priorities, either by design or unintentionally. Various potential emission reduction policies produce ancillary benefits by enhancing environmental quality, promoting the sustainable use of resources, enhancing social welfare, enhancing food security, or generating revenue for the government. For example, increasing the use of renewable fuels generated within a particular state could reduce emissions of pollutants from fossil fuel combustion, increase energy independence, lower the balance of trade, and contribute to a state's economic well being. Alternatively, ancillary costs can occur when any policy indirectly works against the factors described above. For example, tree planting programs that sequester carbon, halt erosion, and improve air and water quality may also require large tracts of land to implement, potentially increasing land prices in agricultural areas and thereby increasing prices for agricultural commodities.

In addition to the substantive criteria listed above, state policy-makers experienced with climate change programs have recommended two additional process-oriented criteria that may help provide focus for evaluating policy options.

- *Measurability*. Policy-makers in the climate change field repeatedly emphasize the benefits of being able to measure policy effects. These benefits include accurate emissions forecasting, a sound basis for policy comparison now and for future program analysis and modification, and increased political legitimization of certain options based on their measurable impacts. In addition to the complications surrounding measurability described above, however, some powerful long term and qualitative policies are inherently difficult to assess. For example, it is difficult to quantify the impacts of public and consumer education and of long range land use and urban planning changes. States should be careful not to eliminate these policies from consideration because they are difficult to measure, but rather should anticipate that such policies have different implications for analytic, administrative, and political processes during program planning.

- *Flexibility*. Programs and policies will need to change and adapt over time as more is learned about actual climate change impacts and about the effectiveness of various options for mitigating those impacts. Similarly, flexible state programs may channel their internal and external resources to the most effective applications. This underscores the importance of considering the appropriate time frame in initial program development and is also one of the primary reasons why states may benefit from initiating climate change mitigation programs on their own terms now rather than waiting for less flexible national or international standards. This may have direct implications for policy choice.

PART II

TECHNICAL APPROACHES AND POLICY OPTIONS FOR REDUCING GREENHOUSE GAS EMISSIONS

The following two chapters provide an overview of specific steps states might take to reduce greenhouse gas emissions.

- Chapter 5, *Technical Approaches and Source-Specific Policy Options*, is broken into twelve sections, each corresponding to a single emissions source. It provides background technical information and offers policy options for addressing each source.

- Chapter 6, *Cross-Cutting Themes and Program Development*, discusses policy options and issues that are relevant to more than one emissions source and indicates areas with the greatest potential for comprehensive emission reduction measures.

These chapters are designed to be used as reference materials, providing self-contained information on each emissions source. Each section provides references to other sections where appropriate. These chapters are not necessarily intended to be read through in a comprehensive way.

These chapters present policy suggestions that generally follow the structure described in Chapter 2 for addressing specific barriers to greenhouse gas emission reductions. In this context, the policy options here fit generally into four categories: education and information provision, restructuring of institutional and legal barriers, development of financial incentives, and direct regulation.

Greenhouse Gas Sources Not Elaborated in this Document

This document does not elaborate on several sources of greenhouse gases, such as methane emissions from wastewater treatment and wetland drainage and carbon loss from soils. These sources are difficult to address for various reasons. In some cases, the current scientific understanding of the emission source is insufficient to warrant thorough discussion. Similarly, the scientific uncertainties surrounding the emission reduction options for these sources are often too great to consider such measures as viable alternatives. For other emission sources, there are no viable technical approaches to reduce emissions effectively.

Rather than to address these tangential sources, this document emphasizes areas where states can focus their efforts and resources to mitigate significantly the threat of future climate change. States should, however, still include these sources as part of a complete greenhouse gas emissions inventory since they are a part of a state's overall contribution to global warming. The most significant sources not elaborated in detail in Chapters 5 and 6 are summarized below.

- *Wetlands Drainage*: This document does not contain emission reduction measures for wetland drainage because of the potentially offsetting effects of this activity on climate change. That is, wetland drainage may decrease emissions of one greenhouse gas, methane, while increasing emissions of another, carbon dioxide. Wetlands drainage results in a reduction of methane uptake and an increase in carbon dioxide emissions as the soils change from an anaerobic to an aerobic state. However, depending on the fate of the drained wetlands, these soils may also become a net sink of methane. It is difficult, therefore, to quantify the net effect of any reduction measures. Furthermore, while net emissions of nitrous oxide and carbon monoxide may be affected by this activity, the direction and the magnitude of the effects on these gases are highly uncertain. It may be more useful for states to implement policy measures that have a clearer mitigative impact.

- *Conversion of Grasslands to Cultivated Lands*: This document does not address conversion of natural grasslands to managed grasslands and to cultivated lands because of the scientific uncertainties associated with this emissions source. Conversion of natural grasslands to managed grasslands and to cultivated lands may affect net carbon dioxide, methane, nitrous oxide, and carbon monoxide emissions. Conversion of natural grasslands to cultivated lands may result in carbon dioxide emissions due to a reduction in both biomass carbon and soil carbon. Such a land use change has been found (at least in the semi-arid temperate zone) to also decrease carbon dioxide uptake by the soils. The effects on nitrous oxide and carbon monoxide fluxes are highly uncertain.

- *Greenhouse Gases from Production Processes*: Direct greenhouse gas emissions from the industrial sector result from a variety of chemical, thermal, and mechanical processes that are employed to extract, refine, and process raw materials and produce a variety of end-products. For example, aside from the emissions resulting from on site power generation and heating, a significant amount of carbon dioxide is released during cement production. Similarly, nylon production results in the release of nitrous oxide. Section D in the Phase I document contains a list of additional industrial processes that produce greenhouse gas emissions. Because there are few additional reduction measures currently available, this document does not address other greenhouse gas emissions reductions from this source category. The most effective emissions reduction method for the industrial sector usually is to improve energy efficiency, which is discussed in Section 5.1.5.

- *Methane from Wastewater Treatment Facilities*: Anaerobic treatment of wastes produces methane. This is generally considered to be a bigger problem in many developing countries than in the United States, since most U.S. facilities treat waste aerobically. In addition, many municipal waste water treatment facilities in the U.S. already capture the methane they do produce and use it during on-site energy production. While not addressed further in this chapter or the Phase I *States Workbook*, policy-makers should consider this issue as it applies to their local circumstances.

- *Emissions of Ozone-Depleting Substances*: This document does not address emissions of CFCs and other Ozone-Depleting Substances (ODSs) that, in addition to depleting stratospheric ozone, also function as greenhouse gases. This document also does not address the greenhouse effect of many of non-ozone depleting chemical replacements for the ODSs, such as hydrofluorocarbons (HFCs). ODSs and HFCs are emitted as a result of a variety of processes, including refrigeration, air conditioning, solvent cleaning, foam production, and aluminum production. Emissions of ODSs, except for those stemming from aluminum production, are already rapidly declining. They are being phased out under the *Clean Air Act Amendments of 1990* in coordination with U.S. obligations as a signatory to the *Montreal Protocol on Substances that Deplete the Ozone Layer*. CFC replacements such as HFCs, on the other hand, are controlled under EPA's Safe New Alternatives Program (SNAP) and are targeted for certain actions under the *Climate Change Action Plan*.

Additional Information on Policies and Actions to Reduce Greenhouse Gas Emissions

The CCAP presents a variety of programs and actions the federal government will be undertaking to reduce greenhouse gas emissions. Exhibit II-1 lists the specific actions highlighted in the CCAP. Many of these may supplement the policy ideas elaborated in Chapters 5 and 6. A copy of the CCAP can be obtained from EPA.

Exhibit II-1: Actions Specified in the U.S. Climate Change Action Plan

Foundation Actions

- Launch the Climate Challenge to encourage electric utilities and other eligible firms to submit voluntary greenhouse gas reduction portfolios
- Launch Climate-Wise Companies to encourage U.S. industry to take advantage of the environmental and economic benefits associated with enrrgy efficiency improvements and greenhouse gas emission reductions

Commercial Energy Efficiency Actions

- Coordinate *DOE Rebuild America and EPA Energy Star Buildings*
- Expand EPA's *Green Lights* Program
- Establish State Revolving Fund for Public Buildings
- Expand Cost-Shared Demonstrations of Emerging Technologies
- Establish Energy Efficiency and Renewable Energy Information and Training Programs

Residential Energy Efficiency Actions

- Form *Golden Carrot* Market-Pull Partnerships
- Enhance Residential Appliance Standards
- Promote Home Energy Rating Systems and Energy-Efficient Mortgages
- Expand *Cool Communities* Program in Cities and Federal Facilities
- Upgrade Residential Building Standards
- Create Residential Energy Efficiency Programs and Housing Technology Centers

Industrial Energy Efficiency Actions

- Create a Motor Challenge Program
- Establish Golden Carrot Programs for Industrial Air Compressors, Pumps, Fans and Drives
- Accelerate the Adoption of Energy-Efficient Process Technologies Including the Creation of One-Stop-Shops
- Expand and Enhance Energy and Diagnostic Centers
- Accelerate Source Reduction, Pollution Prevention, and Recycling
- Improve Efficiency of Fertilizer Nitrogen Use
- Reduce Pesticide Use

Transportation Actions

- Reform the Federal Tax Subsidy for Employer-Provided Parking
- Adopt a Transportation System Efficiency Strategy
- Promote Greater Use of Telecommuting
- Develop Fuel Economy Labels for Tires

Energy Supply Actions

- Increase Natural Gas Share of Energy Use Through Federal Regulatory Reform
- Promote Seasonal Gas Use for Control of Nitrogen Oxides (No_X)
- Commercialize High Efficiency Gas Technologies
- Form Renewable Energy Market Mobilization Collaborative and Technology Demonstrations
- Promote Integrated Resource Planning
- Retain and Improve Hydroelectric Generation at Existing Dams
- Accelerate the Development of Efficiency Standards for Electric Transformers
- Launch EPA *Energy Star Transformers*
- Reduce Electric Generation Losses Through Transmission Pricing Reform

Methane Reduction and Recovery Actions

- Expand *Natural Gas Star*
- Increase Stringency of Landfill Rules
- Expand Landfill Outreach Program
- Launch Coalbed Methane Outreach Program
- Expand RD&D for Methane Recovery from Coal Mining
- Expand RD&D for Methane Recovery from Landfills
- Expand *AgStar* Partnership Program with Livestock Producers
- Improve Ruminant Productivity and Product Marketing

HFC, PFC and Nitrous Oxide Reduction Actions

- Narrow Use of High GWP Chemicals Using the Clean Air Act and Product Stewardship to Reduce Emissions
- Create Partnerships with Manufacturers of HCFC-22 to Eliminate HFC-23 Emissions
- Launch Partnership with Aluminum Producers to Reduce Emissions From Manufacturing Processes
- Improve Efficiency of Fertilizer Nitrogen Use

Forestry Actions

- Reduce The Depletion of Nonindustrial Private Forests
- Accelerate Tree Planting in Nonindustrial Private Forests
- Accelerate Source Reduction, Pollution Prevention and Recycling
- Expand *Cool Communities* Program in Cities and Federal Facilities

CHAPTER 5
TECHNICAL APPROACHES AND SOURCE-SPECIFIC POLICY OPTIONS

This chapter describes opportunities for state policy-makers to control greenhouse gas emissions from specific sources. To facilitate presentation, these opportunities have been divided into technical approaches and policy options. "Technical approaches" refer to technical or engineering methods which, when implemented, will reduce emissions from the source category. "Policy options" are instruments through which one or more technical approaches are promoted. Exhibit 5-1 illustrates how these terms are used in this chapter.

Exhibit 5-1
Examples of Terminology Used in Chapter 5

Source Category	**Technical Approach**	**Policy Option**
Greenhouse Gases from the Transportation Sector	Reduce Vehicle Miles Traveled	• Improve Mass Transit Systems • Provide Incentives to Employees to Establish Van Pools • Develop Tele-Commuting Programs
Methane from Landfills	Recover and Use Methane Gas	• Sponsor Technology Demonstration Projects • Develop Tax Credits for Methane Recovery Projects • Initiate Regulatory Requirements to Capture Gas

Information regarding emissions, and approaches to reducing emissions, are not always easily categorized for policy analysis. The emissions sources or grouping of gases to prepare emissions inventories are often scientifically based and do not necessarily support effective policy analysis and development. This part of the document is generally organized around the emissions source categories from the *States Workbook*, but adjusts those categories where appropriate to facilitate policy development. Exhibit 5-2 shows the relationship between the emissions sources defined in the *States Workbook* and categories used to organize this chapter.

Within each source category information is presented in the following format:

- An *introduction* to the source category summarizes how specific greenhouse gases are generated and emitted by the source and discusses federal, state, and local policy objectives that may be relevant to emission reductions.

Exhibit 5-2

Emissions Source Category As Defined in Phase I Workbook		Source Categories Described in Chapter 5 of This Document
Greenhouse Gases from the Residential Sector	➤	Greenhouse Gases from Energy Consumption: Demand-side Measures
Greenhouse Gases from the Commercial Sector	➤	
Greenhouse Gases from the Industrial Sector	➤	
Greenhouse Gases from the Electric Utility Sector	➤	Greenhouse Gases from Electricity Generation: Supply Side Measures
Greenhouse Gases from the Transportation Sector	➤	Greenhouse Gases from the Transportation Sector
Greenhouse Gases from Production Processes	➤	Not addressed in Chapter 5
Methane from Oil & Natural Gas Systems	➤	Methane from Oil & Natural Gas Systems
Methane from Coal Mining	➤	Methane from Coal Mining
Methane from Landfills	➤	Methane from Landfills
Methane from Domesticated Animals	➤	Methane from Domesticated Animals
Methane from Manure Management	➤	Methane from Animal Manure
Methane from Flooded Rice Fields	➤	Methane from Flooded Rice Fields
Nitrous Oxide from Fertilizer Use	➤	Nitrous Oxide from Fertilizer Use
Greenhouse Gases Due to Changes in Forests and Woody Biomass Stocks	➤	Emissions Associated with Forested Lands
Greenhouse Gas Reductions/Sequestration from Forestry Projects	➤	
Greenhouse Gases Due to Conversion of Grasslands to Cultivated Lands	➤	Not addressed in Chapter 5
Greenhouse Gas Emissions from the Abandonment of Managed Lands	➤	Not addressed in Chapter 5
Methane Emissions from Wastewater Treatment	➤	Not addressed in Chapter 5
Greenhouse Gases from Burning of Agricultural Wastes	➤	Greenhouse Gases from Burning of Agricultural Wastes

- Each *technical approach* to emissions reduction is presented, including a general description of the approach along with associated administrative and implementation considerations, such as emission reductions, cost, time frame, key drawbacks or limitations, possible ancillary effects, and related examples.

- *Policy options* for each technical approach suggest ways state governments might be able to promote and implement that approach, drawing from a wide variety of perspectives and examples.

As the introduction to Part II of this document explains, "cross-cutting" issues or policy options that potentially affect more than one source category in this chapter are elaborated in Chapter 6. One important cross-cutting issue of which policy-makers should be aware, and that affects or is affected by all source categories, is that greenhouse gases are linked to energy consumption in all sectors. While Section 5.1 examines this issue, it is important to note that energy consumption in all sectors of society result in greenhouse gas production. This encompasses, for example, agricultural, forestry, industrial, and residential concerns. This issue is too broad to examine exclusively and concisely without considering its relevance in the context of all other emission sources. Accordingly, the rest of this document makes specific reference to energy consumption issues where appropriate.

The information summarized in this chapter is designed to be used selectively, allowing policy-makers to focus on the specific sources in which they are most interested. This document does not advocate particular approaches or options.

5.1 GREENHOUSE GASES FROM ENERGY CONSUMPTION: DEMAND-SIDE MEASURES

Carbon dioxide is emitted through combustion of fossil- and biomass-based fuels to produce direct heat and steam, and to generate electricity, either at utility plants or directly on-site where the energy will be consumed. The amount of carbon dioxide released to the atmosphere is directly proportional to the carbon content of the fuel used. Coal is the most widely used of all fossil fuels for electricity generation and has the highest carbon content, natural gas is second in electricity generation use while third in carbon content, and oil is third for electricity generation but second in carbon content.[1] In the U.S., electricity use by the residential, commercial, and industrial sectors each accounts for about one-third of total carbon dioxide emissions.

Several perspectives may help policy-makers identify measures to decrease energy sector carbon dioxide emissions:

- First, emissions reductions can be achieved through actions taken either to reduce energy consumption or to alter energy supply.

- Second, these actions can reduce emissions either by reducing energy consumption or by improving the efficiency with which energy is used. Decreasing the number of processes used, commonly called energy conservation, requires a reorientation of business practices and lifestyles, such as utilizing different transportation networks or following non-typical work schedules. Energy-efficiency options, on the other hand, achieve the same level of output or activity while using less energy, often through improved technology. A more efficient furnace, for example, may allow a household to maintain the same or even higher indoor temperature while using less fuel.

  Third, either energy conservation or energy-efficiency options on the consumption- or supply-side can be exercised using a variety of policy levers. At the state level this usually means either undertaking direct energy planning and programmatic initiatives through state energy, natural resources, and economic development offices (as many states have since the mid-to-late-1970s), or using utility regulatory authority to encourage or mandate utility involvement in energy

[1] The burning of biomass-based fuels (wood, agricultural refuse, etc.) also releases carbon dioxide. However, biomass burning releases carbon that was sequestered from the atmosphere to begin with, rather than releasing carbon that was previously stored deep in the earth as is the case with fossil fuels. In this context, combustion of biomass fuels that are sustainably grown (meaning each time biomass crops are harvested they are replaced with new plants and trees) does not significantly affect the atmospheric carbon balance while burning fossil fuels does.

conservation, energy efficiency, and load management programs (as has been done increasingly since the 1980s).

The remainder of Section 5.1 addresses energy consumption. It identifies technical approaches for improving energy efficiency and briefly outlines both direct state actions and regulatory agency-driven utility actions to implement those approaches. Section 5.2 presents energy production issues. Chapter 6 discusses specific policy options for reducing energy demand and increasing supply of low-carbon or no-carbon energy.

While separated here for descriptive clarity, these three sections are linked and should be considered together during policy analysis and development. Each section, for example, highlights how both the consumers and the producers of electricity can take actions to affect energy demand and supply, and each section also points out how, in many circumstances, certain facilities can simultaneously act as energy consumers and producers. Because of wide variations among the states, the information provided here should be considered as background to be investigated and clarified further as it applies to distinct state circumstances.

Introduction To Consumption-Side Issues and Demand-Side Management

Between 1973 and 1986, conservation and efficiency measures, combined with strategic energy planning and increased use of renewable energy sources, helped keep U.S. energy consumption at nearly constant levels while the country's gross national product grew by thirty-five percent. This demonstrates the significant potential for reducing the economy's energy intensity. Enormous opportunities for further demand reduction are still available using existing and newly developed conservation and efficiency measures.

Demand-side management (DSM) is the term for programs that focus on getting end-users to consume less energy. These programs are administered by a wide range of entities, ranging from utilities to state agencies, local governments, community action agencies, and not-for-profit organizations. Basic types of demand-side management programs include:

- Building or business audits to identify potential energy savings;
- Performance based rebates paid on a per-kilowatt or per-kilowatt conserved basis;
- Technology based rebates for specific energy-efficiency measures such as compact fluorescent lights and occupant sensing light switches;
- Reduced interest financing for energy-efficiency investments;
- Direct installation of energy-efficient equipment;
- Energy load management programs designed to shift consumption of energy to different times of the day, including time-of-day pricing and peak-load pricing, imposition of demand charges, and voluntary load shifting agreements with particular commercial and industrial customers;

- Educational and advertising campaigns targeted either at the general public or at specific commercial or industrial sectors; and

- End-use fuel substitution.

Exhibit 5-3: EPA's Energy Star Buildings and Green Lights Program

EPA's Energy Star Buildings and Green Lights Program is designed to reduce pollution, promote public-private partnerships, use market forces, and recognize environmental leadership. Participants in the Program sign a Memorandum of Understanding committing them to perform upgrades where profitable — Green Lights participants upgrade lighting within 5 years, and Energy Star Buildings participants fulfill Green Lights commitments and perform whole-building upgrades within 7 years. In return, EPA provides technical support targeted to overcome barriers, such as state-of-the-art software to support decision-making, technical information on building systems, reports on lighting products, and networking with equipment manufacturers. EPA also provides opportunities for public recognition.

As of August 31, 1997, there were 2,487 participants, whose combined commitment to perform lighting upgrades exceeded 5.5 billion square feet. The annual emissions avoided by the program is estimated at over 3 million tons of CO_2, 25,000 tons of SO_2, and 11,000 tons of NO_x. In terms of energy, over 4.5 billion kWh, or $335 million, has been saved. For more information, contact the Energy Star & Green Lights Hotline at 888/STAR-YES.

A large array of federal, state, and local policies affect the energy sector and influence demand-side issues. The Federal Energy Regulatory Commission (FERC), for example, has jurisdiction over wholesale (inter-utility) power transactions and natural gas transportation, while states have traditionally regulated utilities through public utility commissions (PUCs), which oversee rate setting and approve energy supply expansion and power plant construction. Additionally, pollutant discharges from utilities are regulated by an intertwined network of federal, state, and local environmental statutes. Federal laws that directly affect energy-related emissions and the operation of utility companies include the Clean Air Act (CAA), the Public Utilities Holding Company Act (PUHCA), the Public Utilities Regulatory Policies Act (PURPA), the Federal Power Act, the Natural Gas Policy Act, and the Energy Policy Act of 1992 (EPAct). Additionally, the federal government administers several programs to encourage energy efficiency and demand-side management. These include, for example, EPA's "Green Lights" program, which provides information, education, and technical assistance to businesses and state and local governments to encourage use of energy-efficient lighting. EPA has expanded this voluntary program to include other energy uses such as heating and cooling, industrial motors, and computer equipment in its Energy Star program. In addition, the Department of Energy (DOE) sets minimum energy-efficiency standards, under the National Appliance Energy Conservation Act (NAECA), for certain appliances. DOE also administers many programs to research and promote energy efficiency, including public information initiatives requiring disclosure of efficiency ratings for competing appliances and programs that target research on energy use in buildings.

State and local governments have enormous opportunity to supplement federal actions because they retain jurisdiction in policy areas, including utility rate reform, city and regional planning, and establishing building codes (see Chapter 6). In addition, proximity to local energy use allows states to promote policies that considers their unique opportunities and constraints.

Through greenhouse-gas reducing actions in the energy sector, state and local governments also support other policy objectives. Foremost, policies that affect energy consumption and production can reduce emission of air and water pollutants and support local economic development. For example, some states are promoting and supporting energy efficiency as a way of lowering industry costs in order to attract investments and increase their state's economic productivity and competitiveness.

However, demand-side management programs around the country have often been slow to take hold as an effective mechanism for helping regions meet their energy needs. While the technologies to support large-scale energy efficiency have existed for several years, those technologies in most cases have not substantially penetrated the residential, commercial, or industrial sectors. This problem is rooted in a set of common institutional and political barriers, summarized below, that either prevent development of more energy-efficient practices or actually promote wasteful actions:

- *Perceived High Initial Cost and Delayed Return on Investment in Energy Efficient Technology*. Many energy efficient technologies have higher up-front costs than the standard technologies they could replace. Compact fluorescent light bulbs, for example, can cost up to fifteen times as much as standard incandescent bulbs; the value of the electricity savings, however, significantly outweighs these costs but may not be realized for some period of time. Consumers and firms may accordingly choose not to make the investment. Additionally, new technologies can require extra time and effort to install and potential consumers often view installation as contributing to initial costs.[2]

- *Lack of Information*. Consumers and firms are often uninformed about the cost, performance, and reliability of efficient technologies. Furthermore, preconceptions of problematic early energy-efficiency technologies persist, and may dissuade consumers from choosing energy efficient products and processes. In general, people are also unaware of the connection between energy usage and environmental degradation.

- *Low Priority Given to Energy Consumption.* Energy costs typically represent a small fraction of a firm's overall budget; businesses focused on producing quality products for customers often overlook opportunities for savings through energy efficiency.

- *Low Energy Costs*. Low energy costs have the dual effect of reducing the need for energy efficiency in consumers' minds and reducing the return of investments in energy-efficient technology.

- *Limited Availability*. Energy-efficiency technologies in the residential, commercial, and industrial sectors are generally available only in selected geographic areas, often where they are targeted by government or utility programs, or where there exists substantial customer demand. Correspondingly, retailers in rural areas are less likely to stock unknown or risky products.

- *Popular Attitude and Consumer Habits*. The use of unconventional technologies, such as wind generators, solar electric, solar thermal, or waste-to-energy plants may encounter resistance due to the "not-in-my-back-yard" syndrome, where communities reject the construction of some facilities in their neighborhoods because of aesthetic, health, or other concerns. Similarly, technologies or processes that require changes in established business or personal routines can encounter resistance.

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[2] While some energy-efficient technologies cost more than their less efficient counterparts, the use of integrated approaches to improving building energy efficiency can lead to lower up front costs through downsizing of heating, ventilation, and air conditioning (HVAC) system components.

- *Inaccurate Price Signals*. The prices set for electricity and gas may not accurately reflect the actual costs of supplying energy at different times of the day and year. By not facing the actual costs of energy service, consumers choose levels of consumption that are suboptimal from society's perspective.

Reducing these barriers is the objective of direct state and PUC-driven DSM policies and programs. The barriers' complex and varied nature means that a successful state strategy for reducing them must itself be multi-faceted and comprehensive. The next section describes briefly the types of technical approaches available for reducing energy consumption in the residential, commercial, and industrial sectors. Sections 5.1.2 and 5.1.3 then outline the types of state policy actions that can be taken to encourage adoption of these technical approaches. Sections 5.1.4 and 5.1.5 provide additional details on approaches for reducing energy consumption in the agricultural sector and in urban areas through the use of tree-planting.

5.1.1 Technical Approaches for Improving Energy Efficiency and Reducing Energy Use

DESCRIPTION

Aggregate energy consumption is the product of millions of individual decisions on the type and level of energy service desired, the types of equipment and fuel to use to provide the desired service, the types of buildings in which we live and work, and the kinds of commercial services and manufactured products we buy. This includes, for example, the amount of energy used to produce heat, light, hot water, or manufactured products. Technical approaches for reducing greenhouse gas emissions represent energy consumers' alternatives for reducing the amount of, or altering the source of energy used to produce a desired level of energy services.

These approaches fall into three general categories: improving energy efficiency; shifting energy consumption patterns (*i.e.*, load shifting); and fuel switching. Energy-efficiency improvements can be further divided along three lines: building measures (*e.g.*, building shell measures to reduce heating/cooling requirements); equipment improvements; and process changes. These are the exact technical approaches, elaborated in more detail below, that the policies outlined in the remaining parts of this section (5.1.2 through 5.1.5) aim to promote. These measures offer significant opportunities for reducing greenhouse gas emissions. Significant energy improvements are available for addressing each of these factors.[3]

Building Shell Measures. Approaches to improve the efficiency of building shells include a wide range of building design, construction, landscaping, and retrofit actions. Major decreases in energy use can be achieved by increasing insulation levels, installing improved window technologies, orienting the building to take advantage of the sun for heating, using thermal mass for storing solar energy, and minimizing north-facing window area. Interior design can emphasize minimizing of ventilation energy requirements. While many building shell approaches are practical only during the design and construction of buildings, significant energy savings are available through shell retrofit measures designed to reduce infiltration and heat loss.

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[3] In existing residential and commercial buildings, energy use for heating and cooling accounts for around 57 percent of carbon dioxide emissions, appliances account for around 20 percent, lighting for about 14 percent, and hot water for around 9 percent (OTA, 1991).

- *Device or Equipment Measures*. These measures replace existing energy-using equipment with more efficient technologies, and are available for every energy end use at efficiencies substantially above current levels. The applicability of energy efficient equipment in any given case, however, can be limited by technical, operational or economic barriers.

- *Process Measures*. Substantial energy-efficiency gains can be achieved through changes in the processes used to produce goods and services. Processes can range from substituting an energy-efficient fax machine or electronic-mail system for air couriers to the adoption of electric arc furnaces and installation of cogeneration systems to make use of waste heat in industrial and other facilities.

- *Load Shifting*. Load shifting changes energy consumption patterns to different times of the day to reduce excess energy demand at peak hours. Load shifting does not directly increase energy consumption efficiency, but it can lead to more efficient operation and reduced emissions by energy suppliers. Electric utilities make significant use of programs to electronically cycle air conditioners during peak periods, and peak load pricing programs to shift consumption to off-peak hours, to increase the efficiency and lower the costs of power generation. The potential for emission reductions from load shifting depends on the specific fuel mix and operating characteristics of each utility.

- *Fuel Switching*. The substitution of one energy source for another often is an effective way to reduce greenhouse gas emissions. This can occur at sites that provide power, such as large electricity generating stations, or on a much smaller scale such as in the home. Substituting gas for electricity to heat water, for example, can lead to a reduction in power plant fuel consumption and emissions. Alternatively, replacing current gas technologies with very efficient electrotechnologies can produce net system reductions in energy use and emissions, even after accounting for the losses in the generation and transmission of electricity. As with load shifting, the energy and emissions reductions realized by fuel switching depend heavily on the specific situation.

Exhibit 5-5: Energy Efficient Library in North Carolina

In 1982, the town commissioners of Mt. Airy, North Carolina, planned construction of a library that consumes 70 percent less energy than a conventional building. By using clerestories (skylights where the glass is mounted perpendicular to the roof) across the top of the library, the building provides glare-free, diffuse light to all corners of the library without directly illuminating the stacks, thereby eliminating unwanted heat and glare as well as minimizing damage to the books from sunlight. As a result, the electricity used for lighting was reduced to only one-eighth of the total energy consumption for the building, as compared to the national average of about one-fourth. The building design also incorporates insulation and a zoned system of heat pumps. Although the construction cost was $88 dollars per square foot (as compared to $79 per square foot for a conventional building), the library was found to use 53 percent less energy than a conventional design. Furthermore, the library uses 90 percent less energy than the Mt. Airy City Hall, a building of comparable size.

CONSIDERATIONS

> **Exhibit 5-6: Home Energy Rating System in Indiana**
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> The Indiana Department of Commerce, Office of Energy Policy is coordinating the design and implementation of a Home Energy Rating System/ Energy Efficient Mortgage (HERS/EEM) program. The HERS/EEM mechanism will have two components. The first is a rating system that will classify new and existing homes according to their energy efficiency. This efficiency rating will provide estimates of utility costs and may include recommendations for specific energy improvements. The second component allows mortgage lenders to incorporate the lower energy bill expected in a more energy-efficient house when evaluating mortgage applications. The goal of the program is to improve the energy efficiency of Indiana homes and to allow home buyers to make better informed decisions regarding the costs of operating a home. Contract negotiations have begun with Energy Rated Homes of America to provide the rating system for this program. Once the rating tool is customized for Indiana's needs, a pilot program will be initiated in Lake and Porter Counties. Significant progress is being made in this effort because of the dedicated cooperation of Indiana's builders, lenders, real estate professionals, and utilities.

Two general factors influence whether any given technical approach is feasible. The first concerns whether an approach can be implemented in new, retrofit, and/or replacement situations. Some approaches are feasible only when a building is being constructed since they are key elements of the structure's design. Other measures are feasible whenever existing equipment is replaced due to failure, while still other options can be retrofitted at any time. Energy used for heating buildings, for example, is determined in large part by the type of building, the quality of its construction, and level of thermal integrity. Although building thermal integrity can be improved by retrofitting it with better insulation, once built, the building's basic heating and cooling requirement can seldom be changed and therefore applies for its remaining life, measured in decades.

The second factor affecting the feasibility of the technical approaches listed above is that some energy-efficiency options are not compatible with existing equipment or energy service needs. Replacing electric resistance heating in a home with an efficient heat pump, for example, may be impractical if the home does not contain any duct work. Certain commercial HVAC systems are suited only to certain applications and/or climate zones, or the lighting needs of a retail store may not be compatible with the most efficient type of lighting systems available. The key to successful implementation of energy-efficiency options, therefore, is to target the selected approaches to those segments of the market in which the specific approaches are practical, feasible, and economic.

As stated above, the following sections outline policy options for instituting these technical approaches to reducing greenhouse gas emissions.

5.1.2 Direct State Actions to Promote Energy Efficiency

DESCRIPTION

Direct state actions to encourage adoption of the technical approaches described above usually fit within five categories:

- direct actions to apply these approaches in state-controlled facilities;

- technical assistance and similar efforts to support household, business, and local government efforts to reduce energy consumption;

- financial incentive or direct assistance programs, including tax credits, loans, and grants for energy-efficiency investments;

- energy-efficiency research, development, and demonstration projects; and

- enactment and enforcement of building codes and energy use standards.

CONSIDERATIONS

States historically have played an active role in promoting energy efficiency. Beginning in the mid-1970s, most states took advantage of federal funding to create energy offices to develop and implement federally-initiated programs. The federal programs generally allowed states substantial discretion in the design and implementation of programs, leading to a diversity of creative approaches to energy efficiency.

However, direct federal support for state activities dropped off substantially in the 1980s, leading to a reduction in state activity. During this time the availability of monies from petroleum violation funds, combined with a number of individual state initiatives, allowed many states to continue promotion of energy-efficiency investments.

Although the availability of funding for direct state actions may continue to be constrained, state and local governments possess a wide array of policy options to assist households and businesses to reduce energy consumption. Innovative use of these options can produce substantial energy, economic, and environmental benefits.

A critical role in this process for state and local governments is the adoption of broad energy use or energy-efficiency standards that guide building construction, often through mandatory state or local building codes. One set of standards that is often used by states as well as the federal government is that produced by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). ASHRAE is a voluntary body of professional engineers who are familiar with the technical and economic issues surrounding energy efficiency. Additionally, a series of model building codes produced periodically by the Council of American Building Officials provides guidance for state and local governments on energy-efficiency measures.

In most areas of the country, however, states and localities consider new standards and codes only as they go through a normal building standards review cycle. This can create a lag of several years between the time a new set of standards or model codes are produced and the time states and localities adopt them or integrate their recommendations, frequently delaying use of the most modern (and sometimes the most profitable, because of related energy savings) building measures. Adoption of these standards and codes is also frequently subject to high levels of political controversy due to their impact on different private and public sector stakeholders and their varying geographical applicability. To remedy the problem of states not upgrading their standards to the most energy efficient measures, EPAct strongly encourages states to adopt energy-efficiency provisions that are at least equivalent to the ASHRAE standards for commercial buildings and to the 1992 Model Energy Code for residential buildings. States including Florida, Iowa, Indiana, New York, Washington and California have been particularly aggressive in adopting and implementing energy-efficiency standards.

Promoting energy efficiency in existing buildings (as opposed to in new structures) is complicated for several additional reasons. Foremost, there have traditionally been few efficiency standards for existing buildings. ASHRAE produced the first of such standards to complement their established new building standards. In addition, some areas currently require efficiency upgrades when buildings are renovated. One Florida standard, for example, now advises that existing structures being renovated at a cost of more than fifty percent of their value must be brought into compliance with energy-efficiency codes.

Exhibit 5-7: Light-Colored Roofing in Arizona

To help offset the urban "heat island" effect, where asphalt and lack of trees raise temperatures in city areas, the city of Mesa, Arizona replaced or re-coated the roofs of four buildings with light-colored insulation board and spray styrofoam as part of an energy retrofit. Because light-colored surfaces reduce the amount of heat that a city absorbs, they can improve the energy efficiency of individual buildings. Prior to the retrofit, each of the buildings had a dark green or black roof and no insulation. The new light-colored roof will remain cooler on sunny days than a darker roof, reducing the cooling load in the upper floors of the building. Additionally, light surfaces radiate heat as effectively as dark surfaces and will radiate heat into a building. As a result, the new roofs are expected to reduce the heating and cooling load attributed to the roof by 20 to 30 percent. The estimated payback for this measure is quite long, about 20 years. However, this project was completed as part of a retrofit that included the installation of energy efficient lighting and heating, and improvements in ventilating and air conditioning (HVAC) systems, which all have much shorter paybacks. Thus, most of the savings from the entire retrofit will be realized sooner.

Besides the general need for building standards and codes, the barriers discussed earlier in this section also affect consumer willingness to improve energy efficiency in existing buildings. Overall, the residential or commercial landowners, managers, and renters who may decide whether to improve energy efficiency in buildings frequently are not aware of the benefits, believe it will be costly, or think it will interfere with their schedules and operations.

Usually, the basic incentive to upgrade the level of energy efficiency in a building is to save money. However, two distinct types of disincentives often inhibit these types of upgrades from occurring. First, tenants may feel that they will inhabit their building for short or uncertain periods of time and therefore hesitate to make investments for which they may not capture the long term benefits. Second, potential investors in energy efficiency often do not pay the electric bills and therefore do not realize the benefits. For example, a landlord is rarely concerned about his/her tenants' future electricity bills and therefore has no incentive to upgrade energy-efficiency.

Another distinct factor inhibiting efficiency upgrades in existing buildings is the slow replacement rate of existing equipment. In the residential sector, for example, most homes in the U.S. already have water heaters, refrigerators, electric lights, and central heating and/or air conditioning. The replacement rate of these items with more efficient ones generally depends on the installed appliances' expected lifetimes, which can range from five to twenty years or more.

POLICY OPTIONS

- *Develop Institutional Planning and Support Structures.* States without existing agencies to deal with energy issues may consider developing them as a means for conducting planning and analysis, administering programs, and providing support for utilities, industry, and consumers. In many states these agencies have been instrumental in facilitating energy-efficiency measures.

- *Institute Long-Range Planning*. Many states, including Iowa, Illinois, New York, Vermont, and Washington mandate energy agencies to provide assessments of state energy consumption as well as potential ways to increase efficiency, reduce energy dependence, and increase use of renewable energy resources. These plans provide valuable focal points for policy development through time and across the economic sectors that affect a state's energy consumption.

- *Facilitate Interaction Between DSM Program Sponsors and Potential Customers.* States are in a unique position to facilitate interactions between a variety of important participants and stakeholders in the energy-efficiency field. For example, states may act as the liaison between federal energy-efficiency programs and local industries and governments, or between utilities and potential commercial or industrial energy-efficiency clients. The "Super Good Cents" program in the Pacific Northwest, for example, is a state-utility partnership that involves providing technical information and training, as well as rebates to consumers for energy-efficiency investments in their homes.

- In addition, state governments can lead collaborative efforts involving government agencies, utilities, energy service companies, customers, and advocacy groups to develop consensus approaches to energy-efficiency policies and programs.

- *Rationalize State Tax Policy*. Although practice varies from state to state, tax policies often favor energy consumption over energy efficiency. In some states, purchases of gas and electricity are exempted from states taxes, while energy-efficiency investments (more efficient equipment, insulation, etc.) are not. At a minimum, tax policy may cease to favor consumption over efficiency, but may further serve to discourage inefficient consumption.

- *Provide Information and Education*. States can gather and disseminate information (often working with utilities) on the energy and financial implications of energy-efficiency projects in certain types of buildings and facilities and promote research, development, and demonstration projects. Through their university systems states may also promote energy-efficiency training in professional planning and urban design programs.

- *Take Direct Action to Reduce Energy Consumption in State Facilities*. States can reduce energy consumption on their own properties, including schools and low-income housing projects. Iowa, for example, undertook an energy-efficiency improvement program designed to make all of its public school buildings energy efficient by 1995. Such programs may involve retrofitting existing state facilities, changing state building and procurement practices to require energy-efficiency investments, and modifying state building design requirements. For example, Florida has initiated a broad effort to reduce energy consumption in state facilities by 30 percent within three years. The state also plans to use this effort as a model for local governments and the private sector.

- *Establish and Enforce Efficiency Standards and Codes*. States may wish to encourage more integrated and aggressive approaches to promoting energy efficiency in buildings by supporting and strengthening disparate and outdated building codes. In addition, states should develop mechanisms for agencies to enforce the codes they adopt. An initiative in Florida, for example, requires construction agencies to disclose the material content of their buildings to building inspectors and to the buyer; this establishes a stronger feedback loop and trail of liability if buildings are not built to energy-efficiency specifications, providing incentives for contractors to adhere strictly to the codes. EPAct encourages states to adopt energy-efficiency provisions at least equal to ASHRAE standards for commercial buildings and the 1992 model Energy Code from the Council of American Building Officials for residential structures.

- *Demonstrate Building Efficiency Measures and Facilitate Energy-Efficiency Programs.* States are uniquely situated to initiate energy-efficiency demonstration projects in buildings (often using their own facilities) and to publicize resulting information on energy and cost savings. Similarly, states are often well-situated to coordinate interactions between landlords and tenants, especially in the commercial sector, in order to facilitate efficiency improvements in existing buildings. Programs to achieve these goals can include innovative approaches such as setting minimum efficiency standards for rental properties or developing shared savings programs where landlords and tenants both benefit from energy-efficiency investments.

- *Provide Financial Incentives for Efficiency Improvements*. States can provide financial incentives for accelerating equipment replacement rates through tax credits or low interest loans on efficiency improvements, by taxing inefficient appliances and equipment, or by working with utilities to sponsor rebate programs that induce consumers to purchase efficient products. Hundreds of these types of programs exist throughout the country. For example, the State of Oregon offers a 35 percent Business Energy Tax Credit and a Small Scale Energy Loan Program. Similar programs are supported by the Indiana State Energy Office through innovative public and private partnerships.

5.1.3 Policies to Promote Energy Efficiency, Renewable Energy, and Carbon Offsets

DESCRIPTION

In the recent past, state energy officials and utility regulators have promoted measures to increase energy efficiency, in order to reduce the energy costs borne by state residents. State officials have worked with electric and gas utilities to promote energy efficiency in programs termed either demand-side management (DSM) or integrated resource planning (IRP).

With deregulation of the electric utility sector, the opportunities available to state officials to promote energy efficiency are changing. Once electricity generation is deregulated in a state, prices will be set by market forces. State officials will no longer regulate electricity prices, and thus will not have the opportunity to ensure that utilities employ conservation measures where these are less costly than new generation. Nor will state officials have much direct influence over new suppliers of electricity that enter the market after deregulation.

At the same time, however, deregulation will provide opportunities for states to indirectly influence the markets for energy and energy conservation. These opportunities can be used to promote energy-efficiency and fuels with relatively low GHG emissions.

CONSIDERATIONS

Electric and natural gas service reaches virtually every household, and these energy sources supply the majority of energy used by households and businesses. Policies that serve to reduce emissions from the use of electricity and natural gas can have a major influence on a state's level of greenhouse gas emissions.

POLICY OPTIONS

Chapter 6 discusses five policy options for reducing GHG emissions through energy conservation, renewable energy, and carbon offsets in the electric utility sector. The following options are described in Section 6.1:

- *Ensure Infrastructure Access for Small Power Producers, and Promote Purchase of "Green Power"*
- *Institute a "Social Benefits" Charge or a Carbon Tax on Electricity Generation*
- *Promote Voluntary Adoption of Energy-Saving Technologies*
- *Establish or Support Carbon Offset Programs*
- *Support Emission Trading Programs*

As utility deregulation proceeds, states may consider one or more of these policy options to reduce greenhouse gases in the energy sector; many of these options can reduce energy costs for state residents.

5.1.4 Conserve Energy Through Improved Industrial, Agricultural, and Municipal Waste Management Processes

The preceding subsections have outlined technical approaches for improving energy efficiency, and described general policy approaches -- *Direct State Action* and *PUC Policies* -- for encouraging these actions. Most of the technical approaches and policy options apply equally to the residential, commercial, and industrial sectors. However, the industrial sector presents a challenge to policy-makers because of its diversity, the relative magnitudes of the savings available from individual industrial facilities, and the investment costs required to achieve these savings. The agricultural sector presents challenges as well because many of the policy options exercised in other sectors are not applicable to agriculture. Perhaps more important, PUC-directed utility DSM programs may not be available to rural customers who are served by rural electric cooperatives. In the municipal solid waste management sector, decisions are typically made at the local government level. For these reasons, industrial, agricultural, and municipal waste management policy options are considered apart from the previous discussion.

These sectors use large amounts of energy to produce goods, including heavy industrial products, consumer products (which may result in generation of MSW), and food. Many industrial and manufacturing technologies for extracting, refining, and processing raw materials and for building a variety of finished goods are extremely energy-intensive. Similarly, modern farms grow, harvest, and refine crops, maintain livestock, and process meat and dairy products using machinery and equipment that draw large amounts of energy. There is enormous potential for conserving energy in these sectors by utilizing energy efficient machinery and processes, and by increasing source reduction and recycling (because typically less energy is used when recycled inputs are used in place of virgin inputs). Actions to reduce energy use may also bring significant ancillary benefits, like reduced costs and improved productivity, and therefore general economic stimulation in the regions where the industries and farms are located.

Because they span most types of industries, manufacturers, and farms, the range of approaches for reducing energy consumption in these sectors is too situation-specific to present here. The general energy conservation principle is that these energy consumers can either improve their machinery and technologies to utilize less energy, or they can use the by-products (sometimes just heat) from their operations to produce energy on-site. The latter process often utilizes formerly wasted resources and supplants the need to draw so much power from traditional sources. Section 5.2 elaborates on these types of renewable energy production processes.

Examples of the first category of energy efficient processes include use of variable speed motors that adjust continuously to meet work load demand, thus saving energy when work loads are light, and the use of infrared rather than more energy-intensive thermal processes for drying grain or for drying fresh paint on consumer products.

Several specific constraints, however, may inhibit efforts to improve energy efficiency. For example, besides the general barriers that apply to adoption of all energy efficient technologies, which the beginning of this section discusses, a relatively long time period is usually required for the replacement of industrial equipment. Most energy-intensive industrial processes are capital-intensive and the rate of equipment turnover is often measured in decades. Additionally, the diversity of technologies and operations utilized in these sectors can sometimes make it difficult to apply one type of efficient technology in distinct settings.

POLICY OPTIONS

Programs to encourage energy efficiency and conservation through improved industrial, agricultural, and municipal solid waste management processes can be designed in two ways. First, they can concentrate on specific categories of businesses, like steel producers, small engine manufacturers, or dairy farms. Doing so requires understanding the economic and technical environment surrounding the particular sector being addressed, including how that sector uses energy, available energy-efficiency technologies in that sector, and how these technologies will affect product quality and production. By addressing the distinct needs of each type of business being targeted, states can enhance the prospects for success in reducing energy consumption. States including North Carolina, Louisiana, and New York have developed effective programs of this type.

The second approach is to promote energy efficiency across all categories of industries or farms, or in the cross-cutting area of municipal waste management, providing broad education or incentives to encourage innovation and energy efficiency in as many areas as possible. Specific policy options are listed below.

- *Support Research and Provide Direct Assistance Targeted at Specific Businesses or Sectors.* States, often through energy agencies, can select particular energy-intensive industries to assist with research, financial support, and technical assistance. For example, the Louisiana State Energy Office works with the state's aquaculture industry to develop innovative engineering approaches for increasing that industry's energy efficiency and simultaneously enhancing their economic productivity.

- *Sponsor Technology Demonstration Projects*. States, often working with leading firms in a targeted industry, may demonstrate the potential for using new energy-efficiency technologies to everyone in that industry. The demonstrations can both provide good public relations and prove the technology's success with an industry leader.

- *Provide Broad Incentives for Energy-Efficiency Research and Development.* Broad programs to solicit innovative ideas on energy efficiency from all sectors can provide incentives for research and development in areas that state programs will never directly address. These incentives may be research grants, energy-efficiency loans, or direct financial or publicity rewards for independent innovation.

- *Provide Direct Financial Incentives for Energy-Efficiency Investments.* Similar to subsidizing energy efficiency in buildings and in other sectors, financial assistance, low interest loans, and rebate programs targeted at specific energy-efficiency investments can promote technological conversions. For example, the Bonneville Power Administration in the Pacific Northwest is currently working with its industrial customers to encourage energy conservation through equipment rebate programs (Washington, 1993). Current program savings have consistently met or exceeded the Power Administration's goals. These rebates are often customized to meet the distinct needs of particular customers and situations, in contrast to standardized technology-based rebates that apply in other sectors.

5.1.5 Promote Urban Tree Planting

Another mechanism for reducing demand for energy is through strategic planting of trees and shrubbery in urban areas. This type of program, though potentially significant, is often not considered in traditional demand-side management programs.

Landscaping offers the potential to reduce energy needs related to heating and cooling in two ways. First, by providing shade and lowering wind speeds, vegetation, such as trees, shrubs, and vines, can protect individual homes and commercial buildings from the sun's heat in the summer and cold winds in the winter. Second, collective tree planting provides indirect carbon reduction benefits; evapotranspiration (the process by which plants release water vapor into warm air) from trees and shrubs can reduce ambient temperatures and energy use for entire neighborhoods during hot summer months. Urban tree planting can also generate direct carbon benefits. Because half the dry weight of wood is carbon, as trees add mass to trunks, limbs, and roots, carbon is stored in relatively long-lived structures instead of being released to the atmosphere. Thus, programs to support urban tree planting can help reduce greenhouse gas emissions in a variety of ways.

Urban tree planting also provides a number of non-carbon benefits, such as improving air quality, improving aesthetics, providing wildlife habitat, improving property values, and reducing noise. Trees may also reduce runoff, prevent soil erosion, and slow the buildup of peak water flows during an intensive rainfall. Residential planting can also promote awareness of the potential contribution that the general public may make to reducing U.S. emissions of carbon dioxide. Available data indicate that over half of the available tree spaces in American cities are empty. At the same time, a variety of constraints can inhibit tree planting programs. These commonly include water restrictions in some areas and the fact that compacted soil and urban irritants such as salt can inhibit a tree's natural growth. Additionally, improperly placed trees can reduce solar heat in the winter.

With careful planning, however, tree planting programs can be highly successful. In Minnesota, for example, the Twin Cities Trees Trust has blended the goal of employing disadvantaged adults with environmental improvement in the form of urban tree planting and landscape construction (Minnesota, 1991).[4] The Sacramento Municipal Utility District in California has contributed over a million dollars annually to the Sacramento Tree Foundation for tree planting activities. Grants from the County and City of Sacramento, together with an Urban Forestry Grant from the California Department of Forestry, also support Trees for Public Places, a community tree planting program. At the national level, Cool Communities, sponsored by DOE, encourages the planting of shade trees to improve energy efficiency, while simultaneously sequestering carbon. The Cool Communities program has been tested, and found effective, in Tucson, AZ; Dade County, FL; Atlanta, GA; Springfield IL; Frederick, MD; Tulsa, OK; Austin, TX; and Davis-Monatham Air Force Base, AZ. It is currently being further expanded under the CCAP.

POLICY OPTIONS

State programs to support urban tree planting often involve providing technical assistance, grants, and educational services to local communities and private organizations. More direct programs may target residences and business. Specific policy options include:

- *Provide Institutional Support to Communities.* Technical assistance can aid communities and utilities in designing residential tree planting programs and assessing their energy and carbon benefits. This is especially helpful in areas where localities do not have access to the technical knowledge and resources necessary to coordinate programs.

- *Provide Financial Incentives to Organizations and Individuals.* States can encourage private and local tree planting programs through cost-sharing or direct payments to homeowners or utilities or through direct program financing for local organizations. Direct or guaranteed loans to encourage tree planting may also be successful. Utility demand-side management programs in California directly subsidize residential and commercial tree planting activities.

- *Support Research on the Effects of Tree Planting.* Support for research and development or pilot testing, in the form of direct technical assistance, grants, tax incentives, or loans, can help answer some of the outstanding questions in this area pertaining to the potential benefits and feasibility of tree planting programs in different regions. For example, state grants may encourage non-profit organizations or university groups to investigate the strategic placement of trees in cities or neighborhoods to maximize year-round energy savings.

- *Regulate Tree Planting.* Typically the purview of localities, landscape ordinances requiring tree plantings with new construction have been used in many cities.

5.2 GREENHOUSE GASES FROM ENERGY PRODUCTION: SUPPLY SIDE MEASURES

As described in Section 5.1, measures to decrease carbon dioxide emissions from the energy sector may focus on either reducing energy consumption or reducing emissions during electricity production. This section addresses the electricity production category, highlighting the critical role of utilities and independent power producers. Section 5.1 addressed the consumption category while Chapter 6 combines these issues in a discussion of the economic framework that shapes the energy market in the U.S. While

[4] Minnesota has researched and produced a document entitled *Carbon Dioxide Budgets in Minnesota and Recommendations on Reducing New Emissions with Trees* that specifically addresses reducing carbon dioxide emissions and energy demand through tree planting.

treated separately for ease of presentation, these three sections of the document are closely connected and should be considered together.

Several federal statutes affect the level of greenhouse gas emissions from electricity production including the Public Utilities Regulatory Policy Act (PURPA), the Public Utilities Holding Company Act (PUHCA), and the EPAct. Under PURPA, the federal government and state governments can encourage efficiency among power producers and can encourage transitions to modes of power production that result in lower greenhouse gas emissions, including use of renewable fuel sources. States can also affect greenhouse gas emissions in the power supply sector through their jurisdiction pertaining to environmental protection, as well as through regulation of powerplant siting and certification. States have some jurisdiction in controlling natural resource use, for example, upon which the power supply sector relies heavily, and in protecting wildlife and wildlands, which some utility emissions or power development programs may threaten.

This section discusses approaches to reducing emissions from three types of energy producers: utilities, independent power producers that sell the energy they produce (mostly to utilities), and industrial and agricultural facilities that use their energy on-site to support their own operations. Although many policies to promote emission reductions will affect all three of these producer categories, resulting in some overlap in the information presented below, the distinction between the three remains useful because the size and scale of their operations varies significantly and each faces a distinct set of potential motivations for reducing emissions.

There are three primary actions each of the three types of producers can pursue for reducing emissions, depending on the nature of their current operations:

- *Transition Away from High Carbon Generating Technologies and Fuels.* In a greenhouse gas context, this frequently means utilizing natural gas, hydroelectric, or nuclear energy instead of coal or oil. Universal constraints to switching to natural gas include the need for producers to have access to this fuel, which may be limited by infrastructural or legal constraints in some regions, the relative price volatility of gas, and questions regarding deliverability. Other constraints inhibit the large-scale non-carbon alternatives. Hydroelectric power development, for example, is often limited by environmental concerns such as ecosystem damage through flooding and disruption of water supplies, and nuclear power production is constrained by public safety and environmental concerns, as well as the cost of nuclear units and perceived financial risks. No new nuclear plants have been commissioned in the United States for several years.

- *Use Renewable and Alternative Energy Sources*. Alternative energy sources consist of non-fossil fuel based power generating technologies and processes, including biomass, waste heat used for on-site cogeneration, methane from non-traditional sources, wind, geothermal heat and pressure, solar thermal and solar photovoltaic processes, and tidal currents.[5] Initial installation costs can create constraints and vary significantly among sources; in many cases these costs limit the ability to compete with fossil fuels. Research and development on technologies to utilize many of these sources is gradually enhancing their cost-effectiveness.

- *Reduce Emissions Regardless of Fuel Type Through Technology and Process Upgrades.* Using the most efficient electricity generating technologies and processes can minimize the average

[5] Chapter 6 examines biomass energy programs in more detail, describing how agricultural and forest crops can be used to generate power or to produce liquid, gaseous, and solid fuels for other purposes.

quantity of greenhouse gases emitted per unit of electricity produced. This can be achieved either by operating existing equipment at optimal rates of generating efficiency (which means attaining the highest feasible energy output per unit of fuel input), or by installing new technologies that offer higher levels of power generating efficiency than are currently available. The most frequent constraints on these processes are equipment investment costs and fluctuations in energy demand that make it difficult to maintain optimal generating efficiency. In addition, significant savings may become available through reductions in transmission and distribution losses as new technologies are adopted, as well as through use of cogeneration and district heating.

The sections below discuss each of these three mechanisms as they apply to the electricity generation sector, and to on-site energy producers/consumers.

Alternative policies to promote emission reductions may affect not only the different types of power producers but also the time frames within which certain approaches are implemented and their greenhouse gas reduction benefits accrue. Some approaches are feasible and offer emission reductions immediately, like capturing and utilizing methane at coal mines and landfill sites, while others may take many years to implement, as with certain renewables, whose costs must come down before they are economical. While long term projects in the energy supply sector often require large-scale capital conversion, technological innovation, and infrastructure development, they also offer the highest potential magnitude of emission reductions of all greenhouse gas sources.

Common constraints or barriers can inhibit approaches to reducing emissions during power generation across all types of producers. These include high initial capital costs for new technologies, lengthy government permitting processes for new or modified power production, and regulatory limitations on the size or extent of power producing activities. Other barriers include limited access to transmission lines for remote energy sources (for example, wind or geothermal) and financial risks which require rates of return higher than for traditional power sources. Finally, tradeoffs with other state policy objectives (for example, promoting economic stability by supporting utilities or promoting aesthetic interests where extensive solar or wind power generating facilities are feasible) may also impede emission reductions. The policy options outlined under the following technical approaches address these barriers.

5.2.1 Reduce Greenhouse Gas Emissions from Electricity Generation

DESCRIPTION

The electricity generating sector can help reduce greenhouse gas emissions by improving the efficiency of electricity generation or by generating power using low-emission or no-emission technologies. As mentioned above, because the electricity generating sector uses substantial amounts of fossil fuel, there are opportunities for significant GHG reductions in this sector.

CONSIDERATIONS

Improving processes directly at electricity generating plants can include two types of actions:

- *Switching to low-emission fuels and generating technologies.* In the near term, the greatest opportunities for reducing emissions are likely to involve utilizing natural gas, the fossil fuel with the lowest carbon content per unit of energy.[6] Natural gas can be converted to electricity at high efficiency, using new combined cycle gas turbines. (Extensive literature is available on fuel-switching and efficient technologies for electricity generation.) Under utility deregulation, market forces will determine the extent to which such low-carbon technologies will substitute for coal- or oil-burning generators. Section 6.1 discusses potential policies that states could implement to favor such technologies.

- *Switching to zero-emission technologies.* When renewable energy sources (including photovoltaics, biomass fuels, and wind) are used for electricity generation, no greenhouse gases are emitted. (The carbon dioxide from biomass fuels is not counted because it is biogenic.) Although costs of generating electricity from renewable sources is currently higher than costs for fossil fuels, the costs of photovoltaics and other renewables are declining. Section 6.1 discusses potential policies that states could implement to favor renewables.

- *Improving the efficiency with which energy is produced using existing equipment and facilities.* Technological innovations may offer the opportunity to improve generating efficiency beyond commonly attained levels.

A state may wish to examine the greenhouse gas emissions (and perhaps other pollution) associated with producing electricity, and reflect these "externality" costs in the price of electricity. Section 6.1 discusses two possible approaches -- a "societal benefits" charge or a carbon tax on electricity generation.

Policies designed to reduce emissions from electricity generation should account for several additional issues. Foremost, the actions discussed above to reduce greenhouse gas emissions generally support other environmental objectives as well, such as producing less particulate air pollutants per unit of energy produced. However, switching away from high carbon fuels, especially coal, will also have significant impacts on economies in certain regions of the country that are rich in these resources. Additionally, limited infrastructure for supplying fuels like natural gas in some areas may inhibit the use of these fuels for large scale power generation.

POLICY OPTIONS

Policies to reduce greenhouse gas emissions from electricity generation will ideally (1) promote demand-side management to mitigate the need for new power sources; (2) support alternative low-carbon energy sources to meet new power needs whenever possible; and (3) encourage the transition from existing high-emission fuels and technologies to low-carbon options. Specific options for pursuing these objectives, which are discussed in Section 6.1, include:

- *Ensure Infrastructure Access for Small Power Producers, and Promote Purchase of "Green Power"*
- *Institute a "Social Benefits" Charge or a Carbon Tax on Electricity Generation*
- *Promote Voluntary Adoption of Energy-Saving Technologies*
- *Establish or Support Carbon Offset Programs*
- *Support Emission Trading Programs*

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[6] While natural gas offers the lowest carbon emission rates of the various fossil fuels used for producing electricity, switching to *any* source with lower carbon content than the fuels currently used will yield greenhouse gas benefits. In some situations, for example, this could suggest switching from coal to oil rather than converting to natural gas, although this choice may not be desirable for other reasons, such as national security and trade balance concerns.

In addition, states may wish to consider providing subsidies and marketing support for renewable energy:

- *Provide Direct Incentives for Alternative Energy Development.* States can promote renewable energy development through investment tax credits, equipment subsidies, low-interest loans, copayments with utilities on energy produced from alternative sources, and other incentive programs.

- *Provide Information, Education, and Technical Assistance to Support Alternative Energy Development.* States can conduct demonstration projects, do financial analyses, and provide information about alternative processes to the potential investment community. For particular projects, states may also be able to provide direct services such as financial assessment or technology upgrade audits.

5.2.2 Reduce Emissions Through On-Site Power Production

Various industrial and agricultural facilities can help reduce net greenhouse gas emissions and save money by utilizing on-site resources to meet their energy needs. Coal mines can capture methane and use it to generate electricity for their own use, for example, and dairy farms may use methane from livestock wastes as an energy source. In essence, power consumers in these situations become small scale power producers. They reduce greenhouse gas emissions by meeting part of their energy needs that would traditionally have been met by utilities and, in many circumstances, by utilizing excess methane that would otherwise have contributed directly to greenhouse gas emissions.[7]

Two types of energy may be generated through on-site processes: thermal heat and electricity. Where a site requires thermal energy, cogeneration of both thermal energy and electricity should be considered, because cogeneration is a highly efficient process.

CONSIDERATIONS

These actions can be considered as either production side emission reduction measures or consumption side energy-efficiency measures. They reflect distinct characteristics of each, including demand-side barriers to energy efficiency and supply side constraints for renewable energy.

Additional information on specific opportunities for using methane for on-site energy production is presented in Sections 5.5 through 5.9. Policy-makers should investigate the opportunity for promoting these processes at both existing and new facilities, because the incentive and support structures for retrofitting existing facilities may vary from those for initial investment.

POLICY OPTIONS

Many of the same policies listed in Section 5.2.1 will apply to on-site power producers. In addition, states can:

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[7] Methane is an important greenhouse gas. Biomass wastes contribute to methane and/or carbon dioxide emissions when they are burned for disposal, left to decompose, or placed in landfills.

- *Provide Direct Assistance for Equipment and Facility Conversion.* States may conduct technological and financial analyses for specific industrial facilities in order to demonstrate the value of cogeneration and similar practices. States may also be able to provide ongoing technical support to enhance industry confidence in new processes, and can initiate the type of financial support through taxes and subsidies listed in the previous section.

- *Establish Programs and Regulations to Reduce Risk to Firms.* States may guarantee financial support if new processes do not function as expected and may require utilities to provide backup power to industrial facilities, like coal mines, if those facilities' on-site sources do not meet their energy needs. Without these provisions utilities may have incentives to distort prices or restrict power access to customers who are considering producing their own energy.

5.3 GREENHOUSE GASES FROM THE TRANSPORTATION SECTOR

Carbon dioxide (CO_2) is the main byproduct resulting from combustion of gasoline and other petroleum-based fuels used by the transportation sector. Carbon dioxide emissions are directly proportional to the quantity of fuel consumed: burning a gallon of gasoline releases approximately 20 pounds of carbon dioxide into the air (OTA, 1991). In addition, the extraction, processing, transfer, and combustion of fossil fuels produce other greenhouse gases, lead, and other pollutants, and contribute to acid rain and urban ozone precursors.[8]

The transportation sector consists of highway and off-highway vehicles, marine vessels, locomotives, and aircraft. Highway vehicles include automobiles and light-duty vans and trucks up to 6,000 pounds in weight, light-duty trucks between 6,000 and 8,500 pounds in weight, heavy-duty trucks and buses, and motorcycles. Off-highway vehicles include farm tractors and machinery, construction equipment, snowmobiles, and motorcycles. This section focuses on options to reduce emissions from the highway vehicles fleet.

Activity to the transportation sector from all these vehicle categories is fundamentally a product of the demand for mobility of either people or goods and services in our society. Traditionally, as this demand for mobility increases, so do related emissions of carbon dioxide and other pollutants. Policies to reduce emissions in this sector, therefore, can be targeted either at reducing the demand for mobility in general, or reducing emissions at current or increasing levels of transportation activity. Both of these approaches are referenced throughout this section. In addition, Chapter 6 discusses the potential for reducing emission from the transportation sector through land use change and city and rural planning measures (see section 6.5).

It is important to note that this section provides only a brief introduction to transportation policy.[9] In this complex field, in general, carbon dioxide emissions from the transportation sector are currently not

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[8] These other pollutants include: methane, carbon monoxide, nitrous oxide, non-methane hydrocarbons, oxides of nitrogen and sulfur, and particulate matter. Nationwide, transportation is responsible for 70 percent of carbon monoxide, 40 percent of volatile organic compounds, 40 percent of nitrogen oxides, and 35 percent of lead, particulates, and nitrous oxide. While these other gases from the transportation sector are also considered to be greenhouse gases, they are not thought to be major contributors relative to the carbon dioxide emissions; and, unlike carbon dioxide, some can be partially mitigated through the application of emission controls (NAS, 1991).

[9] For a more comprehensive overview of the environmental implications of transportation measures, see Kessler and Schroeer, 1993 and OTA, 1994. (Note: OTA gives an overview of the U.S. transportation system and options to increase energy-efficiency within this sector.)

regulated, while regulation of other transportation-related emissions and fuel consumption standards have traditionally fallen under federal jurisdiction. Criteria pollutant emissions are controlled through the Clean Air Act (which is implemented at the state level through State Implementation Plans), while light-duty vehicle fuel efficiency is regulated through Corporate Average Fuel Economy (CAFE) standards as established in the 1975 Energy Policy and Conservation Act. Some states, notably California and those in the New England region, have sought additional improvements in their urban air quality through various measures to limit vehicle emissions (South Coast, 1991; New England, 1990). These measures include transportation control and air emissions standards that supersede existing federal standards. The South Coast Air Quality Management District's Air Quality Management Plan for the Los Angeles Basin, discussed in Chapter 2, represents an example of such a comprehensive plan for regional emission reductions.

Technical approaches for reducing greenhouse gas emissions from the transportation sector include reducing vehicle miles traveled, reducing emissions per mile traveled, and using alternative fuels. The remainder of this section discusses these three approaches.

5.3.1 Reduce Vehicle Miles Traveled (VMT)

DESCRIPTION

Reducing total vehicle miles traveled involves decreasing the overall need or desire for driving, replacing single-occupancy driving with alternatives such as mass transit or car pools, or shortening the time and/or the distance required for each trip. Collectively, these are known as transportation control measures (TCM). Reducing vehicle miles traveled in other transportation categories, such as heavy vehicles transport and trains, also involves switching to alternative modes of transportation or combining modes, increasing load factors (for example, reducing empty or partial-load trips for busses and shipping of products), reducing travel needs, and shortening of travel time and/or travel distances.

CONSIDERATIONS

The issues associated with VMT reduction measures that influence how effective these measures will be in attaining emissions reductions include:

- *Infrastructure Issues*. Many regions, especially in the west and south, have less developed mass transit systems. Additionally, transportation control measures might not be feasible for states that are predominantly rural.

- *Financial Issues*. Many cities and states currently do not have the financial means to implement extensive transportation control measures, urban light rail systems, or intercity high speed rail. While some measures can be cost-effective by reducing the time workers spend in traffic,[10] or reducing the energy consumed per-passenger, implementing a transportation control measures package requires significant advance planning and preparation, and may also require extensive commitment from governments with limited resources.

[10] For example, the City of Denver, CO was able to reduce up to 40 percent of commuters' commuting time by instituting high occupancy vehicle lanes and other transportation control measures.

- *Institutional Issues*. Many Americans simply prefer driving over any other form of transportation or prefer goods which must be shipped long distances. Switching to alternative transportation modes or reducing VMT in other ways may require lifestyle adjustments.

Experience from existing transportation control programs to reduce air pollution in various cities offers insights into some ways these constraints can be addressed. These general insights should be considered during the implementation of all types of policies. Foremost:

- *Transportation control measures are often most effective when multiple complementary measures are implemented simultaneously as a single package*. This may include, for example, development of employee ride-share incentives, construction of high-occupancy vehicle lanes (carpool lanes), and increases in rates charged for parking.

- *Transportation control programs achieve larger emission reductions when they are coordinated throughout a region and over an extended period of time.*

- *Transportation control programs function best if implemented locally, so that measures can be tailored to traffic patterns, infrastructure, and zoning ordinances in each individual area*. In all situations, critical characteristics that transportation control programs need to consider prior to new program implementation include factors such as population and employment groupings, highway capacities and congestion levels, and major transportation routes and alternatives (OTA, 1991). Chapter 6 presents information on additional land use and city and regional planning considerations as they affect transportation control measures to reduce VMT.

An additional analytic consideration relating to transportation control efforts is that in many areas there is latent demand for access to primary transportation corridors. This implies that as congestion decreases because of the transportation control measures, some people who were discouraged from driving before due to congestion may begin to use their cars as single-occupants, thus negatively impacting emissions reduction efforts.

POLICY OPTIONS

Options for reducing transportation demand, especially for reducing single-occupancy driving, include:

- *Information and education programs*. States may implement programs to encourage alternatives to driving, including public education campaigns and various types of demonstration or pilot projects. For example, many states support campaigns to promote the benefits of high-occupancy vehicles lanes, ride sharing, and mass transit. In addition, states can work directly with employers to develop new VMT reducing programs. Demonstrating to employers the multiple benefits of offering employees a choice of cash rather than subsidized parking spaces, for example, can lead to decreased employee driving, increased use of mass transit, and therefore reduced carbon dioxide emissions. California has enacted legislation requiring some businesses to pursue this type of program (South Coast, 1991).

- *Institutional support programs*. States may also improve mass transit systems, high occupancy vehicle lanes (HOV), mass transit lanes, and enhanced traffic management systems such as synchronization of traffic signals. Virginia, for example, has instituted HOV lanes on much of its highway system in Northern Virginia as part of its traffic control effort. Similarly, the Connecticut Department of Transportation has helped to establish nearly 12,000 car pools and 180 van pools since 1980, saving an estimated nine million gallons of gasoline yearly.

- *Incentives to businesses and employers*. These include financial incentives (tax breaks or low interest loans) for businesses to initiate car and van pools and encouragement to alter or stagger work schedules and work modes. This may include establishing four-day work weeks or tele-commuting where employees work from their homes or other non-centralized locations, thus mitigating the need for travel to work. A pilot tele-commuting program involving 134 Arizona state employees, for example, reduced an estimated 97,078 commuting miles and saved over $10,000 in gasoline and other costs in a six-month period, and is being recommended for expansion (NGA, 1991).

- *Incentives to transportation consumers*. These include incentives to use mass transit and bicycling or walking, parking management (higher parking fees and/or elimination of subsidized parking), congestion pricing (tolls on heavily traveled roads during peak periods), auto use restriction (higher registration and license fees), and increased gasoline and road taxes. One example is the Federal government's monthly cash allowance for its employees within the District of Columbia metropolitan area who use public transportation.

- *Direct state action*. States and cities may alter local institutional guidelines and regulations that affect transportation. One of the primary opportunities in this area is to zone urban or central areas to exclude expansive development of areas for parking, so that commuters have additional incentive to car-pool or use mass transit. This approach, of course, depends on the ready availability of the low-emission transportation alternatives to single-occupancy vehicles. In a related measure, many state and city laws restrict private transportation system development to taxi cab services. Loosening these restrictions, if in conjunction with other complementary actions, may result in the development of alternative transport systems such as the van services that are allowed for commuting between many urban centers and nearby airports.

Exhibit 5-8: Automated Traffic Signal Controls in Missouri

To move traffic more efficiently in two of the state's major metropolitan areas, the Missouri Department of Natural Resources' Division of Energy granted $560,000 to the Missouri Highway and Transportation Department to install automated traffic signals. The signal control system continually monitors traffic and automatically adjusts signal timing for optimum operation and traffic flow, greatly reducing fuel consumption and travel time for motorists. Each control system is located along a main corridor to allow the bulk of motorists to move efficiently. One system was installed in Kansas City; the other near St. Louis.

In Kansas City, the automated traffic signals have reduced fuel consumption by 87,000 gallons per year, reduced the number of stops by vehicles by 16 million per year, and increased average traffic speeds such that annual motorist travel time was reduced by 120,000 hours. Similarly, in St. Louis fuel consumption has been reduced by 353,000 gallons per year, the annual number of stops has been reduced by almost 33 million, and average traffic speeds have increased to reduce annual travel time for motorists by 336,000 hours. All of these factors reduce carbon dioxide emissions.

- *Other policy options*. Additional options to reduce vehicle miles traveled include instituting auto insurance reforms to reflect the costs of driving (pay-as-you-drive auto insurance, for example) and promoting freight transportation system least-cost planning and/or imposing a load-weight-distance tax on heavy trucks to make trucking more expensive and encourage other less energy intensive modes of freight transport, such as rail. Longer term measures for VMT reduction include urban light rail development, intercity high-speed rail, and integrated and inter-modal transport systems.

As mentioned above, most of these transportation control measures function best when implemented in packages so that they support and reinforce each other.

5.3.2 Reduce Emissions per Mile Traveled

DESCRIPTION

Lowering emissions per vehicle per mile involves either improving the fuel efficiency of one mode of transportation (such as automobiles or freight trucks) or substituting with a more efficient mode (such as using trains rather than trucks). Carbon dioxide emissions are linked directly to fuel efficiency. While vehicle fuel efficiency standards historically fall under the federal government's purview, states can play a role in maintaining or improving the efficiency of the existing fleet by accelerating the replacement of less efficient vehicles with less polluting and more efficient ones. Poor system integration between transportation modes is often the cause for higher energy consumption as well as lengthy delivery times for freight transport. Therefore, encouraging the inter-modal substitution of transportation mechanisms, such as using trains or ships for long distance freight and trucks for local distribution, can also act to promote efficiency.

CONSIDERATIONS

Emission reductions from gains in fleet efficiency can take longer to realize than the gains achievable through transportation control measures described in the previous section. Improving fleet efficiency is dependent on the vehicle replacement rate. The most promising programs, therefore, might specifically target high emitting vehicles, such as light duty trucks or older, less fuel efficient automobiles.

Various institutional issues also affect efforts to increase efficiency. A primary one is behavioral: people maintain well-established habits and preferences. Customers prefer vehicles with amenities and powerful acceleration, for example, while vehicles with higher efficiency often are associated with a lack of amenities, slow acceleration, or certain safety concerns.

The two most significant technological barriers to the propagation of fuel efficient technologies in vehicle engines are reliability and availability. Generally, technologies to increase fuel efficiency also increase the degree of technological complexity and often require a higher level of maintenance and support. As with any newly introduced technology, qualified technicians and/or replacement components may not be widely available, especially in rural areas. Additionally, policy-makers should consider that current and future mandated safety and smog control devices often counteract fuel efficiency gains, impeding carbon dioxide emission reductions. Decisions on efficiency will have to balance these alternative benefits.

POLICY OPTIONS

- *Public information programs*. States may work with industry and other groups to educate consumers on the multiple benefits of fuel efficiency. This may include campaigns to stimulate demand for more fuel efficient vehicles and educate people on optimal driving practices. For example, states may consider expanding the EPA's current mileage rating system for new cars to apply to used vehicles as well and to include additional information such as estimated yearly fuel cost.

- *Incentives to vehicle users*. These include fuel efficiency purchase incentives ("feebates" or "gas guzzler" taxes, for example) and registration fees pegged to vehicle fuel efficiency, gross weight, engine horsepower, or emissions control equipment. Other innovative measures, such as programs to retire older automobiles in some areas, including Southern California and Northern Virginia, have proven to be economic on the basis of air quality improvements alone.

- *Wide-scale transportation planning*. States can support wide-scale transportation planning, including supporting on-going research on transportation efficiency and participating in federal and regional dialogues on fuel economy requirements. Connecticut, for example, has recognized and addressed the potential for traffic congestion and pollution from population growth and increased vehicle traffic through innovative pubic and private research partnerships since 1980. This type of planning most often results in regional development of new transportation modes.

- *Efficiency regulation*. States may choose to establish efficiency standards for vehicles. Because of political sensitivities surrounding this issue, the most successful programs of this type often target distinct sectors, such as establishing fleet fuel efficiency standards for fleets or emission limits for fleets. This may include fleet-specific promotion and use of electric and alternative fuel powered vehicles, although the benefits of these vehicles may vary between regions for a variety of reasons.

- *Support and sponsorship of institutional development*. This may include establishing incentives for shifting between modes of freight transport, supporting regional efforts for rail electrification in areas where electricity is produced with little greenhouse gas emissions, and working with industry and other organizations to promote efficiency and support other innovative measures.

- *Fuel efficiency regulation and enforcement*. This includes establishing and enforcing speed limits, establishing and enforcing state emission and inspection/maintenance standards, and instituting used car efficiency standards.

5.3.3 Use Alternative Fuels

DESCRIPTION

In the long run, alternative transport fuels -- fuels with lower carbon emissions -- offer opportunities to reduce greenhouse gas emissions per unit of travel.[11] The National Academy of Sciences' Mitigation Panel divided alternative fuels into three categories (NAS, 1991):

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[11] Emissions from fuel production, such as the extraction and processing of fossil fuels, mining and processing of uranium for electricity generation (and reactor waste), as well as emissions from the cultivation, harvesting, and processing of energy crops for ethanol fuels are factors to consider while estimating long-term emissions from gasoline and alternative fuels.

1) Those that could (a) result in increased greenhouse emissions relative to gasoline, including: methanol from coal, electricity from coal-fired power plants, and ethanol from biomass but (b) are produced and transported using fossil fuels.

2) Those that will reduce emissions less than 25 percent, relative to gasoline, including: diesel, natural gas in any form, methanol from natural gas, clean/reformulated gasoline with up to 25 percent biomass-derived additives, electricity from gas-fired power plants, and electricity from current power plant fuel mix.

3) Those that eliminate or nearly eliminate greenhouse gas emissions, including: methanol and ethanol from wood biomass using biomass fuel to produce and transport, hydrogen from non-fossil fuel-generated electricity, and electricity from non-fossil fuels.

Conversion to alternative fuels may be controversial because it requires long-term planning, additional capital investment, infrastructure changes, and high levels of political commitment.

CONSIDERATIONS

General consensus indicates that, of the alternative fuels that are under development, those that are most ready for the marketplace will not reduce substantially greenhouse gas emissions from the transportation sector. Those that offer the largest potential reduction in emissions are the furthest from large-scale technical viability, and present the most challenges to wide-scale distribution. Additionally, the successful implementation of any of the available alternative fuels could limit prospects for others in the future, since the delivery systems or required infrastructure may not be compatible. The alternative fuels under consideration also offer shorter operating distances, which may require more extensive supply/filling station networks.

Also, at current oil prices, no single fuel listed above can compete in the marketplace against gasoline. In order for any fuel to displace or even supplement gasoline, investments must be made in the scale of the manufacturing process, in the distribution networks, and in fleet conversions. Environmental or toxicity characteristics may be associated with the new fuel.

Institutional resistance to alternative fuels could be significant: converting to any of the alternative fuels at this point does not offer additional, tangible, and recognized benefits to vehicle operators. Without the certainty of a customer base, few suppliers would venture into the alternative fuels arena. Alternative fuels policies may, therefore, need to address both supplier and customer concerns to ensure program success. An example of a federally-

Exhibit 5-9. Clean Cities

Clean Cities is a voluntary program sponsored by the U.S. Department of Energy. It is designed to accelerate and expand the use of alternative fuel vehicles (AFVs) in urban communities and to provide refueling and maintenance facilities for their operation. Under the Clean Cities program, local governments are encouraged to form a partnership with public and private stakeholders, such as utilities, fuel suppliers, environmental groups, fleet managers, vehicle manufacturers, consumers, and federal, state, and local government agencies. Stakeholders cooperatively draft an implementation plan that quantifies program goals and outlines measures to achieve these goals. DOE provides assistance by operating two national hotlines (Clean Cities Hotline and Alternative Fuels Hotline) and maintaining ten regional support offices throughout the U.S. Additionally, fleet operators interested in acquiring AFVs can coordinate their purchases with the federal acquisition program under the Federal Vehicle Replacement Program. As of September 1997, there were 58 designated Clean Cities. Atlanta was the first of these and has established a goal of having 25,000 AFVs in operation by 1996. Interested parties should contact the Clean Cities Hotline at 1-800-CCITIES for more information.

sponsored program designed to address concerns of all stakeholders is Clean Cities (see box 5-9 for a description).

POLICY OPTIONS

Policy options for promoting use of alternative fuels vary depending on time horizons, government commitment levels, and emission reduction goals. Options include:

- *Target programs to utilize local alternative fuel sources*. The Corn Belt states currently subsidize and publicize fuels made from corn, such as ethanol; other states could similarly promote and develop local resources. These programs may provide experience and knowledge needed for the implementation of larger programs.

- *Convert state or city-owned fleets to alternative fuels*. Governments may directly reduce emissions and demonstrate alternative fuel feasibility by converting their own state vehicles and mass-transit vehicles to use alternative fuels. For example, Burlington, Vermont, and Portland, Oregon, are converting their fleets.

- *Support research and development programs*, including research of non-fossil fuels, research of promising "transition" strategies, and research and incentives for electric/hybrid design and development. Despite the barriers associated with alternative fuels, states could consider sponsoring pilot programs for demonstration and feasibility study purposes.

- *Provide incentives to support institutional development*, including incentives for vehicle conversion, filling station/distributor conversion, alternative fuel vehicle purchase, alternative fuel use in private and government fleet vehicles, and innovative programs to replace gasoline.

5.4 METHANE FROM NATURAL GAS AND OIL SYSTEMS

Methane is the principal component of natural gas. Any leakage during the production, processing, transmission, and distribution of natural gas will therefore contribute to methane emissions. Natural gas is often found in conjunction with oil, and thus gas leakage during oil production and transportation is another source of methane, though minor in the United States. Therefore, options for reducing methane emissions from oil production and transportation are not addressed here.

The U.S. natural gas system is subject to both state and federal regulations controlling leakage, primarily out of public safety concerns. As a result, the U.S. natural gas industry is one of the most efficient systems in the world, in terms of methane emitted per quantity of gas produced. More recently, stringent regional air quality regulations (*e.g.*, controlling VOCs and NOx emissions) impact the operation of natural gas systems, and compliance with these regulations will undoubtedly affect emissions of methane from various stages of the gas system. The rate regulation of the U.S. gas industry by FERC and state PUCs can also help determine the economic feasibility of actions taken by gas companies. State policies designed to reduce emissions from natural gas systems will need to consider the influences of existing economic and safety regulations.

A number of technical approaches exist to reduce methane emissions from natural gas systems. Many of these approaches can be cost-effective for firms in the natural gas industry and ultimately beneficial to natural gas consumers. In fact, many of the approaches discussed here are already in use by companies in the U.S. natural gas industry. State programs addressing informational and institutional barriers to the continued implementation of these technologies could reduce methane emissions in the short term.

DESCRIPTION

The natural gas system includes production sites, processing and storage facilities, and transmission and distribution networks. Methane is emitted from a wide variety of components, processes, and activities in each of these stages. Because the majority of emissions occur in the production, processing, transmission, and distribution stages, options for storage facilities are not considered here. This section focuses on emission reduction options with the highest potential impact, in terms of both the technical and economic feasibility of reducing methane emissions.

The production and processing of natural gas accounts for about 40 percent of methane emissions from U.S. natural gas systems; transmission of gas to distribution facilities accounts for another 35 percent; the distribution of gas to end users through smaller, lower pressure pipes accounts for around 10 percent; and compressor engine exhaust accounts for about 15 percent. The majority of these emissions result from leaks (fugitive emissions), venting from equipment such as pneumatic devices and gas dehydrators, venting during routine maintenance, and compressor engine exhaust (U.S. EPA, 1993a). Options are available for reducing emissions from all of these sources.

- *Pneumatic devices* are gas-powered devices used on heaters, separators, gas dehydrators, and gathering pipelines which control the flow of gas through the facility. Many designs vent (or "bleed") the gas which is used to operate these devices. Options to reduce emissions from these devices include replacing high-bleed pneumatics (devices with high emissions) at the end of their useful life with low- or no-bleed designs where technically appropriate throughout the production stage.

- *Fugitive emissions* are unintentional and usually continuous releases associated with leaks caused by the failure of the integrity of the system, such as a damaged seal, a corrosion pit resulting in a pinhole leak in a pipeline, or inadequately sealed valves, fittings, and assemblies. The primary option for reducing fugitive emissions is the implementation of directed inspection and maintenance programs.

- *Gas dehydrators*, which use a desiccant such as glycol to remove moisture from produced gas, emit methane when the saturated desiccant is regenerated. Options for reducing these emissions include installing flash tank separators before the regenerating unit, and recovering and using the separated methane for boiler fuel (in the regenerating unit).

- *Reciprocating engines* are used throughout the industry to drive compressors that transport gas. These engines emit considerable quantities of methane in their exhaust due to incomplete combustion. The primary option to reduce these emissions is to use turbine engines, which emit significantly less methane, as new transmission lines are constructed and old reciprocators are replaced. This determination needs to be made on a site-specific basis.

- *Venting during routine maintenance* of pipelines occurs when the natural gas must be removed from a section of pipe for safety reasons during repairs. Options for reducing these emissions include using portable evacuation compressors to pump the gas from the section of pipe to be repaired to an adjoining section, rather than venting the gas to the atmosphere. With current gas prices, however, this technology may not be cost-effective in the United States.

In addition to these near-term options for reducing emissions, a variety of technologies and practices that are currently under development may become available commercially over the next decade. These options include: (1) metallic coated seals would be used in place of the rubber seals currently used on moving shafts -- such as shafts in production wells and compressors; (2) "smart regulators" which adjust the pipeline pressure to better accommodate demand at a given time; (3) clock spring composite wraps which can be used to repair leaks on major pipelines without venting the gas; and (4) catalytic converters, which would oxidize the methane released from reciprocating engines. Catalytic converters are increasingly required to comply with air emission regulations for NOx and hydrocarbon emissions.

CONSIDERATIONS

The implementation of options to reduce methane emissions from natural gas systems should focus on high impact applications, such as those discussed above. Because these options can usually be implemented in a short period of time, they will have an immediate impact on reducing emissions. The experience of gas companies in the U.S. shows that many of these options can be cost-effective. Moreover, the economic feasibility of these options will likely improve with the anticipated increases in gas prices over the next decades.

The benefits of the options discussed are not solely related to reduced methane emissions. In addition to being profitable in their own right, these options improve operational efficiency and further reduce safety risks associated with gas leaks. Options to reduce engine exhaust will also reduce the emissions of local air pollutants that form low-level ozone -- NOx and VOCs.

POLICY OPTIONS

- *Provide Information*. A significant barrier to reducing methane emissions from natural gas systems is that information on the economic benefits of emission reduction techniques has not been disseminated widely throughout industry. The other benefits associated with these options have also not been disseminated. States could develop information campaigns to advertise successful programs to industry, regulatory institutions, and other relevant organizations.

- *Address Institutional Barriers*. In many cases, public utility rate structures provide little incentive for reducing methane emissions to the atmosphere. Allowing most of the cost of unaccounted-for-gas to be passed through to consumers, for example, provides little incentive for a company to exceed existing safety standards. State regulatory agencies could develop incentives and remove disincentives to applying technologies and practices that reduce methane emissions. For example, a state public utility commission could adopt regulations that would allow a distribution company that has demonstrated methane emissions reductions to receive a higher rate-of-return on investment so that the value of the gas saved could be allocated to shareholders rather than consumers.

- *Support Research and Development*. States could fund targeted research to reduce costs and to develop improved technologies and practices.

5.5 METHANE FROM COAL MINING

Methane and coal are formed together during coalification, a process in which biomass is converted by biological and geological forces into coal. Methane is stored within coal seams and also within the rock strata surrounding the seams. Deep coal seams have a substantially higher methane content than shallow coal seams, because geological pressure intensifies with depth and prevents increasingly larger amounts of methane from escaping. Methane is released when pressure within a coalbed is reduced, either through natural erosion or faulting or through mining.

State and federal regulations concerning the release of coal mine methane have been developed as a result of safety, rather than environmental, concerns; methane is explosive in low concentrations and hazardous in underground mines. State mine inspectors and the federal Mine Safety and Health Administration (MSHA) share responsibility for monitoring methane levels in underground mines.

Exhibit 5-10. Jim Walter Resources: Methane Recovery Projects

Since the early 1980s, Jim Walter Resources (JWR) has recovered methane from four coal mines in Alabama. Each year, about 13 Bcf of high-quality methane is produced from a variety of mine degasification approaches sold at a nearby pipeline. JWR estimates that this program has reduced mining costs by more than $1/ton and enabled the continued economic operation of these coal mines. In addition, the company is preventing a significant amount of methane from being emitted each year.

For both safety and environmental reasons, other aspects of coal mining are heavily regulated. Federal and state energy, environmental, labor, land management, and other agencies regulate different aspects of the coal mining industry. Significant federal controls include the Coal Mine Health and Safety Act, which regulates virtually all aspects of mining methods and equipment design in order to reduce the dangers of roof falls, explosions, exposure to respirable coal dust, and mechanical accidents. Environmental impacts associated with coal mining -- including geological and hydrological disturbances, blasting, coal preparation, and waste disposal -- are subject to regulation under the Surface Mine Reclamation and Control Act (SMCRA) and state laws and regulations. Additionally, regulations targeting emissions from coal combustion for electricity production significantly impact the coal mining industry. State policies designed to reduce methane emissions from coal mining will need to be coordinated with existing federal and state safety and environmental regulations.

There are two technical approaches for reducing methane emissions from coal mining. The first approach is to recover methane before, during, or after mining and to use it as an energy source. The second approach is to reduce coal-fired energy consumption, which would reduce the amount of coal produced and, accordingly, the amount of methane released from coal mining.

5.5.1 Methane Recovery and Use

DESCRIPTION

Depending on the portion of coal that is produced by large and gassy mines in a state, encouraging utilization of coal mine methane can significantly reduce methane emissions. Methane released from underground mines can be recovered and sold to pipeline companies or used as a feed stock fuel to generate electricity for on-site use or for sale to off-site utilities. For pipeline sales, a coal mine would need to install gathering lines to transport the methane to a commercial pipeline. For power generation, a mine would need to install either an internal combustion engine or gas turbine, both of which can be adapted to generate electricity from coal mine methane. Most methane recovery and utilization technologies can be installed within a year.

Coal mine methane is recovered in a range of purities. Pipeline sales require nearly pure methane, while power generation is a technically viable option for methane concentrations as low as 30 percent (U.S. EPA, 1993b). Techniques for recovery include drilling wells before, during, or after mining. Wells drilled several years in advance of mining will generally be the most expensive, but will recover large amounts of nearly pure methane (up to 70 percent of the methane that would be otherwise emitted). Wells drilled during or after mining can also recover substantial quantities of methane (up to 50 percent of emissions), but the methane may be contaminated with mine ventilation air (U.S. EPA, 1993b). While such a methane/air mixture is normally suitable for power generation, injection into pipelines would require enrichment of the gas, which may not be economically feasible.

Established techniques exist for recovering methane. In fact, over 30 U.S. mines already use recovery wells as a supplement to their ventilation systems to ensure that methane concentrations remain below acceptable levels (U.S. EPA, 1993a). However, this recovered methane is normally released to the atmosphere.

In addition to the highly concentrated methane produced by recovery wells, methane that is emitted in low concentrations in ventilation air also could be utilized. Ventilation air may be used as the combustion air in an on-site turbine or coal fired boiler. However, at the current time, utilization of ventilation air has not been technically demonstrated.

In cases where it is not possible to utilize the recovered methane as an energy source, the gas could potentially be flared, which involves burning the methane so that primarily carbon dioxide, rather than methane, is emitted. However, flaring is not currently considered to be a feasible option for coal mines due to safety considerations, although research is being conducted on this topic. For example, the Energy Policy Act of 1992 includes a provision for further study of this technical approach.

CONSIDERATIONS

Implementation of methane recovery systems should focus on large and gassy mines; in general, recovery and use will be economic only for mines with high coal production and high methane emissions per ton of coal mined. A majority of these mines are located in the Central and Northern Appalachian basins (primarily Pennsylvania, Virginia, West Virginia, and eastern Kentucky), the Warrior basin (Alabama), and a few southwestern states. However, other states may also have mines for which methane recovery and use may be economic.

A few large and gassy mines can account for a very large portion of total state coal mining emissions, and encouraging their use of coal mine methane can significantly reduce emissions. Furthermore, developing methane recovery and utilization projects will have an immediate impact on reducing greenhouse gas emissions. Recovery wells and utilization equipment can usually be installed within a year.

Implementation of programs to encourage recovery and use of methane is facilitated by the fact that such projects can be profitable for coal mines. Currently, ten mines located in Alabama, Virginia, and Utah are making a profit by selling recovered methane to pipelines (See Exhibit 5-10). In 1993, these ten mines recovered for sales to pipelines about 25 bcf of methane that would other wise have been emitted to the atmosphere (U.S. EPA, 1994b). On-site power generation may also be profitable for coal mines.

Given their large electricity requirements, coal mines may realize significant economic savings by generating power from recovered methane. Nearly every piece of equipment in a mine operates on electricity, including mining machines, conveyor belts, ventilation fans, and elevators for workers. Furthermore, the gassiest mines may be able to generate power in excess of their own on-site needs; this excess power could be sold to a utility.

Finally, the benefits of methane recovery and use are not limited to reducing emissions. Recovery and use of methane reduces the risk of explosion in mines, reduces costs for mine ventilation, contributes to energy efficiency by utilizing an otherwise wasted resource, and may create additional financial revenues for coal mines and additional jobs in methane production.

POLICY OPTIONS

Policy options described here focus on programs that could either best be developed at the state level or that could augment federal programs that are planned or already in progress.[12]

- *Provide Information*. The utilization of recovered methane is still a relatively new concept in the coal mining industry. States can disseminate information on methane recovery options and highlight instances of successful methane recovery projects. State agencies may also find a role in identifying and attracting investors in coal mine methane projects and facilitating linkages between local coal companies and potential partners.

- *Support Research and Development*. Several technologies that might help reduce coal mine methane emissions -- such as gas enrichment processes and utilization of mine ventilation air as combustion air -- lack technical demonstration. Additional research is also needed on flaring. States may be able to support research on the potential application of such technologies at coal mines within their jurisdictions.[13]

- *Address Legal Barriers*. Unresolved legal issues concerning the ownership of coal mine methane resources constitute one of the most significant barriers to coal mine methane recovery. For example, ambiguity regarding who may demand compensation for resource development provides a disincentive for investment in coal mine methane projects. Potentially, entitlement could rest with the holder of the coal rights, the owner of the oil and gas rights, the surface owner, or a combination of the three. As part of the Energy Policy Act of 1992, states will be required to develop a mechanism to address ownership issues.[14] One option, enacted by Virginia, is to force pooling of all potential interests in the resource. Under forced pooling, until such time as ownership is decided, payment of costs or proceeds attributable to the conflicting interests are paid into an escrow account. This legislative effort resulted in the rapid development of coal mine methane projects in Virginia (U.S. EPA, 1993b).

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[12] Under the National Energy Policy Act of 1992, the Secretary of Energy, in consultation with the EPA and the Department of Interior, is instructed to study the technical, economic, financial, legal, regulatory, institutional and other barriers to coalbed methane recovery. This study is to be submitted to Congress in October 1994.

[13] States should be aware that the Energy Policy Act of 1992 mandates the establishment of a federal demonstration and commercial application program for advanced coalbed methane utilization technologies.

[14] As part of the Energy Policy Act of 1992, those states determined by the Secretary of Interior as not having statutory or regulatory procedures for addressing ownership concerns will have three years to enact such a program. If the state does not act, the Secretary of Interior will impose a forced pooling mechanism similar to that enacted in Virginia.

- *Address Institutional Barriers*. Pipeline capacity is severely limited in many coal producing regions, which can make it difficult for coal mine methane producers to gain reliable access to pipelines or may necessitate the construction of extensive gathering systems. Accordingly, states with limited pipeline capacity may wish to encourage or expedite new pipeline construction. Similarly, electric utilities in many coal producing regions have excess capacity and low generating costs. Accordingly, utilities may have low "buy-back" rates for power generated from coal mine methane. Furthermore, due to concern over losing a large customer, utilities may discourage coal mines from generating power for their own use. States could consider adopting provisions to encourage power generation from environmentally preferred power producers, such as coal mine methane projects. States may also evaluate the need for actions to ensure that utilities do not inappropriately discourage power generation for on-site use. Section 5.2 of this document, which addresses "supply-side" measures for reducing greenhouse gas emissions from the electric utility sector, discusses these policy options in greater detail.

- *Provide Financial Incentives*. Though methane recovery and use may be immediately profitable for some mines, others may find these projects economically feasible only if given appropriate financial incentives. For example, low interest loans for investment in recovery and utilization projects could encourage recovery methods that would capture the greatest amount of methane. A state-issued production tax credit could also encourage methane recovery (*e.g.* a $/mcf of gas or cents/kwh of electricity produced credit against state tax liability).[15]

- *Ensure Appropriate Operating Standards*. Coal mine methane wells, although similar to conventional natural gas wells, have important technical differences that may necessitate the development of state regulations specifically addressing this type of production. These regulations may be related to well spacing, coal mine safety, and produced water treatment and disposal. States without an existing coal mine methane industry may need to investigate the adequacy and applicability of existing regulations and modify them as appropriate to ensure the safe, environmentally beneficial, and effective production of coal mine methane. The coalbed methane industry has cooperated with regulators in states like Alabama and New Mexico to facilitate the rapid development of appropriate regulatory frameworks. Such regulations may serve as a model for state initiatives to expedite coal mine methane development.

- *Require Methane Recovery and Use*. States could directly require underground mines to recover and use methane. However, this may not be a viable policy option for several reasons, including: (1) methane recovery and use is most economic for mines with high methane emissions; and (2) recovery and use could not be mandated unless there were guaranteed gas or electricity markets for the recovered methane.

5.5.2 Reduce Coal-Fired Energy Consumption

A second technical approach to controlling coal mine methane emissions is to reduce coal-fired energy consumption. This approach would reduce the demand for coal and thus reduce the level of mining activities and the resulting methane emissions. Importantly, this approach could be adopted by most states,

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[15] In 1979, the U.S. Congress enacted the "Section 29" tax credit in order to encourage the development of unconventional gas resources. The eligibility of coalbed methane production under the Section 29 tax credit has expired as of the end of 1992 and gas produced from coalbed methane wells will only be eligible for the credit if they are drilled prior to the expiration date.

regardless of the amount of coal they produce because nearly all states consume electricity from coal-fired power plants. Reducing coal-fired energy consumption could be achieved by encouraging energy efficiency and/or by encouraging fuel switching from coal-fired electricity production to less polluting energy sources. Programs designed to reduce coal-fired energy consumption would likely be implemented in conjunction with general policies targeted to encourage energy efficiency and fuel-switching. See Sections 5.1 and 5.2 for more information on energy consumption and production.

5.6 METHANE FROM LANDFILLS

Landfills are the largest single anthropogenic source of methane emissions in the United States. Municipal solid waste (MSW) landfills account for over 95 percent of landfill methane emissions, with industrial landfills accounting for the remainder (U.S. EPA, 1993a). Methane is produced during the bacterial decomposition of organic material in an anaerobic (*i.e.*, oxygen deprived) environment. The rate of landfill methane production depends on the moisture content of the landfill, the concentration of nutrients and bacteria, temperature, pH, the age and volume of degrading material, and the presence or absence of sewage sludge. Once produced, methane migrates through the landfill until a vertical opening is reached and the gas escapes into the atmosphere.

There are two basic approaches for reducing methane emissions from landfills. The first approach is to recover the methane and to either flare the gas or use it as an energy source. The second approach involves reducing the quantity of degradable organic waste produced and deposited in landfills. In addition, these approaches support other state environmental and public health priorities, such as protecting air, surface water and ground water resources.

5.6.1 Methane Gas Recovery

DESCRIPTION

Landfill gas produced in a sealed landfill can easily be captured by installing a gas recovery system. Landfill gas is typically 50 percent methane (along with 45 percent carbon dioxide and 5 percent other gases including hydrogen sulfides and volatile organic compounds (VOCs)), and is therefore a medium quality gas that can be: (1) recovered, purified, and used to generate electricity; (2) used as a source of natural gas for residential, commercial, or industrial heating needs; or (3) combusted in a flare. In addition, there are several emerging utilization technologies that may be commercially available in the near term, including using landfill gas as a vehicle fuel and/or in fuel cell applications. Gas recovery essentially involves "mining" the trapped methane. This process consists of drilling wells into the landfill, withdrawing the gas under negative pressure, and gathering the recovered gas at a central processing center. Unlike strategies concentrated on reducing the amount of degradable waste landfilled (which curb future methane emissions), methane gas recovery reduces current methane emissions. Recovering methane has other environmental and safety benefits as well, such as reducing the risk of explosions, reducing odor, and reducing emissions of air toxics and non-methane volatile organic compounds.

Methane gas recovery and utilization technologies are widely available, and projects have costs similar to other relatively small renewable energy technologies.[16] The profitability of landfill gas energy recovery projects depends on a range of factors, including the volume of recovered methane, the price

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[16] Costs for methane recovery range from $5,000 to $10,000 per acre for installation. Combustors for flaring range from $15,000 to $90,000. To purify the gas for use in internal combustion engines costs from $50,000 to $300,000 for purification (IPCC, 1992b).

obtained for electricity (or gas) sales, and the availability of tax incentives. Currently, there are more than 150 fully operational landfill gas recovery and utilization projects in the United States, recovering about 1.3 teragrams, or 66 billion cubic feet, of methane gas per year. Nearly 100 additional gas recovery projects are underway around the country. EPA estimates that there may be an additional 500 profitable landfill gas energy recovery projects that could be developed in the U.S., but are constrained by informational, regulatory, and other barriers. Methane can also be flared, which almost completely eliminates the methane contained in the gas, but wastes the energy value of the gas.

Before recovered landfill gas can be used as a fuel source, it must be processed to remove water, particulates, and corrosive compounds. Processed landfill gas can be used to power an electric generator, such as a gas turbine or an internal combustion engine. Thermal energy from combustion can also be used to drive a steam turbine to increase electricity production. Alternatively, landfill gas can either be used directly for industrial, commercial or domestic energy purposes, or upgraded to a high-Btu fuel suitable for supplying a natural gas pipeline.

CONSIDERATIONS

Implementation of landfill gas recovery and utilization projects should focus on large landfills (over 1 million tons of waste-in-place), which will most likely have a high enough gas flow to support a profitable project. While landfill gas recovery will be particularly relevant for states with large urban centers, and their associated large municipal solid waste landfills, all states will have several landfills at which landfill gas recovery may be a viable option.

Landfill gas projects can provide many important environmental and economic benefits. They improve the global environment by reducing methane emissions, and the local environment by reducing emissions of volatile organic compounds (VOC), while simultaneously displacing emissions associated with fossil fuel use. They also provide a secure, low-cost energy supply that can reduce dependence on non-local energy. They also reduce the waste of valuable natural gas by preventing it from being emitted to the atmosphere. In addition, these projects can provide economic benefits, such as creating jobs and generating revenues.

Traditionally, landfill methane has been viewed as a safety hazard and a general nuisance. However, there is an increasing awareness on the part of state and local governments, landfill owners and operators, utilities, and industry, of the environmental, energy, and economic benefits that can result from recovering, rather then emitting or flaring, this gas. For example, utilities, which are a major market for electricity generated at landfills, can play an important role in encouraging economically attractive projects. The benefits of these projects to utilities include: promoting a diversified fuel mix; obtaining additional Acid Rain Credits; and fulfilling Climate Challenge commitments.[17] Utilities can also market power generated from landfill gas as “green power,” thereby appealing to consumers’ increasing interest in environmentally benign products. Landfill owners and operators can benefit by reducing regulatory costs and improving landfill safety. EPA's *New Source Performance Standards and Emission Guidelines*, promulgated on March 12, 1996, require many landfill owners and operators to collect and, at the very least, flare their landfill gas. Utilizing the collected gas for an energy recovery project may offer owners

[17] Climate Challenge, sponsored by DOE, is a CCAP initiative targeted at electric utilities. This action encourages electric utilities and other eligible firms to submit voluntary greenhouse gas reduction portfolios to DOE for inclusion in the Energy Information Administration's database. Through Climate Challenge, DOE is also attempting to stimulate the development and application of clean, sustainable energy technologies, strengthen the U.S. position in the global environmental technology marketplace, and contribute to overall environmental quality.

and operators an opportunity to offset regulatory costs or even generate a profit. Local industries can also benefit from encouraging or participating in landfill gas energy recovery projects by obtaining an inexpensive source of medium quality fuel (or steam, if the project is generating electricity).

POLICY OPTIONS

- *Provide Information*. States can provide landfill owners, project developers, and other interested parties with information on landfills that are candidates for methane recovery projects, on potential electricity purchasers (*i.e.*, utilities and industrial end-users), and on relevant regulatory policy and permitting issues within their state. EPA's Landfill Methane Outreach Program (LMOP) works cooperatively with states to encourage landfill gas energy recovery projects by developing and disseminating these types of information. For this purpose, the LMOP has developed many publications and tools,[18] including:

  * *E-PLUS decision support software*: assists landfill owners and operators in evaluating the costs of landfill gas collection and use.

  * *End-user locator software* (currently under development): helps landfill owners and operators and project developers find buyers for the energy they produce by identifying potential end-users, including schools, prisons, industries, and others.

  * *State Primers:* developed for every state that becomes an ally to the program. Primers facilitate communication and cooperation between states and project developers by identifying project opportunities, detailing pertinent regulations, and providing contact information for individuals at relevant state agencies.

  * *Landfill Profiles database:* lists all landfills that are candidates for gas utilization projects in selected states. The database includes many factors relevant to the development of projects, including landfill name, location, size, gas generation capacity, regional electricity prices, and whether or not the landfill has a gas collection system in place.

  * *Guidance Documents and periodic reports:* can be provided by states to project developers and interested landfill owners. These documents include a guide to understanding the Landfill Rule, the Ally Report and the Ally Update (periodic reports providing information on issues affecting development of landfill gas energy recovery projects), project financing guidance documents and brochures, and "Turning a Liability into an Asset: a Project Development Handbook".

  LMOP representatives also meet with state agencies throughout the country to discuss ways that states can support and encourage development of landfill gas-to-energy projects.

- *Address Institutional Barriers.* Electricity pricing and transmission line access and capacity may confound the development of landfill gas recovery projects. States with limited pipeline capacity may wish to encourage or expedite new pipeline construction or grant environmentally beneficial producers preferential access to existing electric power lines. States could consider adopting

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[18] LMOP products, including E-PLUS, state primers, and other guidance documents, can be ordered by calling the LMOP Hotline at 1-888-STAR-YES (782-7937).

provisions to encourage power production from landfills and evaluate the need for actions to ensure that utilities do not inappropriately discourage power generation for on-site use or for sale to the utilities (see also Sections 5.1 and 5.2).

State regulatory policy and permitting procedures can also present barriers to landfill gas projects. For example, the siting of the electricity generation equipment associated with a project can be extremely difficult in some regions, even though these projects have positive impacts on local air quality. In general, the permitting process for small unconventional power projects can hinder the implementation of these projects. In some cases, regulations concerning the placement and operation of collection wells, developed for gas migration control, can interfere with optimal well placement for gas recovery and utilization. States can review their policies and procedures in order to reduce unnecessary barriers to these types of projects. EPA's Landfill Methane Outreach Program is working cooperatively with state allies to conduct interagency reviews of state regulations and permitting procedures.

- *Provide Financial Incentives*. Methane recovery projects can be encouraged through tax credits, loans or grants for capital investment in methane collection equipment, and state and private investment in research and development of landfill gas recovery technology. States can provide production tax credits to landfill operators that initiate methane recovery for power production or offer consumption tax credits to utilities that purchase methane from landfill projects. States may also subsidize electric transmission line upgrades, pipeline upgrades, and offer other incentives to extend gathering lines to allow for transport of additional capacity. Additionally, states could impose an emissions tax on methane released to the atmosphere or diversion credits for emissions avoided through methane recovery.

5.6.2 Keeping the Organic Fraction of Municipal Solid Waste Out of Landfills

DESCRIPTION

When organic materials are landfilled, some of the carbon is converted by methanogenic bacteria to methane, carbon dioxide, and other gases, and some of the carbon is sequestered. Organic materials that produce significant amounts of methane include paper, yard trimmings, and food scraps. Preliminary research by EPA indicates that when office paper, corrugated cardboard, food scraps, or grass clippings are landfilled, the GHG emissions from methane generation outweigh the GHG sink due to carbon sequestration (EPA, 1997). By keeping these materials out of landfills (through recycling or composting), states can reduce net GHG emissions from the waste management sector.

There are several approaches to reduce the amount of these organic materials landfilled. These include source reduction, recycling, composting, and combustion. Source reduction and recycling also generally reduce the use of fossil fuels in manufacturing, further reducing GHG emissions. This section focuses on keeping the organic fraction of municipal waste out of landfills. Further information on methods to reduce GHGs from municipal waste management (including a more comprehensive discussion of the opportunities for source reduction and recycling) may be found in Section 6.2.

CONSIDERATIONS

The simplest method of managing yard trimmings is “grasscycling,” or leaving grass clippings in place on the lawn to decompose. Some homeowners prefer to use a “mulching mower” for this purpose. In a state with a population of 5 million, and the national average rate of generation of grass clippings, grasscycling will reduce GHG emissions by 10,000 metric tons of carbon equivalent (MTCE) per year, compared to landfilling the grass clippings.

Yard trimmings may also be composted, either in a backyard compost pile or bin, or in a centralized composting operation. Backyard composting eliminates GHG emissions from waste transportation. Centralized composting by a municipality requires land, labor, and a distribution system for the finished compost. Much of the compost may be used for municipal landscaping or highway projects. Alternatively, centralized composting may be done by farmers. In such cases, the municipality typically transports yard trimmings to a farm, where the farmer accepts them at no cost to the municipality. The farmer then makes compost from the yard trimmings, and uses the compost on the farm.

Food scraps may, similarly, be composted either in backyards or in a centralized operation. Commercial composting of food scraps is becoming more common.

Paper may be kept out of landfills through recycling. Prices for recovered office paper and corrugated boxes, in particular, have been consistently good, suggesting that it is particularly cost-effective to recycle these types of paper. An added advantage for recycling office paper and corrugated boxes is that they are generated by commercial sources, so that collection efforts yield high quantities.

Alternatively, paper, food scraps, and yard trimmings may be combusted. Particularly when the combustor incorporates energy recovery, this waste management method generally results in lower GHG emissions than landfilling.

POLICY OPTIONS

States have a number of policy options for keeping organic materials out of landfills. The most popular policy among states to date is a ban on landfilling of yard trimmings; by early 1997 23 states had instituted such bans. Yard trimmings in these states are either composted, combusted, or left on the ground to decay naturally.

States may also promote or require recycling of paper and other materials. To promote recycling, Oregon requires haulers to collect recyclable materials from businesses, and requires that collection service be provided at a cost that does not exceed refuse collection costs.

Composting of food scraps is a significant area of opportunity for further reducing the amount of organic waste going to landfills. Some communities offer households free recycling bins for this purpose.

An educational campaign can be instituted to promote any of the options discussed above. A relatively low-cost policy option would be an educational campaign to promote grasscycling, as well as backyard composting of yard trimmings and food scraps. Minnesota and Pennsylvania are two states that have extensive educational campaigns to promote recycling and composting.

5.7 METHANE EMISSIONS FROM DOMESTICATED LIVESTOCK

Methane is produced as part of the normal digestive processes of animals; this process is referred to as "enteric fermentation." Of domesticated animals, ruminant animals -- including cattle, buffalo, sheep, goats, and camels -- are the major source of methane emissions. Ruminant animals are characterized by a large "fore-stomach" or rumen. Microbial fermentation in the rumen enables these animals to digest coarse plant material that monogastric animals, including humans, cannot digest. Methane is a byproduct of this microbial fermentation.

In the U.S., cattle account for nearly all methane emissions from enteric fermentation. Factors affecting methane production from individual animals include: the physical and chemical characteristics of the feed, the feeding level and schedule, the activity and health of the animal, and possibly genetic traits (U.S. EPA, 1993a). Of these factors, the feed characteristics and feed level most influence the amount of methane produced.

In general, methane production by livestock represents an inefficiency because the feed energy converted to methane is not used by the animal for maintenance, growth, production, or reproduction. While efforts to improve efficiency by reducing methane formation in the rumen directly have been of limited success, it is recognized that improvements in overall production efficiency will reduce methane emissions per unit of product produced. A wide variety of techniques and management practices are currently implemented to various degrees among the U.S. livestock producers which improve production efficiency and reduce methane emissions per unit of product produced. More widespread use of these techniques, as well as the implementation of new techniques, will enable methane emissions from livestock to be reduced.

No existing federal or state regulations specifically focus on reducing methane emissions from domesticated livestock. However, government and industry efforts designed to promote animal production efficiency will also indirectly reduce methane emissions. Several techniques including genetic improvements and the use of productivity-enhancing agents as well as changes to the marketing system for milk and meat products, including the milk pricing system and the beef grading system could potentially reduce methane emissions from livestock (EPA, 1993b).

5.7.1 Improve Production Efficiency Per Animal

DESCRIPTION AND CONSIDERATIONS

Improving livestock production efficiency so that less methane is emitted per unit of product is the most promising and cost effective technique for reducing emissions in the U.S. While U.S. livestock production is among the most productive in the world, opportunities for improvement exist for all sectors of the cattle industry that can reduce methane emissions substantially. In many cases these options can be profitable because they reduce costs per unit of product produced.

Specific strategies for reducing methane emissions per unit product have been identified and evaluated for each sector of the beef and dairy cattle industry. Throughout the industry, proper veterinary care, sanitation, ventilation (for enclosed animals), nutrition, and animal comfort provide the foundation for improving livestock production efficiency. For many producers, focusing on these basics provides the best opportunity for improving production efficiency. Within this context, a variety of techniques can help improve animal productivity and reduce methane emissions per unit of product.

- *Dairy Industry*. Significant improvements in milk production per cow are anticipated in the dairy industry as the result of continued improvements in management and genetics. Additionally, production-enhancing technologies, such as bST, are being deployed that accelerate the rate of productivity improvement. By increasing milk production per cow, methane emissions per unit of milk produced declines (EPA, 1993b).

- *Beef Industry*. Improving productivity within the cow-calf sector of the beef industry requires additional education and training. The importance and value of better nutritional management and supplementation must be communicated. Energy, protein, and mineral supplementation programs tailored for specific regions and conditions need to be developed to improve the implementation of these techniques. The special needs of small producers must also be identified and addressed (EPA, 1993b).

In addition to these near term reduction strategies, several very long term options may become available as the result of ongoing research, including: the transfer of desirable genetic traits among species (transgenic manipulation), the production of healthy twins from cattle (twinning); and the bioengineering of rumen microbes that can utilize feed more efficiently.

POLICY OPTIONS

Though significant efforts by the dairy and beef industries and the U.S. Department of Agriculture are already underway to research and/or promote adoption of practices that will improve animal efficiency and reduce methane emissions per unit product, states can also implement policies designed to reduce methane emissions from ruminant livestock.

- *Provide Information*. Through the USDA Cooperative Extension Service, states may be able to develop information campaigns to encourage the use of techniques that improve production efficiency and reduce methane emissions per unit product. States could develop and make information available on the best management practices for different regions of the state, provide feed analysis services to determine actual protein and dry matter content of feeds, and provide information about and access to feed balancing computer programs.

- *Support Research and Development*. States could promote further research on genetic improvement in beef cattle, on identifying critical nutritional deficiencies that could be corrected through mineral or protein supplementation, and on determining the nutrient content of feeds. States may be able to work with industry on these efforts.

- *Provide Incentives*. Generally, the most profitable livestock management practices do not yield maximum biological productivity from the animals (*e.g.,* maximum milk per cow or maximum weaned calf weight per cow). Targeted financial incentives (fees and rebates) tied to verifiable productivity measures could be used to encourage producers to improve productivity, which would then reduce emissions per unit product produced. Significant research remains to design such an incentive system, including: choosing appropriate and verifiable measures of productivity; developing funding and fee collection mechanisms; and selecting appropriate levels for the incentives.

5.7.2 Improve Overall Production Efficiency of Animal Products by Matching Animal Products to Customer Preferences

DESCRIPTION AND CONSIDERATIONS

The existing systems for marketing milk and meat products in the U.S. have important influences on production efficiency, and hence methane emissions. Refinements to the existing marketing systems hold the promise of improving the link between consumer preferences and production decisions, thereby reducing waste and improving efficiency. Proposed approaches include the following:

- *Dairy Industry*. Dairy industry emissions can also be reduced by refinements in the milk pricing system. By eliminating reliance on fat as the method of pricing milk, and moving toward a more balanced pricing system that includes the protein or other non-fat solids components of milk, methane emissions can be reduced as the result of changes in dairy cow rations and genetics. There is already a trend to reduce reliance on fat in the pricing of milk (EPA, 1993b). To realize methane emissions reductions from this trend, the effectiveness of alternative ration formulations on protein synthesis must be better characterized.

- *Beef Industry*. Refinements to the beef marketing system are needed to promote efficiency and shift production toward less methane emissions intensive methods. To be successful, the refinements to the marketing system require that the information flow within the beef industry be improved substantially. Techniques are required to relate beef quality to objective carcass characteristics. Additionally, the carcass data must be collected and used as a basis for purchasing cattle so that proper price incentives are given to improve cattle quality and reduce unnecessary fat accretion.

  The beef industry has several programs under way to achieve these objectives. Carcass data collection programs have been initiated that provide detailed data on carcass quality to participating producers. Also, a major initiative is ongoing to educate retailers regarding the cost-effectiveness of purchasing more closely trimmed beef (less trimmable fat). As these programs become more widely adopted, the information needed to provide the necessary price incentives to producers will become available.

POLICY OPTIONS

The beef and milk marketing systems are principally regulated through existing federal programs. States have few opportunities to influence these systems through regulatory mechanisms. However, as significant purchasers of milk and meat products, States and related State-influenced institutions (such as schools and hospitals) have an opportunity to purchase milk and meat products in a manner that provides the price signals that lead to improved production efficiency. Significant research remains to be done to fashion an appropriate State-level policy in this regard, but there is substantial potential to influence production practices through the use of specifications in purchase contracts. Alternatives for specifying product characteristics should be explored and opportunities for leveraging purchasing decisions need to be identified.

5.8 METHANE FROM MANURE MANAGEMENT

When livestock manure is handled under anaerobic conditions (in an oxygen free environment), microbial fermentation of the waste produces methane. Liquid and slurry waste management systems are especially conducive to anaerobic fermentation and to methane production. Because confined livestock operations such as dairy and hog farms rely on liquid and/or slurry systems to manage a large portion of their manure, they account for a majority of all animal manure methane emissions in the U.S. Emissions depend on farm characteristics (including number and type of animals, manure management practices, and animal diet) and climatic conditions (including temperature and relative humidity).

In addition to methane emissions, livestock manure can cause surface and ground water pollution, air pollution (*e.g.*, ammonia and strong odors), and human health risks. State and federal regulations require proper manure management practices to avoid these potentially adverse environmental problems. In particular, under Section 319 of the Federal Clean Water Act (CWA), confined livestock operations are regulated as potential point sources of water pollution and are required to control rainfall run-off and to apply manure prudently. This section of the CWA is enforced by individual states through a permit process designed under the National Pollution Discharge Elimination System (NPDES) program.

In order to comply with these federal and state regulations, many confined livestock operations (*i.e.*, non-grazing operations) are utilizing anaerobic lagoons or pits to contain runoff and to manage their manure. These systems are simple, cost-effective, and relatively safe. However, because anaerobic systems produce more methane than aerobic systems, their increased use could significantly increase methane emissions from livestock manure.

5.8.1 Methane Recovery and Use

DESCRIPTION

Feasible and cost-effective technologies exist to recover methane produced from the liquid manure management systems used at dairy and swine operations. Methane can be captured, for example, by placing a cover over an anaerobic lagoon. A collection device is placed under the cover and methane is removed by a vacuum. Alternatively, methane can be recovered from mixed tank or plug flow digesters that produce methane. These and other technologies can be used on individual farms or at centrally located facilities.

Because methane is a fuel, methane gas recovered by any of the available methods provides a renewable energy source. The methane can be used in a variety of equipment:

- *Internal Combustion (IC) Engines*. IC engines are reliable, available in a variety of sizes, and can be operated easily. Electricity generated can be used to replace energy purchased from a local utility or can be sold to the local electricity supply system. Additionally, waste heat from these engines can provide heating or warm water for farm use or for recycling into the recovery system.

- *Boilers and Space Heaters*. Boilers and space heaters fired with methane can produce heat for use in livestock operations. Although this is an efficient use of the gas, it is generally not as versatile as electricity generation and most farms do not require the amount of heating that can be generated.

- *Chillers*. Gas-fired chillers are commercially available and can be used for milk refrigeration on dairy operations. Because dairy farms use considerable amounts of energy for refrigerating milk, chillers may provide a profitable opportunity for on-farm methane utilization.

- *Pipeline Sales*. Available methane can be sold to pipelines for distribution through the existing natural gas pipeline network. However, gas produced from livestock manure is typically composed of about 40 to 50 percent carbon dioxide (CO_2) and trace quantities of other gases such as hydrogen sulfide (H_2S), which need to be removed before the gas can be injected into a pipeline. The cost of upgrading the gas to pipeline quality makes this option uneconomical at the current time.

Methane must be processed before it can be used in most equipment. The amount of processing necessary depends on the specifications of the equipment and the characteristics of the gas.

Exhibit 5-11: Methane Recovery in North Carolina

The Southeast Regional Biomass Energy Program (SERBEP) recently supported a successful demonstration project on methane recovery at a dairy farm near Raleigh, North Carolina. Methane captured from animal waste is a biomass fuel that can be used as a substitute for natural gas or propane. The demonstration project used a methane recovery technique called lagoon digestion, which involves the construction of a deep earthen lagoon in which animal waste is collected. A sealed cover is placed over the lagoon to allow for the collection of methane from the normal digestion of the waste by bacteria. The benefit of the digestion approach is that it does not require elevated temperatures. Furthermore, this technology displayed low operating costs. On average, the project produced 5000 cubic feet of gas per day, with a methane content of 69 percent, which was used to fuel a boiler that provides hot water for the farm's milking parlor.

Depending on the number of large dairy and swine operations in a state, utilization of livestock methane can significantly reduce methane emissions. These systems can reduce emissions at individual farms by up to 80 percent (U.S. EPA, 1993b). Furthermore, developing methane recovery and utilization projects will have an immediate impact on reducing emissions since these systems can be installed within one year.

It should be noted that policies regarding methane recovery systems may be compatible with policies encouraging the use of manure instead of commercial fertilizer. Methane recovery systems could be employed during the storage period before application to fields.

CONSIDERATIONS

Recent trends in manure management, such as using anaerobic lagoons to meet requirements of the Clean Water Act, have prompted interest in developing and installing on-farm methane recovery systems. Many of the operational problems initially experienced with methane recovery systems in the early 1970s have been overcome during the past two decades through advances in the methane recovery industry. EPA's AgStar program focuses on providing support to farms considering implementing methane recovery systems. As of late 1997 there were 40 farm operations participating as AgStar partners.

Implementation of recovery systems usually focuses on large dairy or hog farms (for example, farms with over 500 milking cows or over 1,500 hogs) that use liquid or slurry manure management systems which are especially conducive to methane production. The current trend in livestock production is away from the small family farm (less than 200 cows) with limited manure storage capabilities toward large production farms (over 500 cows) that use manure storage systems as a matter of routine. This trend may mean that an increasing number of farms will find it economic to capture methane. Additionally, methane recovery and use may be more economical for farms located in a relatively warm climate.

POLICY OPTIONS

Policy options described here focus on programs that could either best be developed at the state level or that could augment federal programs planned or already in progress.

- *Provide Information*. One of the most significant barriers to the development of methane recovery projects is lack of information. Current recovery systems must be demonstrated to show that the problems that plagued the earlier systems have been resolved. States can potentially disseminate information on successful methane recovery projects and provide training in the design, construction, and operation of methane recovery systems. For example, states could distribute the AgStar FarmWare software to farmers; this software estimates the net present value of a farmer's investment in a project to capture methane from manure, and use the methane to produce electricity.

- *Support Research and Development*. As recovery technology improves, more farms may find it cost-effective to recover and utilize methane produced from livestock manure. States may further the advancement of these technologies by supporting research and development projects.

- *Address Institutional Barriers*. Several economic barriers that limit the adoption of methane recovery systems are common to other small power producers, cogenerators, or other independent power producers. One problem is low utility "buy back" rates, which limit the value of the energy produced. In the case of methane recovery from livestock manure, low buy back rates may be less significant because usually the energy produced can be used to displace the energy purchased by the farmer from the utility. However, if utilities were to lower their electricity rates in order to compete with these recovery projects, the profitability of these projects would be reduced; profitability is extremely sensitive to electricity rates. States could evaluate the need for actions to ensure that utilities do not inappropriately discourage power generation for on-site use.

- *Evaluate Existing Regulations*. Some existing regulations may hinder the development of recovery systems. In some states, equipment used at livestock operations located near large metropolitan areas must meet air emissions standards that reduce the profitability of the projects. These air emission standards may not consider that these systems are being used to mitigate other harmful emissions. Further, adding a methane recovery system to an existing manure management system may require permit modifications. The cost of applying for and obtaining changes in operating permits reduces the profitability of developing a recovery system. States could evaluate the need for modifying existing regulations that may constrain the wider development of recovery projects.

- *Provide Financial Incentives*. Though methane recovery and use may be immediately profitable for some farms, other farms could find projects to be economically feasible if given appropriate financial incentives. For example, inadequate capital financing may limit the ability of farmers to purchase a recovery and utilization system; this barrier could be addressed through the provision of low interest loans. A state-issued production tax credit would improve the economics of recovery projects and could encourage more farmers to develop projects.[19]

- *Require Methane Recovery and Use*. States could require confined livestock operations to recover and use methane. However, numerous factors -- such as climate, farm layout, current electricity rates -- may impact whether projects will be economical. When conditions are not conducive to the profitable recovery and use of methane, a recovery requirement could impose a substantial economic burden on some farms, particularly those with the lowest emissions.

5.8.2 Increase Aerobic Treatment of Livestock Manure

DESCRIPTION AND CONSIDERATIONS

A second technical approach for reducing methane emissions from livestock manure is to encourage aerobic treatment of livestock manure at confined livestock operations. Normally, the manure produced from these operations is eventually spread on land which is part of the livestock operation. Land application rates must be matched to the carrying capacity of the soil, which is influenced, for example, by crop needs and the seasonal schedule of the producer. Although manure is produced throughout the year, in most cases it cannot be applied to land at all times of the year, such as when the land is wet or frozen or during the crop growing season. During these times, the manure must be stored until it can be applied to land, which results in anaerobic conditions and methane formation. Alternatively, livestock manure can be composted before it is applied or sold as an organic fertilizer. In most cases, however, the amount of compost that can be produced greatly exceeds the current demand.

Increasing aerobic treatment (*e.g.*, composting) of livestock manure, therefore, could be achieved either by: 1) encouraging aerobic treatment of manure while it is being stored; 2) finding alternative uses for the manure when local application is not possible; or 3) expanding the market for composted manure as a fertilizer. The first option -- encouraging aerobic treatment of the waste -- may not be viable in many areas because it would be in conflict with regulations that encourage confined livestock operations to treat manure anaerobically in order to prevent both air pollution and surface and ground water pollution. For some states, the second and third options may be worth consideration if a sufficiently large market for the manure can be identified.

POLICY OPTIONS

- *Provide Information*. Through the Cooperative Extension Service, states may be able to develop information campaigns to encourage the use of aerobic manure treatment. In addition, states could provide manure nutrient analysis services to farmers to determine the nitrogen, phosphorous, and potassium content of the manure produced on an individual farm and, therefore, maximize manure fertilizer use.

- *Support Research and Development*. States could investigate the potential for alternatives to livestock manure storage and the most efficient methods of composting manure. Further information on the nutrient content of composted manure could assist in evaluating its potential as a complete replacement to inorganic nitrogen fertilizers and encourage its use by non-livestock

[19] The Energy Policy Act of 1992 includes a renewable energy production incentive. Qualified renewable energy facilities, which would include facilities producing electricity from livestock manure, will be eligible to receive a subsidy of 1.5 cents per Kwh of electricity produced.

producers. This could expand the market for composted manure and decrease the amount stored anaerobically.

- *Provide Financial Incentives*. Aerobic treatment of manure and the transport of manure to other areas may not be economical for small farms that currently spread manure on a daily basis. Financial incentives may be necessary to encourage the use of aerobic treatment and to assist in expanding the market for composted manure fertilizer.

5.9 METHANE FROM RICE CULTIVATION

DESCRIPTION

Methane is produced in flooded rice fields during the bacterial decomposition of organic material. Non-flooded rice fields and deepwater floating rice fields (*i.e.*, greater than 1 meter floodwater depth) are not believed to produce significant quantities of methane. Rice paddy methane production depends on several factors in addition to water depth, including the concentration of nutrients and bacteria, soil temperature and pH, and the oxidation reduction potential.[20] These factors are strongly influenced by agricultural management practices, such as the application of organic matter which can alter the nutrient content of the soil and increase the soil temperature during its decomposition. Once produced, methane can escape by plant-mediated transport or diffusion or bubbling through the water column. In general, rice cultivation is not as large a contributor to methane emissions in the United States as in other parts of the world, due to differences in climate and farming practices.

CONSIDERATIONS

No federal standards exist to limit emissions of methane from rice cultivation. The Department of Agriculture, however, recommends certain agricultural management strategies that affect rice cultivation practices, including (under certain circumstances and particular production areas), shortened rice field flooding periods, which can reduce methane production. Of the six U.S. states that produce significant quantities of rice, including Arkansas, California, Louisiana, Mississippi, Missouri, and Texas, none have implemented direct regulations to reduce methane emissions from rice fields. However, some state regulations restrict water use in agriculture, which may in turn reduce methane production and emissions. These regulations also serve to protect surface water and ground water from pollution.

Scientific uncertainty surrounds the potential to reduce methane emissions from rice production. Several technical approaches including the selection of cultivars (*i.e.*, plant variety or strain), nutrient management, and water regime management have been identified as potential methods to decrease methane emissions from rice cultivation. However, the ability of these methods to decrease emissions is based mainly on experimental data, which often conflict.

Cultivar Selection

The development of rice strains that produce fewer root exudates may help to limit methane production, although researchers are uncertain about the magnitude of this effect. In addition, modern short-stemmed rice varieties have a grain-to-straw ratio that is about 50 percent higher than traditional

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[20] Oxidation reduction potential in this instance refers to the electrical potential of the water-sediment environment. In reducing conditions, not enough oxygen is available to sustain aerobic bacteria, and anaerobic bacteria populations prevail.

varieties, and therefore, produce less "wasted" organic material (*i.e.*, rice straw that cannot be harvested). These varieties may potentially reduce greenhouse gas emissions, because they decrease the amount of organic material available to decompose in the soil. Different cultivars, however, may adversely affect the ecology of rice fields and may be more costly than existing strains. Even if the cost of methane-reducing cultivars does not significantly differ from existing strains, rice farmers may be unwilling to accept the costs of conversion or the risks associated with cultivating a different strain, such as potentially reduced yields or poorer quality or taste.

Nutrient Management

Nutrient inputs to rice fields affect methane emissions by altering the methane production rate. Application of nitrogen-based fertilizers, ammonium sulfate, and urea generally reduce methane emissions compared to application of non-commercial fertilizers. Conversely, application of organic fertilizers, such as rice straw and animal wastes, has been found to increase methane emissions.

Many rice growers in the U.S. practice multi-year cropping that involves plowing the crop residue (*i.e.*, rice straw) into the soil before planting a different crop. This management practice, which increases methane emissions, is fairly typical in Texas. The alternative -- reducing organic nutrient input to rice fields -- may reduce methane emissions, but may also decrease rice yields. In addition, rice straw or other organic matter that is not used to fertilize the rice field may either be combusted, composted, or landfilled, all of which produce greenhouse gas emissions. Unlike organic fertilizers, mineral fertilizers (such as nitrogen fertilizers) reduce methane emissions to the atmosphere. However, they contribute nitrous oxide, a greenhouse gas, to the atmosphere and cost considerably more than composted rice straw and other readily available organic waste. Section 5.10 specifically addresses nitrous oxide emissions from fertilizer application.

Water Management

Only through continuous flooding do rice paddies remain sufficiently reduced (lacking in oxygen) for methane production to occur. As water is drained from rice fields, the oxidation reduction potential increases and methane emissions decrease. For example, rice cultivated under dry upland conditions does not produce methane emissions; however, production levels may decrease using this production method. Thus, floodwater depth and the length of the flooding period are factors that affect methane production.

The typical practice in the U.S. is to cultivate rice on flooded fields. These fields are flooded at depths of approximately 5 to 10 cm. However, these fields are not flooded for the entire growing season. Usually, seeds are placed into dry land with limited irrigation for approximately 30 days. The land is then flooded for the remaining growing period. This helps to reduce total seasonal methane emissions.[21] Federal and state water management regulations may limit the amount of water that can be used for agriculture, indirectly limiting methane emissions.

POLICY OPTIONS

Because the potential to reduce methane emissions in rice production is limited and scientific uncertainty surrounds the data on the effectiveness of different methods in reducing methane emissions, more research may be needed before policy changes are implemented.

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[21] Methane emissions increase with increased water levels over the range of flooding levels typically used in rice cultivation in the U.S.

- *Provide Information and Technical Assistance.* State agricultural agencies and the Cooperative Extension Service may be able to provide information to rice growers on the benefits of different cultivars, provide on-site technical assistance, develop demonstration programs on cultivar use and optimal nutrient applications, and on water management regimes.

- *Support Research and Development*. States can support research at universities, non-profit organizations, or directly with farmers to conduct studies that better define the impacts of different cultivars, nutrient, and water management practices on methane emissions.

- *Provide Financial Incentives.* Although states do not typically get involved in rice programs, states encourage the use of short-stemmed rice varieties and management practices that contribute most to reducing methane emissions through tax credits, direct payments, grants, or loans. Increased production of rice in dryland conditions can be promoted directly through subsidies.

- *Regulate Water Use*. States can restrict the amount of water allowed to be used in rice production, thus decreasing the amount of methane produced. However, requiring the use of dry upland methods or limiting water use may decrease rice yields. This policy option may be compatible with current state regulations that serve to protect surface water and ground water.

5.10 NITROUS OXIDE AND OTHER GREENHOUSE GASES FROM FERTILIZER USE

Fertilizers, whether industrially synthesized or organic (like animal manure and leguminous plant residue), add nitrogen to soils. Any nitrogen not fully utilized by agricultural crops grown in these soils undergoes natural chemical and biological transformations that can produce nitrous oxide (N_2O), a greenhouse gas.

Scientific knowledge regarding the precise nature and extent of nitrous oxide production and emissions from soils is limited. Significant uncertainties exist regarding the agricultural practices, soil properties, climatic conditions, and biogenic processes that determine how much nitrogen various crops absorb, how much remains in soils after fertilizer application, and in what ways that remaining nitrogen evolves into nitrous oxide emissions. Amid these uncertainties, the policy challenge for reducing greenhouse gases is to determine how to manipulate the nitrogen fertilizers and the time and manner in which these fertilizers are applied in order to minimize nitrous oxide emissions.

In addition to helping mitigate climate change, the policies that promote reduction of nitrous oxide emissions frequently support other state environmental and public health priorities. For example, in many cropping systems between 5% and 30% of the nitrogen applied can escape soils through leaching and water runoff, in addition to producing nitrous oxide. This fugitive nitrogen often pollutes ground water and surface water supplies. In this context, climate change mitigation policies aimed at reducing nitrogen losses to water coincide with many existing and proposed state initiatives to use fertilizers more efficiently and to reduce fertilizer use in order to protect water quality. The Iowa Agricultural Energy Management Initiative (described in Chapter 7), which was developed from the Iowa Consortium on Agriculture and Water Quality, is an example of a program that addresses improvements in nitrogen fertilizer use to enhance groundwater quality and save money in the agricultural sector, and that also decreases nitrous oxide emissions.

Technical approaches for reducing nitrous oxide emissions from fertilizers include improving nitrogen-use efficiency in fertilizer applications. Improvements mean reducing excess fertilizer application by applying only the amount crops will use, and replacing industrially-fixed nitrogen fertilizers with renewable nitrogen source fertilizers.

5.10.1 Improve Nitrogen-Use Efficiency in Fertilizer Applications

DESCRIPTION

At many sites, more fertilizer is applied than can be effectively used by crops. Further, poor fertilization timing or placement often leads to additional nitrogen loss or unavailability to the plant. One major reason for the application of excess nitrogen in the fields is the lack of simple field testing for nitrogen. Also, many farmers believe that some "excess" may be necessary to ensure peak production. This is because precise crop needs are not always known, and weather and climatic conditions that affect crop growth and nitrogen requirements are unpredictable. For these reasons, many farmers apply additional fertilizer to ensure crops have the nutrients they need.

Matching fertilizer formulation and application more precisely to the uptake needs and capacity of crops can improve nitrogen-use efficiency. Thus, matching can reduce nitrous oxide emissions by decreasing overall fertilizer consumption and by minimizing the quantity of nitrogen left in soils or sacrificed to water leaching and runoff. While the direct relationship between fertilizer application rates and nitrous oxide emissions is not well understood, current estimates suggest that better fertilization practices could reduce nitrogen fertilizer use by as much as 20 percent with low risk of yield penalty and with possible input-cost savings to farmers. However, these estimates assume an ability to project field-by-field and crop-by-crop nitrogen needs that probably exceeds existing extension, testing, and management capabilities. This highlights the primary need for further research and institutional development in this area.

CONSIDERATIONS

Seven fertilization management approaches and three specific fertilizer technologies offer opportunities for enhancing nitrogen-use efficiency. Several may be integrated into alternative agricultural systems that incorporate lower fertilizer usage and also achieve energy savings by reducing the need for plowing and other energy intensive practices.

<u>Management approaches</u>

- *Improve fertilizer application rate*. Matching fertilizer application with specific crop requirements would reduce excess fertilization, thus producing immediate greenhouse gas reduction benefits. Typical fertilizer application rates vary depending upon crop type, soil conditions, fertilizer pricing, and environmental policies. Better record-keeping to assess actual yields on a field by field basis can help to fine-tune fertilizer rates that are both economically and environmentally sound. Soil testing, visual inspection, or plant tissue testing could allow farmers to apply nutrients more closely following crop requirements, rather than following broad guidelines that often recommend excessive fertilization. However, efforts to provide adequate nutrition to crops may be hindered by inadequate understanding and forecasting of factors that influence nutrient storage, cycling, accessibility, uptake, and use by crops during the growing season.

- *Improve the frequency of soil testing*. Regular soil testing (*e.g.*, annual testing of all fields in production) could decrease fertilization use. Because this process can be expensive and time consuming, farmers may test soil only every two to five years. Regular soil testing to improve nitrogen management would involve new types of soil and tissue testing, such as the pre-sidedress (late spring) soil tests being calibrated in most corn belt states. Innovative technologies can assist in improving this process. For example, in Kentucky an experimental soil testing and fertilization applicator called the "Soil Doctor" tests soil nitrogen needs and automatically adjusts the fertilizer application rate accordingly. While the initial capital output for a machine like this could be high, it has been shown to decrease application rates by as much as 41 pounds per acre, a potentially significant savings to farmers.

- *Improve timing of fertilizer application*. Limited studies suggest that timing of application affects nitrous oxide emissions. For example, on a broad scale, emissions from fertilizer applied in the fall exceed those from fertilizer applied in the spring. With better understanding of these processes and their implications for crop production, fertilizer timing could be adjusted to reduce greenhouse gas emissions.

- *Improve placement of fertilizer*. Some surface placement and broadcasting of fertilizers results in excess or overlapping fertilizer application. Deep rather than surficial placement of fertilizers can curb nitrogen loss, though this may not be compatible with no-till production practices. In these practices, irrigation after fertilization could incorporate the fertilizer more deeply into the soil.

- *Switch to fertilizer compounds with lower nitrogen content.* Although nitrous oxide production rates of different fertilizers in relation to their benefits for various crops are highly uncertain, switching from fertilizers with high nitrogen content, especially anhydrous ammonia, to fertilizers with lower nitrogen content can reduce emissions, unless farmers increase fertilizer application to maintain the previous nitrogen levels. Preliminary data on nitrogen content and nitrous oxide emissions for various fertilizers are presented in the appendices to EPA's Phase I document, *States Workbook: Methodologies for Estimating Greenhouse Gas Emissions*.

- *Improve crop management for more complete nitrogen uptake*. Crop management techniques can supplement the improved fertilizer application techniques described above. For example, corn is susceptible to high rates of soil erosion because it is a row crop. After the harvest of corn, substantial amounts of nitrogen generally remain in the soil. The surplus nitrogen can be captured by inter-cropping with a grain crop such as rye, which could then be plowed back into the soil. More information on the use of organic fertilizers is presented in section 5.10.2 below.

- *Conservation tillage*. Alternative land tillage systems, such as low-till, no-till, and ridge-till reduce soil losses and associated loss of nitrogen contained in the soil. Tillage practices also affect the efficiency with which the fertilizer can be applied and incorporated into the soil.

Technology approaches

- *Use nitrification inhibitors*. Nitrification and urease inhibitors are fertilizer additives that can increase nitrogen-use efficiency by decreasing nitrogen loss through volatilization. Nitrification inhibitors can increase efficiency by around 30% in some situations.

- *Use fertilizer coatings*. Limiting or retarding fertilizer water solubility through supergranulation or by coating a fertilizer pellet with sulphur can double efficiency, depending on the application.

- *Reduce nitrogen release rate in fertilizers*. Techniques that limit fertilizer availability, such as slow-release or timed-release fertilizers, improve nitrogen-use efficiency by releasing nitrogen at rates that approximate crop uptake. This reduces the amount of excess nitrogen available at any given time for loss from the soil system. In addition, slow-release fertilizer can potentially decrease the number of applications, resulting in an energy and cost savings.

POLICY OPTIONS

Farmers may pursue proven and familiar fertilization practices without understanding the negative environmental impact of excess nitrogen application or potential benefits of reducing commercial nitrogen use. Concurrently, scientific and technological uncertainty inhibits program development in this field. In this sector, policy options are generally oriented around these two barriers to nitrous oxide emission reduction.

The types of policy options listed below can be combined and integrated in a variety of ways to control nitrous oxide emissions. For example, educational and agricultural support programs for farmers in combination with financial or regulatory incentives applied to specific fertilizers may be an effective comprehensive mechanism for encouraging better nitrogen-use efficiency.

- *Provide Information.* Through educational programs or farming and technology demonstration projects, states can communicate to farmers critical information on fertilizer use and farm management practices. Farmers' lack of basic information on nitrogen processes in soils is frequently cited as a major barrier to nitrous oxide reductions. Education programs can target efficient fertilizer use, with particular attention to appropriate application rates based on realistic yield expectation, monitoring of nitrogen levels, and effective application techniques. These programs help address barriers posed by the "insurance value" to farmers of high fertilizer use levels, as well as by farmer habit and tradition. However, states should be cautious about advocating farming techniques and fertilization practices that are surrounded by high levels of scientific uncertainty.

- *Provide Institutional Support.* The Extension Service is an additional means of providing adequate and accessible technical capability for determining precise fertilizer needs by crop type, soil characteristics, moisture, weather, and other variables. For example, states could encourage the use of the soil testing services provided through land grant colleges and extension services by decreasing fees, increasing farmer awareness of the programs, or increasing farmer awareness of fertilization cost savings associated with annual soil testing. Again, however, certainty regarding farming practices to reduce greenhouse gas emissions and maintain crop productivity is limited at the current time.

- *Support Research and Development.* Little field research is being conducted on nitrous oxide emissions from fertilizers in the United States. Many of the technological approaches presented above have not been tested extensively. Research in this area is generally expensive because it is labor- and/or equipment-intensive.

- *Provide Financial Incentives.* Low prices for fertilizers, especially in states where fertilizer subsidies exist, cause excess consumption and nitrogen application. States may be able to revise fertilizer and crop subsidy structures to curb the use of nitrogen-intensive fertilizers or the growth of nitrogen-intensive crops. Similarly, state programs may levy taxes or other price increases to encourage farmers to better monitor and reduce nitrogen application. A few states have also imposed fees on fertilizers to support research and education programs, although these fees are not intended to be nor are they considered large enough to directly affect fertilizer demand. This type of policy may conflict with some state policy goals (such as support of the agricultural sector), while complementing others (like surface and ground water protection).

- *Regulate Fertilizer Use and Production.* Regulating fertilizer application rates and practices is difficult due to the lack of substantial evidence regarding the greenhouse gas benefits and to side effects on crop production. These uncertainties could increase political sensitivities surrounding this issue. In addition, difficulties surround widespread enforcement of the regulation at farm sites. However, regulating nitrogen content in synthetic fertilizers may aid reduction of nitrogen consumption, particularly if accompanied by education and information programs for farmers.

5.10.2 Replace Industrially-Fixed Nitrogen Based Fertilizers with Renewable Nitrogen Source Fertilizers

DESCRIPTION

Animal manures, as discussed in Section 5.12, and leguminous crops are potential organic nitrogen fertilizers. Traditional crop rotation, dual-cropping or inter-cropping, for example, involves rotating lands under cultivation with legumes (such as alfalfa and soybeans) in order to store nitrogen in soils, as an alternative to synthetic fertilizer use. Current data suggest that direct nitrous oxide emissions from organic process uses may be as high or higher than from synthetic fertilizers. In an overall greenhouse gas context, however, replacing industrially-fixed nitrogen based fertilizers with renewable nitrogen source fertilizers may still help reduce comprehensive greenhouse gas emissions in two ways:

1) Organic fertilizers can be used to replace synthetic nitrogen fertilizers where both are currently applied. In current agricultural systems, farmers frequently do not consider the nitrogen content of the organic fertilizers they apply. In these situations, they add additional synthetic fertilizers, resulting in excess levels of nitrogen in soils. Nitrous oxide reductions would occur if farmers took full advantage of organic fertilizers and only used synthetic fertilizers when needed as a supplement. To adhere to this process, farmers must know and understand the nitrogen value of the organic fertilizers. Benefits from this approach would accrue immediately upon reduction of excessive nitrogen application in soils.

2) Using organic fertilizers can conserve significant amounts of energy that would have gone into synthetic fertilizer production. Aside from direct nitrous oxide emissions, energy savings from reducing production of high-energy industrially-fixed nitrogen based fertilizers will result in decreased greenhouse gas emissions. The 1991 report of the Missouri Commission on Global Climate Change & Ozone Depletion suggested that it would be "prudent to use livestock wastes as fertilizer rather than incurring the costs of waste treatment and using additional energy to produce chemical fertilizers and causing greenhouse gas emissions." Quantification of nitrous oxide emissions from organic fertilizers per unit of nitrogen supplied to the soil is required to make this determination, as current estimates of nitrous oxide emissions from these sources cover a wide range. The emission reduction benefits from this type of program may be difficult to quantify, and would not accrue until currently active synthetic fertilizer plants ceased production.

CONSIDERATIONS

The most likely renewable fertilizer for replacing synthetic fertilizer is manure. This may cause shortages of manure in areas where manures are productively applied to other uses, while it may help alleviate manure and waste management problems in other locations. Economical ways or incentives are needed to distribute manure to areas where it can be beneficially used. Such programs have sometimes been discussed as manure brokering, arranging exchanges among farms to transport the excess manure to a farm that can advantageously and economically utilize it as a nutrient source. Similarly, in programs where farmers may come to rely on organic fertilizer use, it would be necessary to guarantee a constant and dependable fertilizer supply from the renewable sources.

The scientific uncertainty regarding nitrogen uptake from renewable fertilizer sources also makes it difficult to develop renewable fertilizer programs. Programs that both help farmers accurately assess the needs of their crops and provide reliable information on the nitrogen replacement value of renewable fertilizers seem most promising.

Broad guidelines, based on the solids content and source of manure, have been designed in Wisconsin and Michigan to determine the nitrogen, phosphorous, and potassium levels of manure. Using these guidelines in experiments in Minnesota, manure has been shown to be a sufficient fertilizer for alfalfa. Likewise, some dairy farmers in Georgia have used manure for several years to produce both corn and wheat. In addition, experiments in Minnesota have demonstrated that the use of either manure or leguminous crops, in rotation and plowed under, can increase the dry matter content of the crops grown. This could be advantageous to dairy and cattle farmers, because increases in dry matter content can increase feed efficiency.

POLICY OPTIONS

Potential policy mechanisms for promoting the use of renewable fertilizers are similar to those presented in Section 5.10.1 above. The same policy approaches, especially research programs and farmer education and extension services, could be crafted to encourage a switch from industrially based fertilizers to organic ones. For example, improved methods for determining the fertilization quality and the application of manure could be developed. Similarly, broad subsidy or tax programs, or regulation of fertilizer production could provide additional incentives for renewable fertilizer use.

5.11 EMISSIONS ASSOCIATED WITH FORESTED LANDS

Trees and other vegetation remove, or sequester, carbon dioxide from the atmosphere as they grow, storing it as carbon in trunks, limbs, roots, and soil. Through this process, forests provide an important terrestrial "sink" for carbon dioxide. Furthermore, wood products are relatively long-lived structures that store carbon, which makes up about half the dry weight of wood, rather than allowing it to be released back to the atmosphere. Forest-related land use changes can affect the concentration of greenhouse gases in a number of ways.

- *Forest Clearing by Burning* results in immediate emissions of CO_2 and other by-products of combustion, such as CO, CH_4, and N_2O. While CO_2 will later be sequestered during regrowth, emissions of these other combustion by-products (which can include N_2O and methane) represent a net increase to the atmosphere.

- *Forest Regeneration* will, over time, result in uptake of CO_2. The net impact of forest clearing on emissions depends on whether the forest regrows to its original level of biomass density (*i.e.*, the quantity of biomass per unit of land area).

- *Conversion of Forests to Other Land Uses* can result in net emissions of CO_2 because land uses such as crops, pastures, or suburban development sequester and store less carbon than do forests.

- *Mechanical Forest Clearing* changes the emissions profile of CO_2 and other by-products of decay, such as methane. The magnitude and timing of these emissions depend on the fate of the biomass (*e.g.*, whether it is left on-site to decay or used for longer-lived wood products).

- *Disturbance of Forest Soils* can lead to CO_2 emissions as organic material in soils is oxidized. Losses of nitrogen, possibly in the form of N_2O, are also thought to occur. Some data indicate that conversion of forest land to other vegetative uses diminishes the capacity of soils to absorb methane, thus potentially increasing atmospheric methane levels.

Approximately 59 percent of timberland in the U.S. is owned by nonindustrial private forest owners, 27 percent is publicly owned, and 14 percent is owned by the forest industry (RPAA, 1990).[22] Much of the publicly owned forest land is controlled federally through the U.S. Forest Service (USFS), the National Park Service, the Bureau of Land Management (BLM) and the Department of Defense. While the ability of states to affect the use of federal forest land may be limited, states can play a key role in affecting the use of both privately owned and state owned forests within their borders. Opportunities for state action described in this section are not mutually exclusive and frequently offer other significant benefits, such as increased timber productivity, reduced soil erosion, improved water quality, increased biodiversity, improved fish and wildlife habitat, and recreational opportunities.

This section presents five basic technical approaches to controlling emissions of greenhouse gases associated with forested land. The first approach addresses maintaining the carbon storage capacity of existing forested lands. The second addresses opportunities for enhancing the long-term potential to sequester carbon in existing forests through increases in productivity. The third and fourth suggest that climate change issues be integrated into state strategies for fire management and pest control, respectively. The final approach addresses policies that affect the demand for forest products.

5.11.1 Maintain Carbon Storage Capacity of Existing Forests

DESCRIPTION

During the past 25 years, the United States has maintained a relatively stable area of forest land. (EQ, 1995). If forests were being converted to other uses with lower biomass densities, there would be a reduction in carbon sequestration, since the carbon stored in vegetation and soil is greater for forested lands than for alternative land uses (such as crops, pastures, or commercial and suburban development). Therefore, maintaining existing forest and timberland can significantly contribute to stabilizing carbon sinks.

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[22] Two-thirds of the Nation's forests (490 million acres) are classified as timberlands. Timberlands are defined as forests capable of producing 20 cubic feet per acre of industrial wood annually and not reserved from timber harvest. An additional 36 million acres is reserved from harvesting and is managed as parks or wilderness. Total forest land in the U.S. for 1992 was approximately 737 million acres, of which the USFS owned 19 percent, the BLM 5 percent, other federal agencies 18 percent, and non-federal entities 66 percent.

State policy-makers may be able to maintain existing forests to preserve forest carbon sinks by:

- Slowing or stopping the conversion of forested lands to less-biomass dense, non-forest land uses;

- Ensuring, for forest lands where timber harvests do occur, that replanting occurs to replace the carbon sequestration potential of the harvested forest;[23] and

- Ensuring, for extremely carbon-dense forests (*e.g.*, some old growth forests) where replanting may not offer the same level of carbon-density, that harvesting does not occur and the land is preserved as a set-aside.

In addition, while there is considerable uncertainty about the net effects of logging on long-term soil carbon emissions, logging can cause soil erosion which may contaminate water supplies, disrupt wildlife habitat, and deplete aesthetic value of the forest. Because of these concerns and the possible climate change benefits, states may find it desirable to undertake policies to minimize soil erosion in existing forests.

CONSIDERATIONS

Whether maintaining a specific forest ultimately reduces net emissions of carbon depends on the potential for change in its biomass density. Halting conversion of forests to non-forest land uses almost certainly will provide significant benefits because alternative land uses store considerably less carbon than do forests.

It is important to remember, however, that if over the long run harvested lands are replanted or allowed to regrow with trees of similar carbon content and to a similar biomass density, net cumulative emissions may be close to zero. Determining the emissions reduction value of policies targeted at timber harvesting on lands that remain dedicated to forestry therefore requires a case-by-case assessment.

The carbon benefits of maintaining existing forests will vary by region and species. For example, forests of the Pacific Coast states, comprised principally of Douglas fir, contain on average 102 tons of carbon per acre, while forests of the South Central region of the country, primarily oak-hickory forests, contain an average of 58 tons per acre (Birdsey, 1991). In addition, state policy-makers will need to characterize the process of reforestation (either natural or assisted) and assess whether new growth timber will offer the same carbon sequestration capacity as the existing forest.

Halting all timber harvests in certain forests, such as old growth forests, may yield carbon reduction benefits because these forests tend to have greater biomass densities and therefore store greater amounts of carbon than do the younger, secondary, forests that may replace them. The effectiveness of halting old growth timber harvesting in lieu of converting old-growth to secondary growth, in terms of carbon storage potential is, however, subject to some debate (Harmon, et al., 1990). Further, the uses for harvested material may themselves provide a carbon pool, as in the case of long-lived wood products, such as furniture or construction.

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[23] Because of the potential to offset carbon emissions from any source, opportunities to create newly forested areas are described in Chapter 6 as a cross-cutting policy option.

State policy-makers should also consider that the net change in the carbon pool over time depends on the extent to which reduced harvests are offset by increased harvests elsewhere. For example, even if net carbon dioxide emissions from U.S. forest land may be reduced by harvesting restrictions, global carbon dioxide emissions from logging may remain the same or perhaps even increase if the demand for wood products does not change. Policy-makers should carefully weigh these issues when evaluating alternative policy options.

As noted above, efforts to control soil erosion may yield multiple environmental benefits. Federal water pollution control statutes have been a major impetus behind state efforts to control timber harvesting activities near streams. State controls range from voluntary compliance with guidelines developed as "best management practices" to mandatory legal restrictions. For example, states may require that roads be constructed away from stream banks, that cross drainage be provided for roads with significant slope, that erosion control bars be installed throughout a site, and that roads or adjacent areas be seeded after harvesting. In addition, since clear cutting is associated with significantly more soil erosion than selective harvesting, some states have restricted its use.

Reduced timber harvesting, reforestation requirements, and forest management standards may create unwanted economic impacts. Without a decrease in demand for forest products, harvest restrictions may result in higher wood prices and lower levels of production. Given this potential consequence, states in which forestry is a leading industry are unlikely to have the political support to significantly restrict harvesting, though less costly forest management measures may find support. In addition, harvest restrictions may reduce revenues to state and local governments from lease payments and taxes on timber production.

POLICY OPTIONS

- *Support Research and Development*. States may support or conduct forest carbon life cycle analysis to resolve the debate on carbon benefits of forest set-asides and on the change in carbon sequestration capacity associated with harvesting and subsequent reforestation. Such studies could be conducted on a regional basis, considering species composition, and physiographic and climatic features of the region, as well as economic issues, where appropriate.

- *Provide Financial Incentives*. States can offer private owners of forest land incentives to keep their lands out of production, to employ best management practices, or to encourage prompt efforts at reforestation.[24] In North Dakota, the Woodland Tax law provides tax relief for landowners who agree to prohibit clear cutting, grazing, burning, and destructive cutting on woodlands. Similarly, the State of Missouri provides tax relief to land owners who agree to maintain property as forest cropland.

- *Control Development.* Some states have issued tradeable property allowances for privately owned forest areas that they wish to preserve. For example, New Jersey has been successful in capping development in the Pine Barrens through this type of system (Task, 1991). In addition, state and local governments may be able to use their land use planning authorities to restrict the conversion of forested lands to other land uses. States could also establish a fund for forest land purchase and subsequent set-asides.

[24] Chapter 6 provides additional information on options for encouraging the planting of trees.

- *Promulgate Regulations.* States may limit the amount of timber that may be removed from a given site, specify logging practices, or impose reforestation and best management requirements. States can do so either with a permit system or as part of lease provisions for timber harvests on public lands. States could also require that least cost planning that incorporates environmental benefits be conducted for timber harvests on state lands.

- *Monitor Forests.* Some states monitor private industry implementation of best management practices, particularly at timber stands near streams. Florida monitors these harvests by air, targeting counties where foresters fail to use best management practices for increased technical assistance.

- *Address Institutional Barriers*. States should recognize that, in areas where local economies are heavily dependent on timber production, state and local policy-makers often exert significant pressure on field managers of federal forest lands to maintain harvests, perhaps at unsustainable levels. States may wish to consider whether such pressures might undermine the goals of their climate change policies.

5.11.2 Improve Productivity of Existing Forest Lands

DESCRIPTION

By increasing the productivity of forest species, demand for forest products could be met with fewer trees extracted, less carbon released to the atmosphere, and potentially more carbon sequestered. Management approaches that can be used to improve timber stand productivity and carbon sequestration include: thinning trees to decrease competition and stocking additional trees to achieve optimal forest density, planting or replanting unstocked timberland, and enhancing planting sites by providing drainage and/or adding fertilizer. The USFS estimates that if current commercial forests were fully stocked, their net annual growth could increase by about 65 percent. These techniques have been extensively researched and are readily available.

In addition, the use of improved seed stock from cross-breeding or genetic manipulation can enhance productivity. The USFS credits genetic improvements in seed stock, achieved primarily through plant breeding and silvicultural techniques, with substantial increases in annual tree growth in southern conifers.

Wood utilization technology is also being developed by the forest industry and the federal government to meet the demand for wood products with low value, previously underutilized timber. Doing so may mean that less wood residue is left on the forest floor or discarded at the mill to decay. The carbon benefits derived from improved wood utilization depend upon the degree to which such utilization allows for reduced harvests of virgin timber.

CONSIDERATIONS

Several federal and state programs encourage improved forest management. The principal federal programs are the Cooperative Forestry Assistance Program and the Federal Incentives Program (FIP). The Cooperative Forestry Assistance Act of 1978 authorizes federal financial and technical assistance to state forestry agencies for nursery production and tree improvement programs, reforestation and timber stand improvement activities on nonfederal lands, protection and improvement of watersheds, and programs to provide technical assistance to private landowners and others.

FIP authorizes cost-share payments for reforestation and timber stand improvement, site preparation for natural regeneration, and firebreak construction. FIP is jointly administered by the U.S. Forest Service and the Agricultural Stabilization and Conservation Service within the U.S. Department of Agriculture. A number of states also have cost share programs similar to FIP. In addition, the Cooperative Extension Service has traditionally been the primary channel for disseminating new research findings to forestry professionals and landowners.

While public timberland is generally intensively managed, most nonindustrial timberland is not. Various studies identify a number of reasons why nonindustrial timberland owners may not manage their forests for higher productivity. First, many landowners are not aware of what can be done to improve forest growth. Second, among those who are aware of the opportunities, many may be unwilling to undertake projects with a long payback period or relatively modest rates of return. Third, many lack the up-front capital needed to invest in a crop that, although profitable, may not generate income for 10 to 15 years. Additionally, landowners may resist investing in improving their forested land because of the low financial liquidity of young stands and an inability to use future forest values as collateral. Last, some landowners use their timberland for other purposes, such as recreation, which do not require high productivity.

Not all timber stand improvement practices support the goal of reducing greenhouse gas emissions or other environmental goals. For example, increased use of nitrogen-based fertilizer in forests could increase direct emissions of nitrous oxide (a greenhouse gas), cause ground and surface water contamination from its application, produce carbon dioxide emissions from its manufacture, and lead to soil methane emissions, by slowing the activity of methane consuming bacteria acting at the soil surface. Intensive management disturbs forest soil which may increase soil erosion and thus reduce water quality. Also, methods such as stand thinning expose the forest floor to more light, increasing soil surface temperature and accelerating decomposition which liberates carbon.

In contrast to timber stand improvement techniques, some seed stock improvement techniques are currently unavailable for widespread use. For example, while cross-breeding is widely used, genetic manipulation for tree improvement is still in its infancy. Like certain stand improvement techniques, some uses of genetically improved seed stock may also work against the goal of increasing carbon sequestration and storage. Monoculture plantings, for example, lack biodiversity and may be more susceptible to factors, such as pestilence and disease, that reduce forest health and long term carbon storage potential.

POLICY OPTIONS

- *Provide Information and Technical Assistance*. States may disseminate information on the multiple benefits of improved productivity in conjunction with the Cooperative Extension Service. State foresters could act as the clearinghouse for new developments in timber stand and tree improvement techniques or provide direct technical assistance to private landowners on how to manage their forests to achieve a variety of objectives. Presently, some states have initiated forest management and seed stock improvement demonstration projects.

- *Support Research and Development*. States could support research laboratories for research and development in stand improvement techniques, tree breeding techniques, and seed stock, that would be particularly appropriate for use in the state and private forests within their jurisdictions.

- *Provide Financial Incentives*. States could also provide tax incentives to private landowners and forest industry to improve productivity through timber stocking or other methods. Direct payments, tax incentives, and loans could be used to provide encouragement to nonindustrial owners of private timberlands to improve forest management and breeding techniques, or to encourage the testing and use of new seed stock. Some states may be able to implement cost-sharing programs modeled after FIP.

5.11.3 Integrate Climate Change Concerns into Fire Management Policies

DESCRIPTION

Carbon stored in biomass is released upon combustion during forest fire. Soil carbon is liberated both during and after fire disturbance. Some of the forest carbon lost is recaptured during the rapid regeneration of plants following wildfire. However, the direct and post-fire soil carbon emissions from wildfire are thought to outweigh the carbon sequestered by regrowth. Wildfire burned more than 5 million acres of U.S. forest land in 1990; forty-five percent of this land was state and privately-owned forests (USDA, 1992).

A state's fire management strategy is likely to address multiple concerns in addition to the potential for carbon emissions. Such concerns include protection of life and property, conservation of valuable timber, preservation of species habitat, air quality issues, and maintenance of recreational areas, as well as a countervailing concern that wildfire can serve an important ecological benefit by clearing the land of dead and diseased vegetation and allowing opportunities for new growth. Because of the significance and importance of these other considerations, it is suggested here only that the impact of forest fires on climate change be considered when developing state fire management policies.

CONSIDERATIONS

Two principal fire management strategies can be employed to reduce carbon emissions from fire, including:

- *Active fire suppression* -- which halts direct carbon emissions. Some research, however, suggests that fire suppression results in an accumulation of dead and dying timber on the forest floor and a greater fire risk. Fire management by suppression may also affect species composition, particularly of fire adapted forest communities.

- *Controlled or "prescribed" burning* -- which contributes to direct carbon emissions in the short term, but reduces fuel accumulated on the forest floor and may prevent or lessen the extent and intensity of future wildfires. Prescribed burning also fosters goals to improve wildlife habitat, and eradicate forest disease and pests.

More research on fire management is required to determine which strategy or combination of strategies is best for minimizing carbon emissions over the long term. Some consideration must be given to the fact that fires, in addition to liberating carbon, also liberate particulates and other air pollutants. States may want to consider the climate, physiography, forest species composition, and air quality within their jurisdictions to assess the optimal fire management strategy.

POLICY OPTIONS

- *Support Research and Development*. States could undertake studies of fire patterns in forests in their jurisdictions to assess strategies for optimizing carbon storage in coordination with other forest management goals.

- *Inter-Agency Cooperation*. State policy-makers responsible for climate change issues may work with fire officials to ensure that climate change issues are reflected in fire management decisions.

5.11.4 Integrate Climate Change Concerns into Pest Management Policies

DESCRIPTION

Forest insects and diseases attack tree foliage, bark, and woody biomass, eventually killing trees. Downed trees are decomposed by microorganisms and in the process biomass carbon is eventually returned to the atmosphere as either carbon dioxide or methane. Because of the threat to valuable timber and to agricultural operations, virtually all states already have some form of pest management program. Because minimizing the impact of pests and diseases on existing forest land helps enhance carbon storage potential as well as reduce emissions from biomass decay, it may prove useful to integrate climate change concerns into pest management policies.

CONSIDERATIONS

Several methods can be used to check the development or spread of forest pests and disease. Prescribed fire, chemical controls, biological controls, and salvage clearing have all been used successfully in forest ecosystems. Although they contribute to reducing forest losses, each of these controls may have long term impacts on the integrity of the ecosystem. For some infestations, none of these control methods is successful. More research is required to find appropriate control methods for unmanageable forest pests and disease.

The Forest Health Monitoring Program, jointly administered by the USFS, the Bureau of Land Management, and EPA, provides assistance to state foresters in monitoring disease and insect infestation in state forests. In addition, most states routinely monitor forest health and provide assistance to private landowners and state land managers for the control of pests, such as training on tree health and on the effects of environmental stress on trees.

POLICY OPTIONS

Pest management policies must be tailored to the specific species composition, climatic, and geographic conditions of the forest in which they are implemented. Policy options in this area include the following:

- *Provide Information*. Many states work jointly with the Cooperative Extension Service to provide information to private landowners on methods to prevent and reduce forest pestilence and disease.

In addition, forest health demonstration projects may be sponsored by some states. States may also supply pest and disease resistant seed stock to landowners.

- *Provide Financial Incentives*. States may help develop a market for timber salvaged from private forests and provide incentives for monitoring pest incidence and downed timber on forest lands.

5.11.5 Institute Policies to Affect Demand for Forest Products

States may be able to reduce emissions associated with forested lands by pursuing policies that do not directly affect forest land but that instead focus on the demand for forest products. This section addresses three options for implementing this approach. The first addresses opportunities to improve the efficiency of wood burning to reduce the demand for fuelwood. The second focuses on policies to encourage the use of long lived durable wood products. The third addresses recycling of paper products to reduce demand for timber.

Improve Wood Burning Efficiency

DESCRIPTION AND CONSIDERATIONS

Wood can be used as a direct source of heat for homes and small buildings or as a source of electric power. In addition to producing carbon dioxide, wood combustion produces particulates, nitrous oxides, sulfur dioxide, and carbon monoxide. Improvements in wood combustion efficiency can reduce fuelwood consumption and decrease carbon dioxide emissions, emissions of other pollutants, and ash accumulation. For large scale wood combustion facilities, emissions of non-carbon pollutants can be mitigated by a combination of improved combustion efficiency and air pollution control devices.

POLICY OPTIONS

States can employ several policies to encourage more efficient wood burning. These include the following:

- *Provide Information and Education.* States may educate residents and businesses on technologies available to increase wood combustion efficiency.

- *Support Research and Development.* New technologies, such as high efficiency wood stoves for home heating, combust fuelwood more completely and reduce fuelwood consumption relative to less efficient wood stoves. States can support the development of wood combustion efficiency technology for both residential and commercial users of fuelwood.

- *Promulgate Regulations.* States may establish technology-based standards for wood burning stoves. Alternatively, states may restrict fuel consumption or limit allowable pollutant emissions in order to control greenhouse gas emissions from wood burning and to encourage improvements in wood burning technology. For example, for large scale wood combustion facilities that produce more than 1 million Btu per hour, New York State requires air permits that limit the allowable emissions for each pollutant, including carbon dioxide.

Encourage the Use of Durable Wood Products

DESCRIPTION

The potential for forests and forest products to absorb and store carbon dioxide can be expanded by increasing the use of timber products as construction materials, furniture, and other durable wood products, which continue to store the wood carbon after harvest. Carbon contained in wood products may remain for several decades before returning to the atmosphere through decomposition or burning. Some research indicates that the average life and, therefore, duration of carbon storage for certain wood construction materials is approximately 70 years (Row and Phelps, 1991). Particularly if the timber harvest used for these products comes from afforested or reforested lands, rather than depleting existing stands, the aggregate carbon pool may be expanded. Switching from non-renewable construction products -- many of which are energy intensive in their production, such as steel -- can also reduce carbon dioxide emissions by reducing energy consumption.

CONSIDERATIONS

Timber is used for a variety of products, including lumber, structural and non-structural panels, pulpwood, silvichemicals, fuelwood, and other miscellaneous industrial products, such as poles and piling, posts, and mine timber. A large portion of the total timber harvest, about 38 percent, is used to produce lumber, and 27 percent is used in pulp (including paper) products. U.S. consumption of timber has increased steadily over the past three decades, from about 12 billion cubic feet in the early 1950s to 20 billion cubic feet in 1988.

Because the trees that are planted may eventually be harvested and release their stored carbon, timber end-use can be an important component in increasing long-term sequestration. Wood end-uses that are most relevant to long term carbon storage include new residential and commercial building materials, materials for building repair and remodelling, and material for furniture, cabinets, and fixtures. Increased use of these durable wood products can offset carbon emissions both by promoting a sink for carbon and by substituting timber for energy intensive construction materials.

The use of durable wood products can be expanded in several ways:

- By encouraging longer tree rotations, which yield timber that can more easily be converted into durable wood products;

- By encouraging the demand for durable wood products, through price or other incentives; and

- By encouraging the supply of durable wood products directly.

Because wood cannot be substituted for non-wood products used in construction on a one-for-one basis, feasibility constraints may reduce achievable carbon savings or limit the applicability of substitutions. In addition, state policy-makers need to take a broad view of the potential costs and benefits of efforts to encourage the use of durable wood products. Key considerations include: regrowth of the forest's original biomass density; the energy related emissions associated with harvesting, transporting, and using the wood product; and the emissions associated with production and use of the non-wood product being replaced.

POLICY OPTIONS

Several policy options are available to encourage either the supply of or the demand for durable wood products.

- *Provide Information.* States can encourage the production and use of durable wood products by disseminating information on the carbon benefits of their use, or by assisting local governments in examining alternative specifications for building codes.

- *Support Research and Development.* States can support research to develop wood-utilization technologies or forestry methods that reduce the cost of producing timber for durable products. States can also study the extent to which wood can be substituted for non-wood products, with an emphasis on its cost and technical feasibility and on the associated change in total greenhouse gas emissions.

- *Provide Appropriate Financial Incentives.* Financial incentives promote both the supply and the demand for durable wood products. Potential incentives include tax credits for the production and/or use of durable wood products, energy or carbon taxes to raise the relative price of energy-intensive construction materials, and timber subsidies to encourage longer harvest rotation periods.

Encourage Paper Recycling and Recycled Paper Use

By replacing virgin fiber sources with wastepaper, recycling has the potential to reduce net carbon emissions by reducing levels of timber harvesting. Ultimately, the amount of carbon that can be sequestered depends critically on the effects recycling has on both planting and harvest decisions and, thus, on timber inventories as a whole. Because paper and paperboard products currently account for 32 percent of the municipal solid waste stream and contribute to methane formation, recycling may relieve some of the pressures of solid waste disposal on landfill space (U.S. EPA, 1993a). Policy options for encouraging recycling are presented in full detail in Section 5.6.

5.12 GREENHOUSE GASES FROM BURNING OF AGRICULTURAL WASTES

Large quantities of agricultural crop wastes (such as straw, stubble, leaves, husks, and vines) are produced from farming systems. In preparation for each cropping cycle, this waste must be eliminated. This is most often done through open field burning, which increases the field's production capacity by releasing nutrients into the soil, eliminating troublesome weeds and diseases, and removing dead material which may block sunlight or impede crop growth. The burning of agricultural crop wastes, however, also results in significant emissions of CH_4, CO, NO_x, and N_2O.[25] Emissions reductions from this source can be achieved through the disposal of agricultural waste through alternatives to burning.

Previous concern over agricultural waste burning has focused primarily on emissions of particulate matter rather than greenhouse gases. To control particulate emissions as regulated under the *Clean Air Act* (CAA), some states have instituted smoke management programs. These programs are generally administered by state health, environmental, or air quality agencies, or a consortium of agencies.

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[25] Burning of crop residues is not thought to be a net source of carbon dioxide (CO_2) because the carbon released to the atmosphere during burning is reabsorbed during the next growing season.

Because agricultural crop waste burning is uncommon in many parts of the U.S., little federal action has been taken in this area. Under the CAA, biomass burning is regulated to the extent that it affects air quality standards. Beyond that, reducing the burning of residues has primarily been a state concern. Recently some areas have set limits on the burning of agricultural crop wastes, particularly in the Pacific Northwest. For example, Oregon has passed legislation to gradually phase-down the burning of agricultural residues until 1998, at which time the maximum number of acres which can be burnt will be set at 40,000 (an 80 percent reduction from current levels) (Oregon, 1990).

The viability of any burning alternative depends on several factors, including: 1) its ability to meet the same objectives that prescribed burning accomplishes, 2) economic competitiveness with prescribed burning, and 3) technical feasibility. Options available for reducing emissions in this area include plowing residues back into the soil, removing crop residues for other uses, using alternative burning techniques, and replacing with alternative crops.

5.12.1 Plow Residue Back Into Soil

DESCRIPTION

One option for returning nutrients to the soil without burning is plowing the agricultural wastes back into the field. For example, plowing corn husks back into the field will enhance soil quality, which is one of the primary objectives of open field burning. This method is limited, however, because many crops are perennial. Such crops, like rye grass, will continue to live and produce over several seasons and therefore cannot be plowed for several years. An alternative is slot-mulching, where slots are carved throughout the field and farmers incorporate as much residue as possible into these slots.

CONSIDERATIONS

The potential for the incorporation of crop residues into the soil as a burning alternative is limited primarily by economics, lack of adequate pest and disease control, and decomposition rate. The relative importance of these factors varies with crop type and geographic location. For example, California straw is not readily degradable, whereas rice straw in the southern rice belt rapidly decomposes. Straw decomposition rates can vary even among soil series within individual states. In general, high straw yields, dense clay soils, and wet environments are not conducive to straw decomposition. Improvements in straw choppers can help overcome such adverse conditions.

Another potential problem with soil incorporation is pest, disease, and weed control. Soil incorporation of weed seeds increases the need for weed control treatments, and can jeopardize product quality in the marketplace. In cases where stem rot disease is a problem, continued plowing under often results in substantial yield reductions (U.S. EPA, 1992b).

POLICY OPTIONS

- *Support Research and Development*. Additional field research on the benefits of crop residue soil incorporation is needed before widespread acceptance can be expected.

- *Provide Information*. States can disseminate more information describing the soil benefits achieved with this practice, effective use, and optimal situations. In doing so states may use resources such as USDA's Soil Conservation Service and the Cooperative Extension Service.

- *Provide Financial Incentives*. States could also implement a fee structure to encourage the use of emissions reduction techniques and alternatives to burning. For example, states may establish the use of registration fees ($/acre burned) or emissions fees ($/ton emitted).

- *Establish Legal Limits*. States can also limit the amount of acres burned through legislation. For example, Oregon currently sets the maximum acreage that can be burned at 250,000 acres per year (U.S. EPA, 1992b). In addition, a state may elect to restrict the time of year when burning can be conducted or prohibit certain types of burning during historical seasons of nonattainment (with respect to particulate emissions). Washington and Idaho are additional examples of states that have set restrictions on burning, specifying when residues can be burned as a function of meteorological conditions and other constraining factors. Specifying the time when residues can be burned will reduce emissions only when such restrictions reduce the quantity of the residues burned. Greenhouse gas emissions occur regardless of the time the residues are burned.

5.12.2 Remove Crop Residues and Develop Alternative Uses

DESCRIPTION

Historically, it has been difficult for grass straw to compete in existing markets as a raw material resource. Low bulk density of the straw (which requires costly densification), high transportation costs, uncertainty of long-term supply, and low volume of supply in fiber markets have usually made straw non-competitive with other raw materials, particularly wood wastes (U.S. EPA, 1992b).

The potential usefulness of agricultural waste includes not only composting prior to reapplication to the soil but other uses such as alternative (biomass) fuels or building materials. Such applications require the mechanical removal of residues from the field. While compliance with some commodity support programs may prohibit this removal, if no conflicts or restrictions exist the crop residues can be used and marketed in a variety of ways.

Composting. Composting involves gathering agricultural wastes and setting them aside to decompose. Residue collection methods with this application include raking, residue flail-chopping, and vacuuming into sacks with soil and nitrogen sources such as chicken manure, and crew-cutting. After the waste has decomposed, the decayed material can either be marketed or returned to the soil as fertilizer.

Supplemental Feed Market. Agricultural crop wastes such as grass straw can be collected and sold in a supplemental feed market. The straw must be gathered, baled, stored, and compressed so that it can be shipped on order. This practice is currently one of Oregon's primary alternatives to burning. Approximately 150,000 - 250,00 tons of straw are shipped to Japan each year (Britton, 1992). Untreated straw makes for poor quality livestock feed because of low protein and high fiber content. With appropriate treatment (*e.g.*, ammoniation), the digestibility and palatability of straw can be increased substantially, making straw a potential component of maintenance diets for ruminant livestock.

Alternative Fuel Source. Agricultural residues can be used as an alternative (biomass) fuel source for cooking, space heating, drying of agricultural products, and the production of power by steam engines or Stirling motors (Strehler and Stützle, 1987). Specific applications include burning the residues in furnaces to generate heat for drying units or for space heating at home. There is tremendous potential for improving the end-use efficiency in such energy conversion processes (Lashof and Tirpak, 1990). Biomass fuels can also be used to produce motive power or electricity by using a steam engine, a Stirling motor, or a gasifier. Gasifiers can convert agricultural residues from solid fuel into gasified fuel. They have been used to provide electricity and to power tractors and irrigation pumps. In all of these applications it is important to use biomass with a relatively low moisture content; otherwise, the energy loss due to water vaporization will be too high.

Paper and wood product substitution. Agricultural residues can also be used for non-energy purposes. For example, residues can be gathered for fiber or building materials. Weyerhauser, a paper and lumber company, is investigating the possibility of using agricultural residues as filler in particle boards.

CONSIDERATIONS

Composting can be relatively time-consuming compared to burning. The level of effort necessary for a productive program depends on several factors, including decomposition rates and weather and moisture conditions. Also, the process of large-scale composting is not fully understood or refined. The Agricultural Research Service (ARS) in Corvallis, Oregon, is researching the effectiveness of low-input composting and ideal composting procedures. The USDA/ARS in Beltsville has had a successful research program in large-scale composting and developed the Beltsville Aerated Rapid Composting (BARC) method, currently in use at the WSSC Calverton Composting Facility.

Marketing straw in the United States may be more difficult than in foreign markets due to the erratic and competitive nature of U.S. markets. For example, supplemental feed markets may only be a profitable option if a drought occurs with a significant impact on crop yields, forcing the price of feed and other agricultural products to rise. Furthermore, any physical and chemical treatments to enhance the quality of the straw will increase the cost of this alternative. Finally, because Japan can obtain straw from other countries such as Australia or Argentina, it may not prove to be a reliable customer for U.S. sources.

Combustion for heat generation may be the most appropriate means of replacing fuel oil with residues, because much less investment is necessary compared to replacing fuel oil in power generation. Also, the total maximum efficiency of the power produced by means of a turbine or steam engine is approximately 15 percent, even though the combustion of biomass can be accomplished with high efficiency (Strehler and Stützle, 1987). The disadvantages of gasifiers include a high particulate and tar content of the gas. Furthermore, current gasifier designs do not accept all types of crop residues.[26] Finally, after biomass burns, a silicate remains, creating a sludge problem that inhibits acceptance of residues as an alternative fuel.

Using agricultural residues to manufacture paper products is a possible alternative. Traditionally, paper products are manufactured using wood chips, which are cheap and readily available. However, wood chips do not require storage from rainy weather and replacing them with agricultural residues may require major retooling in the wood fiber industry. Despite this, however, grass straw is becoming a more economically attractive alternative to using hardwoods. The reason for this is the projected shortage of hardwoods in the near future and the fact that straw fibers from grass seeds are very similar in structure to hardwoods.

POLICY OPTIONS

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[26] For a more complete technical discussion of agricultural residues as an alternative fuel source, see Strehler and Stützle, 1987).

Currently, significant scientific uncertainty inhibits development of programs in this field. Therefore, research and development projects which support alternative uses for agricultural residues could prove extremely beneficial. States could encourage alternative uses for crop residues by designing policies compatible with those mentioned in Section 5.12.1 and Section 5.2, which address the advantages of using biofuels and renewable energy sources for energy production, including co-generation and direct combustion.

- *Provide Information*. Information dissemination campaigns may be an effective way to encourage alternative uses for crop residues. Given information on these alternatives, farmers may be convinced to participate in voluntary emissions reduction programs to reduce smoke and particulate emissions as well as greenhouse gases. Though information is available on composting, most farmers have little experience with this practice. States can disseminate information describing the potential soil benefits associated with this option, the manner in which it can be implemented, and conditions under which it works best. The Cooperative Extension Service is an appropriate state vehicle for this.

- *Support Research and Development*. Ideal composting methods need to be identified and a better understanding of large-scale composting achieved, before widespread adoption can be expected. In addition, states can fund projects that investigate the viability of alternative uses for crop residues. For example, states can provide funding to support research into wood product substitution for grass straw. To date, a number of studies have indicated the great potential that biomass fuels have as an alternative fuel source. This issue needs to be examined further.

5.12.3 Use Alternative Burning Techniques

DESCRIPTION

A number of alternatives that still involve burning can also reduce emissions. This can be accomplished, for example, either by creating a hotter, more controlled burn that combusts crop residues more thoroughly, or by reducing the frequency of burning in conjunction with mechanical crop removal techniques. Technologies and methodologies to achieve these objectives include:

- *Mobile Field Sanitizer*. This is a machine designed to burn agricultural residues in place. It serves as a method of both straw removal and field sanitation. While field tests have shown that sanitizers can reduce carbon monoxide and hydrocarbon emissions, their applicability appears limited. Technical and economic evaluations of field sanitizers have found problems with high operating costs, durability, maneuverability, energy use, and operating speed. Based on these studies, many states have discontinued research and development of mobile field sanitizers, although there has been some success with their private development.[27]

- *Propane Flaming*. Propane flamers consist of a propane tank and a series of nozzles. The propane is released, ignited, and directed at ground level. Because straw residue must be removed first for this method to be effective, this technique is typically used with other disposal methods such as bale/stack burning (described below). While these practices are thought to bring about a slight reduction in emissions when used together, they are much more time consuming than open

[27] For example, an Oregon farmer currently uses a privately-developed mobile field sanitizer. Due to the high value of this farmer's crop, it was economical to develop and maintain the sanitizer (U.S. EPA, 1992b). The high costs associated with development frequently prevent other farmers from pursuing this option.

field burning. If most of the straw residue is removed prior to flaming, this technique should not result in major seed yield losses.

- *Bale/Stack Burning*. Bale/stack burning, the collection of crop residues into bales or stacks to facilitate controlled burning, is a companion practice to propane flaming (which requires straw removal). Some growers have turned to bale/stack burning to dispose of unmarketable crop residues. As mentioned above, this practice results in slight reductions in emissions, but is more time consuming than open field burning.

- *Less-Than-Annual Burning*. This involves alternating open field burning with various methods of mechanical removal techniques. The periods may involve burning every second or third year.

CONSIDERATIONS

There are a number of uncertainties that limit the applicability of some alternative burning techniques. For example, mobile field sanitizers have not been fully developed and have proven successful only in isolated cases. The technical problems associated with field sanitizers mentioned above need to be addressed before widespread acceptance of this option can be expected. Similarly, improvements in techniques like propane flaming may be required to make it an attractive alternative. For example, studies have shown that because of the temperature and duration of propane flaming, many of the weed seeds are not destroyed, ultimately resulting in increased weed infestation (U.S. EPA, 1992b). Moreover, the fossil energy inputs required for these techniques emit greenhouse gases, so the net effect on emissions is not clear. These problems will need to be addressed in order to facilitate acceptance of these alternatives.

POLICY OPTIONS

States could encourage alternative burning techniques for crop residues by designing policies compatible with those mentioned in Section 5.12.1. Specifically, states may wish to focus on research and development efforts or demonstration projects to eliminate some of the problems and uncertainties discussed above.

5.12.4 Replace with Alternative Crops

DESCRIPTION

Crops whose residues are typically burned can be replaced with crops that potentially grow and thrive under a system of non-burning, such as meadowfoam, rapeseed, and Pyrethrum. Switching crops in this way is highly dependent on economic, agronomic, institutional, and other factors. This is an area of current research and relatively high uncertainty regarding net impact on greenhouse gas emissions.

CONSIDERATIONS

Whether this alternative is feasible depends on its ability to compete economically and its agronomic capabilities compared with existing crops. Limited potential for major crop shifts exist where crop patterns have developed in accordance with agronomic conditions and market demands.

Research in Oregon has shown that alternative crops with the best agronomic viability have not been economically competitive with perennial grass seed production in the Willamette Valley. In

California, rice farmers have been reluctant to stop farming rice because the high clay soils are unsuitable for growing other crops (U.S. EPA, 1992b). Further research may determine whether there are crop species that thrive without open field burning and that approach production levels of existing crops.

POLICY OPTIONS

- *Support Research and Development*. Research programs are necessary to determine economically feasible substitutes for crops whose residues are typically burned. The USDA/ARS and CSRS support research into new crops. Much of the current research on the use of alternative crops has taken place in Oregon. The results of this type of research are often specific to a state and/or region.

CHAPTER 6
CROSS-CUTTING THEMES AND PROGRAM DEVELOPMENT

This chapter introduces potential organizing principles for policy development that span the various greenhouse gas source categories examined in Chapter 5. The approaches presented here offer some of the most significant opportunities for large-scale emission reductions, and may serve as focal points for coordinating long-term, comprehensive planning for reducing emissions.

Programs that affect various source categories usually focus on either one economic sector, one particular type of policy, or a more specific substantive goal. For example, a program may target the energy or the agricultural sector, or may target municipal solid waste. Alternatively, a program may establish an energy or carbon tax that affects various sectors. Finally, a program may focus on a substantive issue such as biomass energy development or public education.

While the specific cross-cutting options presented here offer potential for large emission reductions, policy-makers may want to develop other sectoral or substantive focal points that match their local circumstances. Programs in each region of the country should certainly respond to local needs and make full use of local resources such as available wind, solar power, or other renewable energy sources. Customized programs that cut across source categories are especially promising in areas dominated by one type of economic activity such as agriculture, forestry, or coal mining. In these areas, comprehensive programs can foster diverse policies that support each other even though they address different greenhouse gas sources. For example, comprehensive agricultural programs can simultaneously utilize methane from waste products for on-site power production, increase energy efficiency, and reduce transportation emissions stemming from waste disposal.

This chapter discusses six specific cross-cutting topics:, (1) energy conservation, renewable energy, and carbon offsets in the electricity sector, (2) municipal solid waste management, (3) biomass based energy development, (4) carbon sequestration through forestry, (5) city and regional planning, and (6) agricultural sector planning. This information is meant to provide background for policy development across greenhouse gas source categories by introducing these concepts and referring policy-makers to related and more specific information in Chapter 5. In most circumstances the information presented here is not as detailed as in Chapter 5. For more information on the linkage between these two chapters, see the introduction in Part II of the document.

6.1 ENERGY CONSERVATION, RENEWABLE ENERGY, AND CARBON OFFSETS IN THE ELECTRICITY SECTOR

The recent trend toward deregulation of electricity generation is transforming the U.S. electricity sector. Electricity production previously involved only utilities constructing and operating power plants. However, the trend now is for utilities to compete with other firms in generating electricity, with utilities maintaining their historical role in transmission and distribution of electricity.

This section examines how states can promote greenhouse gas reductions within the context of electricity deregulation. It provides a background for the specific technical approaches and policy options presented in Sections 5.1 and 5.2. While separated here for clarity, these three sections supplement each other and should be considered together during policy analysis and development.

The remainder of this section summarizes five approaches states might either initiate directly or utilize for guidance.

Ensure Infrastructure Access for Small Power Producers, and Promote Purchase of "Green Power"

One potential environmental benefit of electricity deregulation is the opportunity for electricity consumers to choose to purchase power from generators using low-carbon fuel (i.e., natural gas) or no-carbon renewable fuels. For consumers to have this option, generators using low-carbon and no-carbon fuels must be able to connect to the electric utility grid, so that they may provide electricity over the utility's transmission and distribution system.

In the past, two factors have inhibited non-utility power producers from entering the electricity market. First, these producers face high costs in linking or "interconnecting" to power transmission and distribution networks. In addition, although the Public Utilities Regulatory Policy Act requires utilities to provide interconnections on nondiscriminatory terms and at just and reasonable rates, in practice, many non-utility power producers have encountered substantial resistance from electric utilities. Beyond the basic interconnection issue, non-utility power producers historically have had difficulty selling power directly to consumers (rather than to a utility as a middleman). State options to address these issues include increased scrutiny of utility interconnection and back-up pricing practices to ensure that they are nondiscriminatory to non-utility power producers, as well as policies to encourage electric utilities to provide transmission services for non-utility power producers.

Once consumers have the option of buying power directly from a variety of electricity generators (both utilities and non-utilities), the state government can encourage firms to offer "green power" (i.e., electricity generated with low-carbon or no-carbon fuels). At the same time, the state government could publicize the greenhouse gas benefits of green power, to increase demand for this environmentally friendly option.

Institute a "Societal Benefits" Charge or a Carbon Tax on Electricity Generation

At least three states (Massachusetts, California, and New Jersey) have instituted a tax, often termed a "societal benefits" charge, on all electricity purchased (no matter what fuel is used to generate the electricity). Proceeds from this tax are typically used to promote energy efficiency and renewable energy through research and development funding, production subsidies, tax credits, low-interest loans, or other means. Other uses of the tax proceeds include helping low-income households pay for their energy needs.

An alternative approach would be to institute a carbon tax on fossil fuels used for electricity generation. A carbon tax may reduce greenhouse gas emissions by encouraging energy efficiency or fuel-switching to low-carbon energy sources. Note, however, that although related measures, such as "externality-adders" or gasoline taxes, have been employed at the state level, a carbon tax at the state level may result in undesired consequences. For example, it might provide incentives for industrial and commercial energy consumers to relocate outside the state.

Promote voluntary adoption of energy-saving technologies

In the past, some states have become involved in promoting energy efficiency by encouraging electric utilities to help their customers purchase energy-efficient equipment. Such programs were known as “demand-side management,” or DSM. DSM programs contributed to “integrated resource planning, ” or IRP (in which future electricity demands were met by investments both in energy-efficient equipment and in new generating capacity). With the trend toward deregulation of the electricity sector, many states are turning away from the utility-focused DSM and IRP programs. However, states still have opportunities to promote voluntary adoption of energy-saving technologies. For example, a state government could provide one-stop shopping for information on how to participate in a variety of federal energy conservation programs, from the US EPA’s Green Lights program to the US Department of Energy’s Motor Challenge program.

Establish or Support Carbon Offset Programs

States could require, or provide financial incentives to encourage, electricity generators and other greenhouse gas producers to reduce emissions or sequester carbon in proportion to the emissions that new activities, such as a new power plant, will create. One option is to allow these emissions reductions to take the form of "offsets", *i.e.*, a utility that wants to construct a new coal-fired power plant, for example, could be required to sponsor a carbon sequestration forestry project or a program to reduce emissions in some other sector, such as transportation. Combining the emissions offset project and the new power plant project would aim to ensure that there is no net increase in the amount of greenhouse gases emitted to the atmosphere.

In addition to directly mitigating the impacts of emissions from new sources, these types of "offset" programs provide an incentive for utilities to select non-carbon energy sources when feasible. This is because requiring carbon offsets will raise the costs of high-carbon options, making alternative energy sources relatively more desirable.

With these factors in mind, some states and utilities are beginning to pursue offset programs as one of the most promising options for mitigating the impact of energy related emissions. Applied Energy Services, for example, pioneered a forestry project in Guatemala to offset the emissions from a 100 megawatt coal-fired power plant in Connecticut and the New England Electric System is sponsoring similar projects in Russia and Malaysia.

Several issues complicate offset program design and administration. Many are related to the fact that large scale offset programs are a relatively new and undeveloped technique that will presumably be refined. Another constraint is the difficulty associated with measuring the greenhouse gases emitted and sequestered through various activities, especially long-term forestry projects where success depends on many climatic and other uncontrollable factors. Issues of predictability and dependability become more significant if offset programs permit investment in forestry projects in other parts of the world, where the projects usually cost less. Further, states pursuing offset options will also have to evaluate how to treat emissions linked to electricity received from or sent to other states or offset projects located in other states.

Support Emission Trading Programs

Emissions trading programs allow private entities to buy and sell pollution reductions that are achieved. These market-based systems present opportunities for reducing aggregate pollution levels at a lower cost to society. Forms of tradeable permit systems, for example, are currently utilized in the U.S. to control non-greenhouse pollutants including sulphur dioxide and lead. These programs provide broad incentives to all polluters to reduce emissions and improve their production processes and could conceivably be applied to carbon dioxide emissions as well, either domestically or internationally. Tradeable permit programs may not be feasible or desirable at the state level, however, because of complications arising from complex cross-boundary, administrative, and enforcement issues. They are noted here as background on national or regional initiatives that states might support in order to help reduce their own emissions.

In one form of tradeable permit system, the government sets an aggregate level of permissible emissions for society as a whole and then allocates permits that allow their holders to emit a certain quantity of pollutants. Private entities that want to increase their levels of pollutants (presumably to increase production of their products, such as electricity) must buy permits from others who hold permits in excess of their current needs. In this way, the government achieves its target level of aggregate emissions at a minimum social cost and simultaneously provides an incentive for individual private sector actors to reduce emissions so they can gain profits by selling excess permits.

Complications in designing these programs include setting a target level of emissions, distributing initial permits, addressing equity concerns in initial permit distribution between different polluters, designing the system for facilitating permit sales and purchases, dealing with cross-boundary issues, and determining the optimal allowable aggregate emission levels.

> Cross-cutting policies in the energy sector may affect all of the emission source categories in Chapter 5. For example, energy taxes will affect all methane and transportation issues in addition to traditional electricity production and consumption. As stated at the beginning of this section, it is particularly important that the information presented here be considered in the context of technical approaches and policy options in Sections 5.1 and 5.2.

6.2 MUNICIPAL SOLID WASTE MANAGEMENT

Continuing to promote the municipal solid waste hierarchy of waste management methods—i.e., promoting increased source reduction and recycling followed by combustion and landfilling of waste—can result in significant GHG reductions. States have a number of opportunities for increasing source reduction and recycling, thus achieving GHG reductions in the waste management sector.

As of late 1997, 45 states have statewide goals for source reduction and/or recycling (SR&R). Most of those goals were set at ambitious levels, and many states are in the process of re-evaluating the goals. As this section describes, the climate benefits of SR&R are significant; states may consider these benefits as they reevaluate their SR&R goals. Although GHG emissions from the waste sector typically represent just five to ten percent of a state's GHG inventory, they may represent up to 20 percent of the GHG reductions in a state action plan, due to GHG reductions across many sectors (e.g., energy-related GHGs, manufacturing non-energy GHGs, and landfill methane). EPA has conducted research to quantify the GHG benefits of SR&R, and is providing technical assistance to states developing mitigation plans for the waste sector.[1]

The way in which municipal solid waste (MSW) is managed affects GHG emissions in several ways. The use of energy in material production can be reduced (with accompanying GHG reductions) through source reduction;[2] the same is generally true for recycling. Source reduction and recycling can also reduce manufacturing non-energy GHG emissions (e.g., perfluorocarbons); in some industries—notably aluminum and steel—such emissions can be significant. In the short run, the amount of carbon sequestered in forests will increase when paper is source reduced or recycled (because timber harvests will be reduced). Methane emissions from landfills can be reduced by managing the organic fraction of MSW by means other than landfilling. However, in a properly managed landfill, landfilling can serve as a long-term carbon sink for organic materials. Exhibit 6-1 shows the GHG sources and sinks associated with materials in the municipal solid waste stream.

Source reduction and recycling in one state may in some cases result in GHG reductions in another state. For example, a state that recycles office paper may as a result reduce energy consumption (and CO_2 emissions) in another state where office paper is manufactured. If the first state exports its waste for landfilling out of state, it may also reduce landfill methane emissions in a third state. The same phenomenon can occur with state programs to reduce energy consumption: because many states import electricity, one state's efforts to reduce electricity consumption may result in GHG reductions (from reduced electricity generation) in other states. With any type of state program that may result in GHG reductions out of state, it is important to remember that climate change is a global problem, and the state is still helping to reduce greenhouse gas emissions, and helping the nation to meet its international greenhouse gas commitments. Thus, a state program to reduce GHG reductions from MSW management is worthwhile, even though some of the GHG reductions may show up on other states' GHG inventories.

The EPA Office of Solid Waste (OSW) has quantified the GHG impacts of different methods of managing various components of MSW. In general, source reduction (including backyard composting), recycling (including centralized composting), and combustion have lower GHG emissions than landfilling. EPA plans to evaluate the GHG emissions of emerging technologies for MSW management, such as conversion of organic materials to biomass fuels.

This section examines five means by which states can promote greenhouse gas reductions through improved management of MSW. A useful reference for quantifying the GHG emission reduction benefits from source reduction and recycling of selected materials in MSW is a draft EPA report, *Greenhouse Gas Emissions from Municipal Waste Management*. The report is available on the Internet at http://www.epa.gov/epaoswer/non-hw/muncpl. Also, Appendix 2 of this guidance document presents a mock-up for a state solid waste climate change mitigation package.

Promote Voluntary Waste Prevention and Recycling in the Commercial Sector

When businesses implement source reduction and recycling programs, they do so because it saves them money (e.g., by reducing waste disposal costs). Thus, from a state perspective, promoting voluntary

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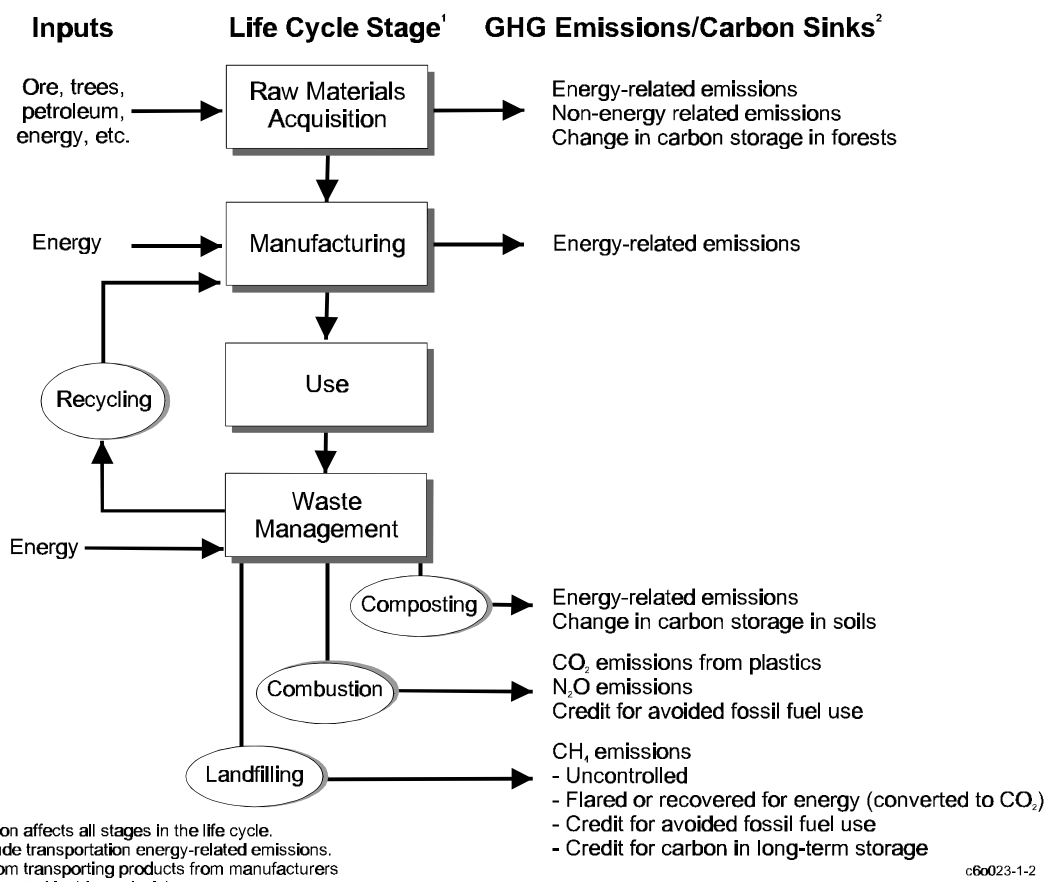
[1] To reach EPA staff that can provide technical assistance to state GHG planners on MSW management options, contact EPA's Municipal and Industrial Solid Waste Division (phone: 703-308-8300; fax 703-308-8686).

[2] Source reduction, also known as waste prevention, involves altering the design, manufacture, purchase, or use of products and materials to reduce the amount and toxicity of what gets thrown away. Source reduction reduces or eliminates pollution at the source.

commercial source reduction and recycling is a "no regrets" option: it makes sense even without considering the greenhouse gas reductions achieved. Offices, grocery stores, and other businesses often can source reduce and recycle large volumes of office paper, corrugated cardboard, and other materials. State governments can foster commercial source reduction and recycling through a state government "buy recycled" program, and incentives such as business development assistance and tax cuts or tax credits.

Exhibit 6-1
GHG Sources and Sinks Associated with Materials in the MSW Stream



[1] Note that source reduction affects all stages in the life cycle.
[2] All life cycle stages include transportation energy-related emissions. (except that emissions from transporting products from manufacturers to consumers were not counted in this analysis).

EPA's WasteWi$e Program is a flexible program that allows partners to design their own solid waste reduction programs tailored to their needs. It challenges companies to set and achieve source reduction and recycling targets. EPA offers technical assistance and recognition to partners (the entitities who commit to achieve waste reduction) and endorsers (groups who help promote WasteWi$e). States, local governments, and tribes can sign on as partners; many (85) have already joined the program in this capacity. Also, over 600 businesses currently participate in the WasteWi$e Program. By diverting waste from disposal, these programs reduce waste collection and disposal costs, reduce greenhouse gas emissions, and reduce other environmental emissions as well. Information on WasteWi$e is available from EPA's hotline for the program (1-800-EPA-WISE) or the program's web site (http://www.epa.gov/wastewise).

Promote Collection Efficiency for Recyclable Materials and Maximum Diversion Programs in the Residential Sector

Small cities in the US have been able to achieve recycling rates of 50 percent or more, while some large cities are approaching a 50 percent recycling rate. Loveland, Colorado (population 44,300) has achieved a 57 percent recycling rate by providing curbside recycling and charging volume-based trash fees for waste disposal. Ann Arbor, Michigan (population 112,000) recovers 50 percent of its residential waste through curbside recycling of 30 different recyclables. San Jose, California (population 850,000) recovers 44 percent of its waste, including 55 percent of waste from single-family households, which pay volume-based rates for trash service.

The best means of achieving GHG reductions from increased recycling in the residential sector is often to institute curbside recycling. Compared to a recycling program based on drop-off centers, curbside recycling dramatically increases both participation in recycling, and the amounts of material recycled. Curbside recycling is most cost-effective in larger communities, where marketable quantities of recyclables may be collected each week. Thus a state may consider encouraging larger communities to provide curbside recycling. Some communities combine curbside recycling with waste collection by using "co-collection" trucks with bins for each type of recyclable material, plus a compartment for non-recycled waste.

Some cities have focused on increasing the efficiency of their waste management operations (thus decreasing costs), and increasing recovery at the same time. Some of the techniques used to increase efficiency include increased automation, changes in collection frequency, and improved routing. Rochester, New York and Mesa, Arizona both instituted curbside recycling as part of an overall efficiency upgrade. The amount of materials recovered increased from zero to six pounds per household per week in Rochester, New York, and from zero to ten pounds per household per week in Mesa, Arizona.

Institute "Pay As You Throw" Pricing for Waste Collection

"Pay as you throw" (PAYT) programs may be implemented to further increase recycling, and to provide an incentive for source reduction. Under a PAYT program, households are charged for the amount of waste they discard. By increasing the amount of waste that they recycle and source reduce, households can reduce the amount of discarded waste and thus will reduce waste disposal costs. PAYT programs have traditionally charged households for the *volume* of waste disposed, measured by a standard-sized bag or trash can. Where bags are used, households must either pay for each specially-marked bag they use, or pay for pre-printed stickers to place on each ordinary trash bag they set out. Where containers are used, a household pays a monthly or annual fee for the size and number of containers it uses.

Over 3,000 communities have implemented PAYT programs, with many communities reporting average waste reductions ranging from 25 to 35 percent. Information on PAYT is available through the web site maintained by EPA's Pay-As-You-Throw program (http://www.epa.gov/payt) and the program's help line (1-888-EPA-PAYT).

Target Specific Materials in the MSW Stream

Many communities have instituted programs to divert specific materials from landfills. Such programs have ranged from promoting composting of grass clippings to collecting second-hand electronic goods for repair and resale.

Several communities in the U.S. collect durable goods for reuse. Programs include curbside collection of durable goods for distribution to charities, local swap meets where individuals may trade durable goods, or drop-off sites where individuals may leave goods that are broken or no longer of use to them, and others may take what they can fix or use. States may promote such programs by emphasizing the full range of benefits, including reduced disposal costs, greenhouse gas reductions, and, where applicable, employment opportunities (e.g., repairing electronic goods).

A state may reduce emissions of methane from landfills by reducing landfilling of grass clippings. Grass clippings from a state with a population of 5 million, which generates grass clippings at the national average rate, will emit about 103,000 metric tons of carbon dioxide equivalent (MTCDE) of methane if landfilled. Because grass clippings decompose readily, they generate more methane when landfilled than leaves, branches, and many other types of organic wastes. Grass clippings may be kept out of landfills through "grasscycling" (leaving grass clippings on the lawn to decompose) or composting. Many communities have successfully implemented backyard composting programs by giving residents free plastic composting bins. Collection of grass clippings for centralized composting is another alternative.

Ensure Adequate Financing of Source Reduction and Recycling Programs

States can help to expand source reduction and recycling efforts by establishing financing mechanisms for support of new programs. Alameda County, California imposes a surcharge of six dollars per ton of waste landfilled in the county, to support waste reduction and recycling. The fee has generated more than 30 million dollars in revenues since 1991. This surcharge not only ensures revenue for waste reduction activities but also creates financial incentives to reduce the amount of waste landfilled. Other types of financing could also be developed.

For more information on municipal waste management issues see:

5.1 Greenhouse Gases from Energy Production: Demand Side Measures
5.6 Methane from Landfills
5.11 Emissions Associated with Forested Lands

6.3 BIOMASS ENERGY DEVELOPMENT

Biomass resources, including wood and agricultural wastes, timber, and grain crops accounted for about 3.3 percent of U.S. energy consumption in 1990. Because plants that produce these resources sequester carbon while growing, using biomass as a renewable energy source to displace fossil fuels helps mitigate carbon dioxide buildup in the atmosphere. Additional information on how trees and plants sequester carbon is presented in Section 5.11, *Emissions Associated with Forested Lands*, and Section 6.3, *Tree and Timber Expansion Programs*.

Biomass can be converted to gaseous, liquid, or solid fuels that may substitute for common transportation, power generation, industrial, and heating fuels now used. Gaseous fuels from biomass can be used just like natural gas. Liquid fuels, mostly ethanol and similar alcohol products, can directly substitute for liquid petroleum fuels such as gasoline. Solid fuels, usually meaning the biomass itself after being dried, can be burned to produce thermal energy for uses like heating buildings or can be used in direct combustion processes at power plants in the same way as coal.

Wood wastes and agricultural crop residues are often considered to be the most cost-effective biomass resources since they result from other productive economic activities and are readily available. Wastes and residues are currently used extensively for energy production in some sectors such as the paper industry. In addition to replacing fossil fuels that produce greenhouse gas emissions, increasing the use of these resources may help alleviate other problems such as costs and methane production associated with waste disposal and landfills. Wood and crop residues can be gasified, liquified (into ethanol), burned directly for use in on-site power generation, or burned to heat commercial buildings and homes.

Short rotation woody crops, mostly trees, can be burned to heat buildings or to fire conventional power plants in a process similar to coal combustion. For example, in 1990 New York state generated around 3 megawatts of electricity using wood power and in 1991 Vermont generated approximately 1.7 percent of its electricity from biomass at a woodchip burning plant. Wood can also be transformed into liquid fuels such as ethanol through enzymatic processes, although these processes are expensive to use at the current time. Several short-rotation woody crops have been identified as "model" energy crop species based on their rapid biomass yield potential. These crops include silver maple, sweetgum, sycamore, black locust, eucalyptus species or hybrids, and poplar species or hybrids. The highest yielding crop appropriate for a given region may be among these model crops or may be different, depending on soil and other characteristics within a geographical region (Sampson and Hair, 1992).

Grain crops, especially those high in sugar content such as sugar cane and corn, can be converted to ethanol through fermentation and distillation processes. This procedure is being pursued aggressively in some areas, especially throughout the corn-belt states where various programs promote ethanol to enhance energy self-sufficiency and support the local economy. Residues from these crops can also be used for direct combustion or gasification, as described above.

The challenge for biomass in the future is to ensure a sustainable harvest, possibly from plantations, to develop efficient and non-polluting systems for fuel conversion and use, and to lower production costs so these fuels can compete with traditional sources. The total costs of biomass fuel development will vary depending on crop productivity and biomass handling and transportation costs. Other questions surrounding biomass fuel development include the net effect of sequestering carbon (including impact on carbon content in soils), the effect on other greenhouse gas emissions like nitrous oxide from fertilizer applications, the vulnerability of large plantations to pests and diseases, the competition for woody biomass to make pulp for paper manufacturing, and competition for land with traditional agricultural crops (NAS, 1991).

- A variety of policy options may help resolve these uncertainties and promote greenhouse gas reductions through substitution of biomass fuels for fossil fuels. Policies in this area might include:

- Research, pilot programs and financial incentives to encourage the development of high-quality, low-cost, and continuously available bioenergy crops. Tax or other credits for biomass production or reducing tax incentives for fossil fuels may help in this way.

- Research and demonstration projects to encourage the development and application of more efficient technologies that may be more competitive with other sources of energy.

- Testing or construction of commercial facilities and infrastructure for using and distributing biomass-based fuels in order to support their widespread use in the long-term.

The 1991 Vermont Comprehensive Energy Plan illustrates how states might promote biomass fuel development, emphasizing how wood products can offset the state's use of nonrenewable fuels like coal or oil for electricity generation as well as direct heating. Similarly, the 1992 Iowa Comprehensive Energy Plan emphasizes increasing that state's energy self-sufficiency by developing renewable resources including ethanol and other biomass products.

For more information on biomass issues see:

5.2 Greenhouse Gases from Energy Production: Supply Side Measures
5.3 Greenhouse Gases from the Transportation Sector
5.6 Methane from Landfills
5.10 Nitrous Oxide from Fertilizer Use
5.11 Emissions Associated with Forested Lands

6.4 TREE AND TIMBER EXPANSION PROGRAMS

Trees provide an important terrestrial "sink" for carbon dioxide by removing or sequestering this greenhouse gas from the atmosphere as they grow, and storing it in wood, foliage, and soils. Permanently increasing the acreage devoted to forests and timberland can therefore contribute to reducing net carbon emissions. Policies to pursue this aim can be valuable in "offsetting" or counter-balancing emissions from other sources such as power plant operations. This section focuses specifically on increasing carbon sequestration through expansion of forested lands; Section 5.11, *Emissions Associated with Forested Lands*, provides more details on emissions issues related to conversion of existing forest land and consumption of wood products.

Carbon sequestration benefits may accrue through projects designed specifically for this purpose or they may accompany broader policy objectives such as enhancement of natural resources, reduced soil erosion, or improved wildlife habitat. Several federal level forestry programs and planting initiatives and some private sector efforts support tree planting objectives. The federal programs are administered primarily by the U.S. Forest Service and other agencies within the U.S. Department of Agriculture and by the Department of the Interior.

One of the most significant federal efforts dedicated to expanding forested area in the U.S. was the U.S. Tree Planting Initiative. As part of the 1990 Farm Bill, this initiative focussed on planting and maintaining one billion trees per year in urban and rural areas. Linked with this initiative are existing federal programs, including the Stewardship Program, the Stewardship Incentive Program, and the Urban and Community Program, that work towards the goal of tree maintenance and planting. All 50 states have formed State Forest Stewardship Coordinating Committees to assist state foresters with these programs.

Federal programs designed to meet other policy objectives may also help increase carbon sequestration through tree and timber expansion. For example, the Conservation Reserve Program, aimed at protecting highly erodible croplands, converted about 2.4 million acres into permanent tree cover since its inception (Callaway and Ragland, 1994). Carefully tailored support for this sort of initiative illustrates the types of multiple-benefit or "no regrets" actions that states may be able to pursue to help mitigate the threats of climate change.

Additional tree-planting initiatives have been undertaken by electric utilities, often with the assistance of state governments and some non-governmental organizations, in an effort to "offset" carbon emissions from other sources, including power plant operations. For example, PacifiCorp is implementing carbon dioxide offset projects in Oregon that assist non-industrial landowners in planting rural lands. This project includes cost-sharing and a requirement that trees not be harvested for at least 65 years. American Forests' *Global ReLeaf for Energy Conservation Program* is also focusing on encouraging utility companies to plant trees for energy conservation.[3] Further, New England Electric Systems is sponsoring forestry programs in Malaysia and Russia to offset emissions from their U.S. based generating stations. Section 6.1 discusses utility offset programs in more detail.

Tree and timber expansion programs in general may include reforestation (replanting former forests) and afforestation (converting other land uses to trees). Either way, the net amount of carbon dioxide that is sequestered annually by new tree growth varies with the quality of the land, the age of the tree and its species, climate, and other factors. For example, southern pines planted on cropland may sequester about 22 percent more carbon per acre than pines planted on pasture land in the southeast (Birdsey, 1992). At the same time, however, slower growing tree species that offer longer crop rotation periods or wood that can be used in longer-lived products, such as furniture, may supersede the apparent carbon benefits of faster growing species planted in the same regions.

Policy options to support tree planting include: planting programs on public lands, direct payments or tax subsidies for private sector tree planting, partnerships or educational seminars targeted at timber and other forest interests, technical support for non-profit or other private groups, and forestry based carbon offset programs. The real range of opportunities in this area depends on local circumstances including perspectives shared by different interests involved in the forestry sector.

Because of this diversity of policy options and the technical complexities and uncertainties involved in forestry expansion programs, the design of large-scale tree planting programs is critical to their success in sequestering carbon over time. Programs that do not adequately consider certain important interests in the tree and timber industry may even neutralize the carbon sequestration benefits they are trying to achieve. For example, private forest owners not enrolled in new government forestation programs may reduce their own tree planting because they anticipate lower timber prices when surplus government timber is harvested. This may result in less net carbon sequestered by the government program. As another example, because much of the carbon stored in the soil and in the woody biomass of the tree is released when the tree is harvested, carbon benefits are reduced if the land planted under the program does not remain permanently forested. Assuring that the planted trees remain in the ground may require long-term commitments by landowners.

It is also important to note that most subsidies for tree planting do not preclude harvesting. Net effects on carbon sequestration may, therefore, be unclear, especially if energy consumption associated with harvesting activities is considered. Further, tax incentives and other subsidies must be carefully crafted to encourage incremental behavior -- *i.e.*, to avoid rewarding individuals for activities that were already planned. At the same time, care must be taken to avoid penalizing the forest industry and other individuals already engaged in the desirable activity of planting trees -- making these actors ineligible for benefits under a tree planting program may be counter-productive.

[3] American Forests is a non-profit organization in Washington, D.C.

Federal tree planting programs have employed a number of different methods to induce individuals to participate and to ensure long-term success. For example, the Conservation Reserve Program employs cost-share arrangements that cover a variety of land management and treatment costs, such as site preparation, planting, and thinning. Technical assistance has been a component of the Stewardship Incentive Program. In addition, these programs typically specify land and landowner eligibility requirements in order to prevent perverse results, such as clearcutting and replanting in order to receive subsidies.

One example of a state level forestation program is the Missouri Department of Natural Resources' *Operation TREE* (Trees Renew Energy and the Environment). This program's goals are to reduce demand for heating and cooling with strategic landscaping, to remove carbon dioxide from the atmosphere, to arrest soil erosion, and to enhance natural water filtration. The Division of Environmental Quality also incorporated a land reclamation program for mine sites into Operation TREE. Because mine sites are typically steep and the soil is of poor quality, they are often more amenable to trees than to other types of cover.

In addition, Minnesota recently completed a major report assessing that state's carbon dioxide budget and making recommendations for reducing emissions with forestry. They conclude that, while land availability is a constraint on carbon sequestration forestry projects, tree planting could be an important component of an overall program to reduce net carbon dioxide emissions.

6.5 CITY AND REGIONAL PLANNING

Coordinated urban and suburban planning of energy issues can lead to substantial greenhouse gas reductions. These reductions will stem largely from improvements in the transportation sector and from increases in efficiency during electricity consumption and production. They may also incorporate better use of urban and regional resources such as recyclable products, district heat, and methane from landfills.

The greatest opportunity for reducing emissions through city and regional planning stems not simply from achieving direct reductions in these areas, but rather from exploiting the interactions between different greenhouse gas producing activities. For example, the combination of a high density of dark buildings in urban areas and high levels of energy consumption that generates heat, such as vehicle traffic and commercial building energy use, tends to trap heat, creating an "urban heat island" effect. This can lead to demand for more air conditioning, refrigeration, and other energy draining activities. Similarly, a commercial building's energy requirements depend not only upon the building's construction and source of energy but also its external environment, including the density and distribution of surrounding buildings and the local climate. Additionally, the proximity of peoples' jobs to where they live is a key determinant of how much energy or fuel is consumed for transportation purposes. By addressing these issues through land use planning and community design, coordinated city and regional planning offers tremendous opportunity for reducing aggregate emissions of greenhouse gases.

State and local governments have the predominant jurisdiction to enact policies that will promote these types of reductions. City and regional planners determine where and how residential, commercial and industrial development takes place, states frequently set energy-efficiency standards and localities enact building codes, and both these levels of government plan and support transportation system development. In this context, local control over land use and zoning offers one of the greatest opportunities for promoting greenhouse gas emission reductions. It is important to realize that zoning ordinances affect these emissions whether they intend to or not, and therefore, that city and regional planners should become aware of the climate change implications of their actions. Zoning that permits extensive parking in urban areas, for example, often discourages the use of energy efficient public transportation. Similarly, zoning that excludes businesses from residential areas creates a higher need for mobility as people must travel farther to work, causing higher levels of emissions.

Planning agencies are also optimally situated to identify areas where excess heat or other resources in one sector, like industrial production, might be used to meet the energy needs in another sector, like commercial heating. This is a function that only local and state governments can perform.

The US EPA's $mart Growth Network provides resources to government, business, and civic sector leaders interested in developing cities and towns in ways that are environmentally, economically, and socially "smart." The network's mission includes encouraging (1) transit- and pedestrian-oriented development and (2) infill development in urban areas, to reduce suburban sprawl. Both of these policies help to reduce the use of automobiles, and thus help reduce greenhouse gas emissions from the transportation sector.

Exhibit 6-2: The Land Use, Transportation, Air Quality (LUTRAQ) Project

1000 Friends of Oregon, a nonprofit membership organization dedicated to the wise and responsible use of land, has initiated a research demonstration project to identify and analyze alternative development patterns to automobile-dependent suburban sprawl. By emphasizing the connections among land use, transportation, and air quality planning, the project participants hope to demonstrate how changes to local land use policies and development designs can increase the economic feasibility of alternatives to automotive travel, thereby reducing energy consumption; reduce the demand for automobile-oriented facilities; increase mobility for all segments of society; provide for sustainable population and economic growth; minimize negative environmental impacts, such as climate change effects from increasing greenhouse gas emissions; and enhance community character and awareness.

The LUTRAQ project will study a proposed $200 million bypass freeway and a surrounding 115 square mile area in the Portland, Oregon metropolitan region. Using well-known transportation and air pollution models (EMME/2 and MOBILE4), the project will identify replicable methods for altering land use development patterns to promote pedestrian, bicycle, and mass transit travel. These new methods will provide important tools for policy makers, planners, and citizens calculating the feasibility of alternative modes of transportation. The project research will be conducted by a team of internationally recognized experts in the fields of land use planning, urban design, and computer modeling.

The International Council for Local Environmental Initiatives (ICLEI), an international association of local authorities dedicated to helping localities mitigate environmental threats and enhance the natural and built environments at the local level, works with local governments to identify these types of opportunities for reducing emissions of greenhouse gases and other pollutants. Through their *Urban* CO_2 *Project*, ICLEI works with the cities of Denver, Minneapolis, Miami, San José, Portland, and others on greenhouse gas emission reduction programs.

Specific measures to reduce greenhouse gas emissions through city and regional planning should focus on coordinating the proximity and mix of residential, commercial and industrial sites in order to help mitigate the urban heat island effect, reduce or facilitate transportation needs, and use potential energy-saving or emission-reducing resources that are currently being wasted, such as heat from industrial sites or methane from landfills. For example, In 1994, 16 San Bernadino jurisdictions prepared a "Land Use, Transportation, and Air Quality" manual in response to a mandate from California's South Coast Air Quality Management District. The focus of the document is to improve air quality through land use measures such as transforming auto-oriented subdivisions into pedestrian neighborhoods. Other specific planning ideas are presented below.

- Establish self-sufficient, mixed-use communities by ensuring that employment, shopping, entertainment, medical care, and similar services are located near residential areas in order to minimize transportation needs. Florida has developed several model communities with these purposes in mind, as reflected in Dade County's "traditional neighborhood development ordinance."

- Support *central district heating and cooling*, which involves capturing and channeling waste heat (usually from industrial facilities) or heat from a central boiler to meet heating needs in commercial or residential buildings. This may involve developing infrastructure to transfer the heat (as steam or hot water) between locations and planning industrial, manufacturing, commercial, and residential centers in relative proximity to each other. Almost half of the homes in Sweden are heated this way.

- Plan the density, distribution, color, and facades (may include glass-types) of buildings so heat can escape the city to help mitigate the urban heat island effect. Develop urban tree programs to provide summer shade and to act as shelter belts against cold winds in the winter that draw the heat from buildings.[4]

- Establish and enforce building codes and energy-efficiency standards that help minimize residential, commercial, and industrial energy consumption.

- Design and build "green space", *i.e.*, parks, urban green wards, etc., These green spaces can help reduce urban heat island effects, while also sequestering carbon dioxide.

- Facilitate and promote public transportation systems in coordination with all the other planning measures listed above, reducing direct carbon dioxide emissions from automobiles and decreasing transportation systems contributions to the urban heat island.

- Support innovative work and transportation alternatives such as telecommuting in order to reduce overall commuting needs, again reducing direct carbon dioxide emissions and urban heat trapping.

6.6 AGRICULTURAL SECTOR PLANNING

Concentrating on one sector of the economy can provide a useful focal point for comprehensive and well-coordinated policy development. As an example, the agricultural sector contributes to greenhouse gas emissions in a variety of ways. For example:

- Greenhouse gases are emitted through energy consumption during field operations and agro-chemical production, including fertilizers, pesticides, and herbicides;

- Greenhouse gases are emitted when agricultural crop wastes are burned;

[4] Cool Communities is a voluntary program sponsored by DOE. The function of Cool Communities is to encourage the strategic planting of trees to provide shade and windbreaks to residential and commercial buildings, thereby, improving energy efficiency and reducing the urban heat island effect. These trees also serve as a carbon sink, contributing to the overall carbon reservoir both above and below ground. (Cool Communities is Action #11 of the CCAP).

- Methane is emitted from livestock and poultry manure, through enteric fermentation in domesticated animals, and from flooded rice fields;

- Nitrous oxide is emitted as a result of nitrogenous fertilizer use;

- Agricultural production decisions alter land use, which in turn affect greenhouse gas emissions; and

- Agriculture offers biomass fuel potential.

By focusing on the agricultural sector, therefore, policy-makers can integrate several greenhouse gas reduction measures into a single, comprehensive program.

The greatest opportunities for reducing greenhouse gas emissions in the agricultural sector may involve not only direct actions to address each of these sources, as Chapter 5 discusses, but also innovative approaches that combine policies so that emission reductions from one source support reductions from others. For example, methane can realistically be captured from some manure systems and used as an energy source in production processes or for heating buildings. This decreases direct methane emissions

> For more information on measures particularly relevant to city and regional planning see:
>
> 5.1 Greenhouse Gases from Energy Consumption: Demand Side Measures
> 5.2 Greenhouse Gases from Energy Production: Supply Side Measures
> 5.3 Greenhouse Gases from the Transportation Sector
> 5.4 Methane from Natural Gas and Oil Systems
> 5.6 Methane from Landfills

and reduces the need for energy from traditional fossil fuel sources (see Exhibit 6-3). Additionally, composting crop residues and using them as fertilizer or growing leguminous crops where residues can be plowed into fields as a nitrogen source will reduce carbon dioxide emissions from crop burning and may help decrease nitrous oxide and other emissions associated with fertilizer applications. Similarly, processing crop residues into biofuels has multiple benefits.

States can usually promote these or other innovative mechanisms for reducing emissions from multiple sources through individual projects or by developing broader programs under which a range of specific actions can be undertaken. Projects might include, for example, improving the understanding and increasing the implementation of integrated pest management (IPM) activities. IPM has the potential to not only reduce the need for and use of harmful pesticides, but it can also increase efficiency and productivity, thereby, reducing emissions from energy-related activities. Another potential project could include improving the efficiency of nitrogen fertilizer use. This has the potential to not only result in lower emissions of N_2O from microbial activity occurring in the soil, but also lower emissions of CO_2 from electricity and natural gas consumption during the manufacture of fertilizer. Also, both projects offer benefits to the farmer in addition to environmental, including decreased health risks (from a reduction in pesticide use), increased productivity, and decreased energy costs.[5]

Exhibit 6-3: Broiler Litter Program in Alabama

The Broiler Litter Program is co-sponsored by the Science, Technology and Energy Division of the Alabama Department of Economic and Community Affairs and the U.S. Department of Agriculture's Tennessee Valley Resource Conservation and Development Council. This innovative program addresses improvements in energy efficiency, solid waste reduction, and agricultural productivity. In the pilot program, newspaper is shredded and blown over a poultry house floor. Baby chicks are then brought in and, within a couple of days, the shredded paper becomes matted and slick from the droppings and moisture. A few days later, the matted paper begins to break up. In six weeks, the broilers are taken to market, at which time either a new layer of paper is added to the floor or the floor is cleaned up and the process repeated. When the litter is collected from the poultry house floor, it is spread on crops as fertilizer or is mixed with feed and fed to livestock for its nutritional value.

Because farmers can reduce their purchases of commercial fertilizers, greenhouse gas emissions associated with the production and use of the fertilizer are reduced. In addition to the benefits to the farmer in feed and fertilizer savings, the Broiler Litter Program can enhance recycling efforts by creating demand for old newspapers and by decreasing the flow of wastes to the limited amount of available landfill space. Furthermore, the use of shredded newspaper for bedding also eliminates the need to truck in wood chips from as far away as 250 miles, thereby saving on fuel and transportation costs. Finally, farmers have also noticed decreases in their energy bills, primarily due to the insulating effects of the shredded newspaper. This reduction in fuel consumption results in lower CO_2 and other energy-related emissions. With more than 2,000 chicken producers in the four Alabama counties where project demonstrations are held, more savings are expected as the program gains popularity.

Public recognition or other rewards for farmers who reduce emissions from more than one source simultaneously may also enhance farmer interest in these activities. Support for demonstration projects in multiple-source emission reductions can also generate farmer interest, especially if coordinated with well-known and successful existing farms. Another successful approach may be to make sure that farmers receive a uniform and consistent message about the needs, benefits, and related opportunities for multiple-source emission reductions from all government programs with which they commonly interact. For example, a common message about the imperatives and benefits of emission reductions from state agricultural agencies, environmental agencies, extension agents, and even in trade journals and other publications can consistently reinforce the fact that farms can simultaneously reduce emissions and save money.

States may gain additional benefits by developing broader programs to coordinate all these types of projects. For example, Chapter 7 describes the Iowa Agricultural Energy Environmental Initiative, a wide-ranging program that serves as a base for a variety of efforts to reduce energy consumption and pollution in Iowa's agricultural sector. Under this program, a diverse range of projects are tied to a common theme,

[5] The CCAP provides detailed descriptions and analyses of voluntary programs designed to reduce pesticide use and increase the efficiency of nitrogen fertilizer applications (Actions #17 and #18, respectively).

garnering publicity and political support as well as resources from a variety of external sources. Without the central program in place, several diverse projects could not be linked to a common initiative and would not receive the same level of popular or political support.

For more information on agricultural sector planning see:

5.1 Greenhouse Gases from Energy Consumption: Demand Side Measures
5.2 Greenhouse Gases from Energy Production: Supply Side Measures
5.3 Greenhouse Gases from the Transportation Sector
5.7 Methane Emissions from Domesticated Livestock
5.8 Methane from Animal Manure
5.9 Methane from Rice Cultivation
5.10 Nitrous Oxide from Fertilizer Use
5.11 Emissions Associated with Forested Lands
5.12 Greenhouse Gases from Burning of Agricultural Wastes

PART III

PROGRAM DEVELOPMENT
AND STATE ACTION PLAN PREPARATION

The two preceding chapters provide a menu of policy options that states might include in a State Action Plan. This part of the document explains how states can choose from among those options and meld them into comprehensive climate change mitigation programs. It also provides a framework for the actual State Action Plan.

- Chapter 7, *Climate Change Program Development*, is provided help states anticipate institutional, political, and other organizational issues that may complicate their program design efforts.

- Chapter 8, *Analyzing Policy Options*, clarifies the different processes and tools states might use for analyzing and comparing policy options, highlighting the many complexities involved in this process.

- Chapter 9, *Preparing the State Action Plan*, gives examples of the types and content of State Action Plans that EPA feels would support national efforts in this arena and would provide a consistent base for the federal government in allocating additional resources and technical assistance to states.

This information should help state policy-makers anticipate many of the complications that may arise as they structure actual climate change mitigation programs.

CHAPTER 7
CLIMATE CHANGE PROGRAM DEVELOPMENT

This chapter addresses the process of planning, implementing, and administering climate change mitigation programs. It summarizes complexities that states may encounter during the development of greenhouse gas emission reduction policies and describes how several states have structured their programs to deal with these issues. Ideally, the information presented here will help elucidate some of the criteria that may be important when designing programs, including time frame considerations and political and administrative feasibility, as discussed in Chapter 4.

Specific topics addressed in this chapter include the important actors who affect climate change program design, political considerations relating to climate change program development, treatment of time perspectives, interaction between various agencies within and external to state governments, general program administration, and program financing.

7.1 TIME PERSPECTIVES IN CLIMATE CHANGE PROGRAM DESIGN

As highlighted throughout this document, states should anticipate that climate change policy formulation will be a dynamic, evolving process. For this reason, program design frequently depends upon a state's approach for looking at near-, mid-, and long-range issues. Time frame issues are relevant in the political, organizational and administrative aspects of program planning. For example:

- Greenhouse gas emissions today will affect climate change and its impacts at the local level for many decades.

- The capacity to reduce greenhouse gas emissions, especially through log-range mitigation options, depends on anticipated changes in science and technology.

- One reason current emission forecasts are important is that they provide a baseline for analyzing potential emission reduction impacts from various policy options ranging across time frames.

- Dynamic programs with goals and criteria that vary across time frames may be more effective than programs adhering to one static set of objectives. Programs benefit from qualitative and quantitative short-, mid-, and long-range emission reduction targets and goals.

- Policy evaluation, entailing predictions and measurements of probable program impacts, depends heavily on time frame considerations. Key time frame assumptions are critical for conducting emissions analysis and economic impact analysis. These same time frame assumptions play a significant role in driving any formal emissions or climate change modeling efforts a state may decide to pursue.

7.1.1 Structuring Time Frame Considerations in Program Design

Throughout this document time frame considerations are split into near-, mid-, and long-range classifications. This section defines and examines these classifications in more detail, introducing the advantages, constraints, and opportunities surrounding policy planning and implementation within each one.

Near-Range

Near range actions can be initiated immediately. Among other benefits, these policies offer the opportunity to implement immediate emission reductions, set precedents for state actions on climate change, demonstrate new technical approaches for addressing various emission sources, develop an analytic base for future actions, and generate immediate and future political support by incorporating various important actors in high visibility and popular projects. Within this time frame many "no-regrets" policies can often be implemented at relatively low cost.[1]

The primary constraints associated with near-range actions are typically related to the technical, organizational, political, or financial feasibility of alternative options. These constraints stem from the scientific, economic, and technological uncertainty surrounding climate change mitigation measures and from the frequent need to garner support from diverse sectors of society and to coordinate actions between government agencies. (Other sections in this chapter discuss these political and organizational issues in more detail.)

Additionally, without comprehensive and longer-range program design, actions focused on the near-term can come to dominate state programs and drain financial, analytical, institutional, and political resources from initiatives that can have more significant impacts but that will take longer to develop and implement. Also, states that pursue only "no-regrets" actions often find that they do not innovate or develop new policy ideas for addressing greenhouse gas emissions. For these reasons, near-range actions should generally be envisioned as part of larger and more comprehensive programs and should be communicated to the public and other important stakeholders in this way.

Mid-Range

Mid-range policies are often considered in a ten- to twenty-year time frame, hinging on issues such as technology development and implementation feasibility, as well as on emissions and economic forecasts. Policies in this range often involve significantly more analysis, planning, and investment than near-term measures. They also offer significantly greater opportunity for larger emissions impacts.

Mid-range measures can often be designed to integrate with other state policy objectives such as increasing energy efficiency and decreasing air and water pollution. Careful planning can thus yield multiple benefits to the state and enhance political support for these policies. Furthermore, establishing mid- to long-range climate change mitigation objectives can also encourage technical and political innovation. Plans to reduce utility or transportation sector emissions to a certain level within fifteen or twenty years, for example, may prompt policy-makers to develop innovative approaches to greenhouse gas reductions. Policies planned in this time frame should be careful to maintain flexibility so that they can adapt to changing circumstances, such as technical advances or economic downturns.

Long-Range

Long-range actions to address climate change can incorporate specific policy objectives that may take twenty or more years to enact. Successfully encouraging the complete transition in industrial and

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[1] "No-regrets" policies are defined in Chapter 4.

commercial energy use away from carbon-intensive fossil fuels, for example, may take many years. Similarly, it may take several decades to spread and institutionalize comprehensive public awareness at all age levels about climate change issues. These measures may represent fundamental changes in how our society deals with these and other topics.

These long-range actions are perhaps best viewed as visionary objectives that states can support through a variety of near- and mid-term policies. They are sometimes more difficult to establish outside of a general state plan (in transportation or education, for example) because future economic developments, evolution in our understanding of climate change, and impacts from the interaction between various policies are difficult or impossible to forecast.

Even amidst these constraints, however, these approaches are critically important. They often offer the most hope for permanent stabilization of greenhouse gas emissions. Comprehensive state programs established now can set the groundwork and the context for addressing these fundamental, long-range objectives while maximizing near- and mid-range emission reductions the most effectively.

7.1.2 Models for Including Time Frame Considerations in Program Development

States should integrate time frame considerations into program planning to match local institutional and political circumstances. Policy planning may vary, for example, between states where legislatures work full-time and states where legislatures meet for only part of the year. Ideal programs will probably combine and implement policies that consistently address near-, mid-, and long-range objectives. Specific policies may conceivably address all these time ranges while others will concentrate their impact within only one time frame.

A variety of organizational structures for program design can support policy development amidst these complications. Three possibilities are discussed below in detail, and examples are provided.

Mid-and Long-Range Program Targets Coupled With Near-Term Policy Plans

The State of Oregon developed a program structure that incorporates a mid-range emission reduction objective with repeated two-year emission reduction plans (Oregon, 1990). According to policy-makers in that state, one of the foremost benefits of this approach is that it provides a formal program target in the mid-term that prevents the state from delaying action on this issue, while at the same time utilizing a structure that incorporates opportunities for program development, evaluation, and revision every two years as necessary. This flexibility offers the opportunity for policy-makers to respond to scientific, economic, and political changes, and to make program adjustments based on organizational and administrative issues as well.

One apparent detriment of Oregon's set mid-term target is that it seems to have impeded consideration of potentially important policy options with longer-term orientations. For example, transportation and land-use changes that would take more than twenty years to implement or to produce emission benefits are largely excluded from a system that establishes a mid-term goal with no incentives for longer-term policy development.

Immediate Action to Initiate the Climate Change Policy Formulation Process

Some states have taken immediate-term action on this issue before conducting more comprehensive program planning efforts. For example, Missouri, Vermont, and other states have authorized and conducted climate change studies. Long-term benefits from these efforts seem mixed. In some areas these types of studies have helped set the climate change policy formulation process in motion, generating interest among actors and setting the stage for future action. However, in other areas these studies have provided little momentum, and either further action has not been taken, or it has been delayed.

Iowa's experiences illustrate this point. The Iowa Department of Natural Resources conducted an initial inventory but has taken little coordinated action since then to address climate change specifically, although it has pursued other initiatives, such as energy-efficiency and water pollution reduction programs, that simultaneously help reduce greenhouse gas emissions. Their initial action on climate change has yet to lead to a more structured program for dealing with this issue.

California's initial work on climate change, on the other hand, helped generate significant public and political interest in this issue. As part of their actions towards producing a complete policy report on climate change and greenhouse gas issues, which was mandated by its legislature, California developed an initial interim study that seems to have encouraged many different private and public interests to become involved. The interim study made it clear that the state would be taking further action in this field. Without the mandate for the later policy report, some policy-makers in California are uncertain as to whether the initial report would have generated so much public interest.

Feasibility and "No-Regrets" Standards to Structure Policy Choices

Another approach to initial policy development necessitates that policies be based on factors such as technological feasibility and cost-effectiveness. This conservative approach may span all time frames; in California it is based on the state's intent to initiate select measures which have greenhouse gas reduction benefits, while also completing more policy research that may lead to expansion and refinement of the emission reduction program. "No-regrets" policy guidelines frequently offer similar advantages. These types of guidelines initiate policies that are completely beneficial to the state and may help build political consensus for further action. Both the feasibility-based and no-regrets approaches may help reduce political resistance to new programs while demonstrating some action to address climate change.

These approaches can also suffer from the same constraints as those discussed in the above section (Immediate Action to Initiate the Climate Change Policy Formulation Process). Without implementing some direct mechanism or incentive to initiate actual policy development, like a quantitative or qualitative mid-range target or a specific mandate to action, these feasibility-based and no-regrets actions do not always propel states towards further action. The highest utility from no-regrets and feasibility-based actions seems to come when they are combined with other incentives within the context of larger or more structured programs, perhaps as part of a longer-term no-regrets plan.

7.2 IMPORTANT ACTORS IN CLIMATE CHANGE PROGRAM DESIGN

Interactions between several distinct types of actors set the context for climate change programs. These actors maintain resources and knowledge that contribute to policy development, determine program structure or policy content, or influence program design in other ways.

Specific organizations and individuals will vary in each state depending on how programs address sectors, including transportation, energy supply, energy use, forestry, industry, and agriculture. Some will participate during the initial phases of program design, while others will be more active during policy implementation or long-term program administration. Six broad categories of actors are presented below:

- *Private sector interests*, who often maintain significant data and analytic capabilities relevant to emissions planning, and who may be affected by new emission reduction policies;

- *Citizen and advocacy groups*, including those in the environmental, commercial, health and safety, and scientific fields;

- *State agencies*, which maintain government data and analytic capacity, as well as policy and implementation jurisdiction in the sectors that may be expected to reduce greenhouse gas emissions;

- *State governmental executives*, including those concerned directly with climate change, those involved in managing the state economy, and those who may be prompted to comply with federal initiatives regarding climate change or other policy issues that affect the above-mentioned sectors;

- *Legislators*, whose interests and concerns may vary with regards to the impact of climate change mitigation policies on their constituents, including state citizens and other representatives from the various economic sectors that produce emissions;

- *Federal agencies*, especially those whose field programs in states may be affected, as well as those that provide grant monies, other funding, or technical assistance supporting states' climate change programs.

7.3 POLITICAL CONSIDERATIONS IN PROGRAM DEVELOPMENT

Political feasibility may be one of the foremost criteria for policy selection and program structuring. In some circumstances political controversy has inhibited aspects of state-level program development while, in other situations, deliberate planning around political issues seems to have strengthened program design. States may want to think strategically about how to structure programs in order to draw input from the various important actors while minimizing unnecessary political confrontation.

Political controversy in this field frequently stems from the multi-sector, long-term, and scientifically and economically complex nature of climate change issues. In this context, many of the important actors listed above may see their interests threatened and become concerned about government action. This frequently includes individual citizens and their elected representatives who are aware that these emission reduction policies can significantly impact peoples' lifestyles. Public interest groups, utilities, industry, state legislators, and various state agencies may share certain perspectives and disagree on others. These perspectives may also vary between initial policy planning, program implementation, and ongoing program administration.

While interactions between the various important actors will result in different political dynamics in every distinct situation, recent state experiences highlight three consistent topics that states with new or changing programs may want to consider. States may want to investigate how they can develop programs and processes that foster broad-based political support, how they can use particular policies strategically within the time frames of program development, and how they can plan and utilize legislative and executive actions strategically, when feasible. In addition to summarizing these issues below, discussions throughout the rest of this chapter reflect these types of political complexities and ways states might deal with them.

7.3.1 Developing Programs and Processes that Foster Broad-Based Political Support

Because so many distinct types of actors have an interest in and influence over climate change policy formulation, programs without broad-based support may have difficulty building the momentum necessary to initiate emission reduction policies. Furthermore, climate change mitigation efforts often depend not only on fostering enough political support to initiate programs, but also on continuing support and action to carry out program objectives. For example, states may need direct action by private sector actors to assist in actual emissions reductions; support from citizens groups to communicate with different sectors of the general public; and data and skills from various agencies to complete complex analyses. For these reasons, any program planning that excludes or offends important actors can potentially lead these actors to inhibit program development, either through direct political confrontation or by withholding analytic, enforcement, and other institutional resources.

At the same time, states may encounter organizational and administrative problems if they incorporate too many tangentially connected actors into planning and implementation processes. Some states have indicated that, because of the broad nature of this issue, groups with diverse interests marginally related to climate change have sought to become involved in state planning processes. While their political support may be valuable, states should carefully weigh this against additional burdens that might arise from incorporating distinct actors with agendas beyond the purview of the state's vision of climate change policy formulation.

7.3.2 Using Policies Strategically Within the Time Frames of Program Development

Near-, mid-, or long-range policy criteria may include requirements that some policies help bolster a program's political strength in addition to directly affecting greenhouse gas emissions. For example, policies can be designed to demonstrate success and win broad based support immediately. Alternatively, they can foster the support of specific actors through other mechanisms in the immediate or longer terms.

Examples of policies that may strengthen overall program support immediately include projects with highly visible results that readily demonstrate net benefits to the state while reducing greenhouse gas emissions. For example, aggressive programs that quickly demonstrate the benefits of residential and commercial energy-efficiency efforts or methane processing at landfill sites can encourage citizen groups, politicians, and industries to support state climate change mitigation efforts. These projects emphasize quick success in order to build constituencies and consensus.

States may also find it valuable politically to develop projects advocated by specific citizen or industry groups. Inclusion of such projects may help win the support of these groups for the entire climate change program, while the magnitude of their immediate and direct effects on emissions may vary. Urban tree planting programs, advocated by citizen groups, for example, may have a minimal impact on emissions, but they serve to include these important groups in the policy planning process immediately. This can help generate public awareness of climate change issues, and set a precedent for state or local action to address this topic. However, it is important that states avoid diffusing the momentum behind broader climate change program development by casting these projects as initial steps towards addressing this critical issue, not as near- or long-range solutions in and of themselves.

Other policies or projects may not generate immediate political support but can be designed to do so as they evolve over the longer term. For example, states may design public relations programs that publicize annual or bi-annual achievements towards reaching some preset emissions reduction goal and highlight the economic sectors or specific outstanding actors that have contributed. Alternatively, state policy-makers may write provisions into their initial State Action Plan to help ensure that new projects designed around political criteria, among other factors, are implemented every year or two.

7.3.3 Utilizing Legislative and Executive Action Strategically when Feasible

The type of political authorization programs receive can significantly influence how these programs develop. For example, legislative mandates can help circumvent some potentially destructive controversies over policy formulation, while executive directives in many situations permit quicker and more independent performance by agencies. With careful planning, states may accrue additional benefits and avoid particular detriments related to differences between these two modes of program authorization. States should recognize these among other motives for determining how to approach potentially controversial issues.

Oregon and California's experience in setting quantitative programs goals highlights this point; Oregon has produced a quantitative goal while California has not. Oregon's quantitative greenhouse gas emission target was set by the legislature (Oregon, 1990). This fact seems to have helped minimize the political controversy and amount of state resources needed to assist in goal setting. On the other hand, the California Energy Commission has addressed goal setting in a public forum and has experienced high levels of controversy on this unresolved issue (CEC, 1991). While California has achieved other extremely important objectives through the public forum process, the impasse in this case illustrates how political controversy may affect the results of dealing with certain issues through a particular approach.

7.4 COORDINATING CLIMATE CHANGE PROGRAMS: INTERACTION BETWEEN AGENCIES

Climate change mitigation policies across all time frames are likely to require coordination among various state agencies, as well as between states and federal and local governments. In the initial phases of program development, high levels of interaction will help states address the multi-sector nature of this issue by strengthening program comprehensiveness across sectors, garnering broad-based political support, and tapping all available resources for analyzing and addressing greenhouse gas emissions. In addition to facilitating and promoting the initial phases of program design, ongoing coordination between agencies will help facilitate program evolution and dynamic responses to changing climate change and policy circumstances in the future.

Many current and recent state actions to address climate change illustrate the value of interagency coordination from the outset and provide potential models for structuring such interaction. For example, Missouri, California, South Carolina and others have taken deliberate executive or legislative action to coordinate programs between agencies in this field. The sections below provide additional information and ideas on state partnerships, federal and local partnerships, and procedures for coordinating interagency action. It also highlights potential benefits and drawbacks learned through various experiences.

7.4.1 Partnerships Between State Agencies

To be effective, program design, evaluation, and implementation must incorporate the various government agencies that retain policy jurisdiction and analytic capacity regarding these numerous sectors. Initial program design may also benefit from involving state tax and legal agencies. Integration of various state agencies into the climate change policy planning process may:

- *Enhance program planning and analytic efficiency*. Drawing on each agency's expertise and analytic strengths, integrated climate change programs can use the state's current resources efficiently and heighten the program impact. This may include relying on staff in certain agencies to analyze topics within their jurisdiction, like transportation or agriculture, and it may also involve employing the analytic capacities of various agencies to heighten program efficiency, like utilizing an energy office's forecasting skills. In these ways, pooling the substantive and analytic knowledge of climate change program planners efficiently draws on current state resources and helps ensure comprehensive climate change mitigation programs.

- *Avoid program duplication between agencies working on similar or related issues.* With careful coordination, agencies may complement rather than duplicate or damage each other's efforts.

- *Foster a strong political base*. As noted in the previous section, voluntary consensus on policies among the important actors, including state agencies with jurisdiction in the various sectors, strengthens climate change programs significantly.

- *Support strong liaison with industry and citizen groups in each sector*. Where appropriate, new climate change programs can utilize and perhaps strengthen the ties that state agencies in diverse sectors already have with their constituents, instead of duplicating efforts by building the same liaisons and working relationships from the beginning.

- *Improve each agency's existing programs and administrative capacity.* Tying climate change issues to existing programs may enhance the analytic or political legitimacy of climate change-related programs. For example, strategies aimed at reducing emissions of N_2O through the reduction of nitrogen fertilizer use may consider tying this objective to existing and planned groundwater protection programs that stress the need to reduce fertilizer use. Similarly, the threat of climate change may provide additional reasons for establishing or enhancing reforestation programs and improving and expanding energy-efficiency or mass transit. This is the core of the "no-regrets" approach introduced in Chapter 4.

- *Help prepare agencies for future policy developments.* Individual agencies that are involved in program planning may better anticipate how climate change issues will affect them in the longer term. For example, state agencies participating in climate change program planning may gain a broader understanding of how international and national actions, as well as eventual climatic changes, are likely to affect their areas of jurisdiction.

Exhibit 7-1 provides one example of coordination between state agencies that supports greenhouse gas emission reductions.

7.4.2 Interaction With Federal and Local Agencies

Close liaison with other levels of government can also enhance state climate change mitigation efforts. Deliberate linking with federal and with local initiatives can strengthen a program's effectiveness in many ways. For example, in addition to broadening the program's political base, interaction may provide access to additional skills and other resources that programs can draw upon and may help facilitate productive program interaction in areas where jurisdictions overlap, such as the transportation, buildings, and land use sectors.

Exhibit 7-1: The Iowa Agricultural Energy Environmental Initiative

Summary: The Iowa Agricultural Energy Environmental Initiative is a consortium of federal, state, and local agencies and institutions organized to implement an array of projects focused on pollution prevention in agriculture. The Initiative is predicated on the belief that integrated and innovative policy models are required to deal with broad-reaching environmental issues. It insists that agencies cannot work at cross purposes, and that shared resources and expertise can provide better results than individual efforts. The consortium's goal of "accelerating the adoption of improved farm management practices that reduce the environmental impacts of Iowa agriculture, reduce consumption of non-renewable energy resources, and enhance the efficiency and probability of farm management" is implemented through demonstration, education, and research programs. Major parts of this program include the Big Spring Basin Demonstration Project (reducing the use of nitrogen fertilizer), the Integrated Farm Management Demonstration Project (nitrogen management and crop consulting), and the Model Farms Demonstration Project (management of farm resources). While not its explicit purpose, this program reduces greenhouse gas emissions by promoting energy efficiency on farms and by reducing nitrogen fertilizer consumption, which directly lowers nitrous oxide emissions and indirectly lowers carbon dioxide emissions at the energy-intensive plants that produce the fertilizers.

Organization: The Agricultural Energy Environmental Initiative developed through an earlier coalition of groups which convened in the early 1980s to tackle groundwater problems. The initiative operates on three fundamental principles: (1) Interagency coordination consumes time and energy, and therefore depends on a nucleus of dedicated, willing participants; (2) Consensus on all issues is an impossible goal, but a basic consensus on program directions is necessary; and (3) Agency goals or personal egos must at times be sacrificed for group success. The Initiative began by identifying potential participants in the coalition and the problems, needs, and relevant authorities involved in this issue. With each participant's agenda and potential contributions defined, key individuals help apportion human and monetary resources towards projects that are valued by the entire coalition. The primary responsibilities of the Initiative have traditionally rested with the Iowa Department of Natural Resources, although there is no official lead agency. Similarly, the coalition has no explicit structure, although there are formal working agreements for each project. Projects, after being designed, are fit into various agencies' existing programs in order to achieve maximum implementation efficiency and maximum integration into mainstream agency programming. Member groups include: Iowa Department of Agriculture and Land Stewardship, Iowa Department of Natural Resources, USDA - Soil Conservation Service, Agricultural Stabilization and Conservation Service, Agricultural Research Service, US EPA Region VII, Iowa State University, the Leopold Center for Sustainable Agriculture, the University of Iowa, Iowa Soil and Water Conservation Districts, the Practical Farmers of Iowa, and other private interest groups.

Programs: The Initiative creates pilot programs that local authorities or private farms can adopt as public sector enterprises or private businesses. Prior to project implementation, sociological and farm management surveys are conducted in order to ascertain current practices, problems, and willingness and ability of impacted individuals to contribute. Additionally, the program calls for a structured feedback loop from the local level. This loop allows for continual adjustments and corrections based on what is happening where the project is being implemented, and helps generate grassroots support and commitment. A final requirement is long-term feasibility, based on project transferability criteria. Some demonstration projects integrate and support agribusiness in order to enhance long term process and technology adoption. Once a project is formatted, aggressive marketing generates widespread visibility, and an information delivery plan promotes expansion of impacts beyond those directly involved.

In addition to the potential direct benefits from interacting with federal and local agencies, states possess a unique opportunity to encourage the other levels of government to act on the climate change issue. For example, state action and pressure may set precedents for national policy-making, and innovative state programs can provide incentives for cities and localities to design their standard policies to help reduce greenhouse gas emissions.

Liaison with the federal government may be particularly helpful in terms of accessing grant monies and other forms of program financing, enlisting technical support, facilitating areas of overlapping jurisdiction, and mitigating or setting the context for potential future federal regulatory or other action on this issue. This type of coordination is especially relevant, for example, in areas such as transportation policy design, energy efficiency regulation on appliances, and electric utility regulation. In these areas the federal government has taken certain actions that in part preempt what states can do and in part require or empower states to perform other functions.

7.4.3 Structuring Partnerships/Program Coordination and Administration

It is often valuable for one agency, or some other officially designated government body, to maintain responsibility for program coordination. As illustrated below, this may be an existing agency, a specially designated task force, or some other central organizing unit. By providing a central focal point for the various important actors, as well as a central record-keeping and administrative unit, this type of structure may help circumvent coordination and authority problems. Some states report that lack of a formally designated, centrally responsible agency undermines any agencies who do try to act in this area, even if they are instructed to do so by executive or legislative action.

States involved in climate change policy formulation have dealt with this issue in several ways. For example, South Carolina incorporates two interagency feedback loops into their program structure. First, they involve agency heads in program planning and development. Second, they solicit input from program managers and others who are responsible for actually implementing and administering policies. Exhibit 7-2 presents examples of how various states have approached program coordination with regards to climate change.

State policy-makers have also suggested that it is valuable to develop a mechanism for monitoring recent changes in the understanding of climate change mitigation from scientific, economic, and policy perspectives. This may involve recruiting scientists or university staff who are knowledgeable about greenhouse gases and related issues within a particular state for program planning efforts. Monitoring may also involve efforts to keep abreast of current literature and attend professional and academic conferences on this topic.

7.5 CLIMATE CHANGE PROGRAM FINANCING

While this document does not provide comprehensive guidance in program financing, this topic may influence program structure in various ways. For example, sources of available financing can sometimes dictate the direction that new programs adopt. With this consideration in mind, financing mechanisms should closely correlate with pre-determined program objectives and capabilities during the phases of initial program development, program implementation, and ongoing program administration. Similarly, financing mechanisms may change in the transition between near-, mid-, and long-range emission reduction measures. In general, it may be helpful to separate financing mechanisms into three categories:

- *Financing through Existing Revenue Sources*. This may involve direct budget allocations for climate change mitigation activities or inclusion of climate change mitigation programs under the jurisdiction and purview of an existing agency. The latter approach may be appropriate in the many situations where greenhouse gas emission reduction and other policy goals overlap, such as in transportation and energy planning, ground water protection, and wildlife or habitat preservation.

Exhibit 7-2: Examples of State Approaches to Program Coordination

South Carolina: South Carolina issued an executive order that authorizes the State Water Resources Board to administer a climate change task force. This task force is tied to the governor's office and state legislative committees, and makes recommendations on climate change issues to both branches of government. Its membership is drawn from public and private sector groups, including utilities and citizen organizations. It is structured around working groups that focus on the various economic sectors impacted by climate change. The State Water Resources Board, as the administrative agency, helps ensure broad based participation and maintains centralized contact and coordination with all participants.

Missouri: Missouri has established two separate bodies charged with researching and recommending state action on energy futures issues. The first is the Energy Futures Coalition, a broad based, governor appointed body that examines the impact of energy issues on topics such as economic development and state employment. The second is the Energy Futures Steering Committee, an interagency task force formed by the state Division of Energy to examine energy efficiency issues.

Oregon: In 1990, the Oregon legislature directed the state's Department of Energy (ODOE) to chair a 12-agency task force to analyze the potential impact of global warming in Oregon and make recommendations on how state agencies should respond to the threat. In 1991, the legislature further directed ODOE to prepare a strategy to reduce greenhouse gas emissions to a level 20 percent below 1988 levels by 2005. This target level of emission reductions did not represent a formal state goal, but it did provide a focal point around which state agencies could analyze climate change issues. The strategy resulting from this work was presented as a study, not as an actual implementation plan. In 1992, the Oregon Progress Board, a public-private steering committee chaired by the Governor, adopted a formal benchmark to stabilize carbon dioxide emissions at 1990 levels by 1995. Finally, Oregon's Fifth Biennial Energy Plan, produced in May of 1993, directs ODOE to develop a plan to keep Oregon's carbon dioxide emissions at the 1990 levels. The plan will be a specific strategy to achieve the carbon dioxide benchmark. Stabilizing carbon dioxide emissions will then be one of the guiding elements of the Sixth Biennial Energy Plan, which is due in 1995. In conjunction with these efforts, ODOE coordinates working group sessions with participation from throughout the public and private sectors; these working groups study substantive issues such as utility impact, petroleum fuels, CFCs, and other important topics.

California: Legislation established the California Energy Commission (CEC) as the lead agency in a multi-agency study examining climate change issues and required the CEC to produce a climate change policy report. The initial phases of California action in this area are focused on research and information gathering and dissemination. California has yet to produce an actual strategic policy plan, however. The legislation directing CEC to act on this issue established specific topics and economic sectors to be analyzed and mandated that other specific state agencies be involved. CEC expanded the agency list and adopted a public climate change forum for analyzing all aspects of this issue. The state governor also issued an additional directive, without timelines or other guidance, for CEC to examine potential CO_2 emission reduction goals.

- *Developing New or Dedicated Revenue Sources*. This often entails innovative financing schemes, including those that raise money through fees or taxes that help discourage greenhouse gas emissions. Approaches in this area may include "green fees" and other charge systems, dedicated utility taxes or charges, original private sector capital development programs, or other innovative financing. Examples of this general type of financing scheme include carbon and energy taxes that discourage fuel consumption, landfill fees that indirectly help mitigate methane emissions, and permit fees required for timber harvest.

- *Revenue from External Sources*. This includes federal technical support and money from federal grant programs. Similar to intra-state policy overlap with existing programs, as described above, greenhouse gas emission reduction policies may fall under the domain of existing federal programs. For example, sources with potential climate change applications include U.S. Department of Energy funds allocated to improving energy efficiency, U.S. Department of Agriculture funds allocated to improving fertilizer application and management, and U.S. Environmental Protection Agency funds allocated to enforcing the *Clean Air Act.*

CHAPTER 8
ANALYZING POLICY OPTIONS

Climate change analysis requires choosing strategies that effectively balance trade-offs between potentially competing goals in a politically charged environment that is also fraught with technical, scientific, and economic uncertainties. Central to devising an effective climate change strategy, therefore, is a need for researchers to present clear, concise, and relevant information to policy makers. Policy-makers, then, require a framework that allows them to choose among alternative policies, and to compile a coordinated strategy for achieving greenhouse gas (GHG) emissions reductions. The resulting strategy should not only meet overall goals, but should also combine policy options, that are themselves acceptable.

Consistent with this perspective on climate change policy analysis, this chapter is intended to lend some initial structure to the extremely difficult task of analyzing policies in this field, by illustrating some of the concepts and ideas that may help states develop their programs. The information in this chapter provides only the starting point for a climate change analysis. The first section establishes a basic framework that considers each policy option in light of the issues that are most important to each individual state. This section is followed by three sections that discuss how states can analyze and consider the benefits, costs, and other impacts of policy options. Section 8.5 highlights analytical complexities and fundamental social assumptions that state policy-makers will need to address. Finally, the last two sections introduce some of the methodologies or decision tools states might consider using to conduct analyses, presenting both theoretical approaches and specific models and tools that have been developed to address climate change issues.

8.1 ESTABLISHING A CONSISTENT FRAMEWORK FOR POLICY ANALYSIS

A policy analysis framework can provide a consistent lens through which policy-makers can examine all policies. Without such a framework, it can be difficult to compare and assess potential climate change mitigation policies that affect diverse and unrelated sectors of society over broad time frames. This section describes a basic structure policy-makers can use for comprehensive and consistent policy analysis. States may choose to proceed in a less formal manner than this framework suggests; the information presented here is meant to highlight the most important considerations in climate change policy analysis and to offer some tools that can be used to help structure this issue.

8.1.1 Structure of the Policy Analysis Framework

Any framework for evaluating climate change mitigation policies should help decision makers link those policies to a state's goals and priorities. One established approach for structuring this framework is to consider each policy option in relation to a set of explicit evaluation criteria. If those criteria are rooted in the state's fundamental goals and priorities, this structure will provide a link to the state's most important objectives. Chapter 4, *Establishing Emission Reduction Program Goals and Evaluative Criteria*, examines the process of setting goals and criteria in detail. By fostering comparison of policies on a uniform basis, this approach also helps policy-makers assess the relative strengths and weaknesses of the alternatives in a consistent manner, and can highlight areas where further research or analysis is needed.

One analytical mechanism policy-makers can use is a matrix that lists the set of criteria along the top and policy options down the side. The matrix can then be used to indicate how each policy option ranks under each criterion. Exhibit 8-1 presents a sample matrix in this format.

Exhibit 8-1: Sample Policy-Criteria Matrix

The sample criteria, policies, and other data presented in this box illustrate how a policy-criteria matrix can be constructed to help frame the climate change issue and clarify tradeoffs between policy options. Entries in each cell typically provide a brief summary of the performance of a single option with respect to the indicated criterion. Entries may represent the result of sophisticated engineering or economic research or may result from more informal and subjective judgment. The sample data presented here do not represent the results of actual policy analyses.

Criteria Policies	Emission Reductions (Tons of carbon-equivalent emissions annually)	Private Sector Costs (Normalized to base year using 7% discount rates)	Social Equity Ranking (1 = low, 5 = high)	Existing Institutional Capacity (X = yes; blank = no)
Methane Recovery Technology Demonstration	58.4	$0	4 (medium-high)	X
Methane Emissions Tax	123.0	$985,000	3 (medium)	
Alternative Fuel Tax Subsidy	456.9	$43,000	1 (low)	X

The type and level of information used to relate each policy option to each criterion, indicated in the cells or boxes in the matrix, facilitates not only assessing of the policy in light of state goals and priorities, but also examining the tradeoffs between different policy options. For this reason, it is critical to use the same unit of measurement to evaluate one criterion as it relates to all policies. For example, emission reductions from all the various greenhouse gas sources (for example, methane from landfills, nitrous oxides from fertilizer use, carbon dioxide from electricity generation) can be converted to a common scale, such as million kilograms of CO_2-equivalent, using the global warming potential concept;[1] such conversions will facilitate cross-policy assessments of emission reduction potential.

The units of measurement may vary significantly among the different criteria and may be quantitative or qualitative. If precise quantitative data are unavailable or inappropriate, policy analysts may be able to create a relative scale for ranking policies against criteria; this may involve simply classifying policies on a criterion as high, medium, or low, or it may mean developing a ranking system that utilizes some numerical scale. In other situations, simply acknowledging that a policy meets a certain criteria may prove valuable; in the policy matrix, it means entering an "X" in various cells.

8.1.2 Application of the Policy Analysis Framework

[1] Global Warming Potential is discussed in more detail in Chapter 2. It is important to note that this scale is not precise and that it is the current subject of some controversy because of debates over approaches to integrating the life-cycle effects of carbon dioxide.

The framework presented here provides a starting point for analyzing policy options. Depending on circumstances, policy-makers may need to modify the framework during the analysis process. Three particular issues may require restructuring the framework. These include: 1) the need to develop groupings of policies that are evaluated together in order to maximize benefits or avoid conflicts from interaction between options; 2) to iterate or incorporate new data during the evaluation process; and 3) to consider time frame issues within the framework. Each of these issues is discussed below.

Policy Packages or Multi-Option Strategies

The basic policy analytic framework can be used not only to evaluate individual policy options, but also combinations of options. The matrix structure easily facilitates this analysis, with policy packages or strategies listed down the side rather than single policy options. States may wish to consider various policy "packages," which combine options that together reflect a particular strategy. In this way, policy-makers can evaluate the pros and cons of various potential strategies or broad approaches in relation to a constant set of evaluative criteria.

This type of packaging could be relevant when climate change programs are expected to be comprehensive across multiple sectors of society or when a wide array of policy options are being considered for other reasons. States may wish to evaluate a variety of policy combinations, for example, that are designed to encourage both demand side and supply side emission reductions in the energy sector and to promote alternative fuel use at the same time. Packaging can also facilitate comparisons of overall strategies that target different sectors or strategies that start with the goal of complementarity with other state objectives and programs.

Iteration During Program Development

The optimal combination of policies or the best approach for analyzing options may not be apparent at the outset of climate change program planning. Not only may new scientific or economic information develop, but the process of evaluating alternative policies may itself generate new or additional information that should be folded back into the policy analysis. For example, if in the process of evaluating a state's initial list of potential greenhouse gas reduction policies, policy-makers discover unanticipated conflicts between various options, or if political transitions shift the importance of some criteria relative to others, then policy-makers may want to reformulate their approach, develop new options, and conduct the evaluation again.

Time Frame Considerations in the Policy Analytic Framework

Policies can achieve benefits or incur costs in the near-, mid-, or long-term. The timing of policy outcomes (i.e., benefits, costs, and other impacts) should be clear during policy evaluation so that policy-makers can consider how policies and their impacts may overlap in the future, either in terms of achieving direct emission reductions, generating political support, or fostering other inter-temporal results. One option is to conduct separate analyses for each time frame. Chapter 7 discusses time frame issues in more detail and highlights how some policies may in fact be designed in one time frame specifically to foster benefits in another.

Within the matrix format, considering time frame issues may mean sub-dividing relevant criteria into near-, mid-, and long-term columns so that the relative impact of each policy within each time frame can be evaluated and illustrated. This reflects one aspect of climate change that may complicate the analysis but also significantly enhance the information presented. This is especially true with respect to policy goals or objectives that cross time frames, as mentioned above, and may aid in generating high levels of political support in the near term to build consensus for future program expansion.

8.2 ESTIMATING BENEFITS

Whether implicitly or explicitly, policy-makers often try to gauge the social benefits and costs of alternative policies and then pursue those options that offer the highest net benefits. In the case of climate change, quantitative benefit analysis is extremely difficult, because so few of the physical impacts have been quantified at the state level, and even fewer have been monetized. For example, most analysts would agree that quantifying and monetizing all the impacts of sea level rise and climatic influences on agricultural systems, water resources, or biodiversity is beyond current technical and analytic capacity.[2] Accordingly, it is impossible to measure in standard economic terms the value or benefits of preventative

Exhibit 8-2: Complications in Estimating Benefits

Uncertainty surrounds many aspects of climate change, including:

- The magnitude of global average change in temperature, precipitation, and sea level rise;
- Regional projections of temperature change, precipitation, and soil moisture;
- The timing of changes in climate and related variables, such as sea level rise;
- The potential of commercially managed systems, such as agriculture and forestry, to adapt;
- The response of unmanaged ecosystems, including terrestrial and marine vegetation and animal species, to climate change;
- Impacts of climate change on other sectors, such as water resources, coastal wetlands, human health, and energy supply and demand; and
- The value to the public of mitigating these potential impacts.

policies. Exhibit 8-2 summarizes some of the complications surrounding analysis of the benefits of climate change mitigation policies.

This does not mean, of course, that it is not worth taking extensive action to mitigate these potential threats. In fact, many policy-makers believe that the foremost public benefit of greenhouse gas emissions reduction policies is to guard against the possibility of devastating impacts to the earth. In this sense, emissions reduction policies become an important insurance mechanism for the states, the nation, and the world, and they are a measure of our society's willingness to pay to prevent or ameliorate the impacts of climate change.

Three primary categories of benefits are somewhat more tangible and measurable, and thus more practical to use in policy planning and analysis. The remainder of this section discusses these categories, while Sections 8.5 and 8.6 provide more information on comparing costs and benefits of various options.

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[2] EPA is conducting extensive research on the benefits of climate change mitigation and on alternative frameworks for dealing with the uncertainties surrounding this issue.

The three categories outlined below include use of greenhouse gas emissions reductions as a proxy for the benefits of mitigating climate change, considering ancillary benefits of emissions reduction policies, and considering political and organizational benefits of addressing climate change.

8.2.1 Using Greenhouse Gas Emissions Reductions as a Proxy for the Benefits of Mitigating Climate Change

Estimating how policies affect greenhouse gas emissions is the most direct way to judge their role in mitigating the threats of climate change. Essentially, greater benefits come with larger emissions reductions. While even estimating a policy's actual level of emissions reductions is not a simple process, it provides a basic structure for comparing the climate change mitigation potential of various policies.

The basic process for estimating a policy's probable effect on greenhouse gas emissions anticipates how implementing the policy will change the equations used to calculate emissions from each greenhouse gas source. These can be changes in the magnitude of the independent variables that drive those calculations or changes in the fundamental structure of the actual equations. Chapter 3, *Measuring and Forecasting Greenhouse Gas Emissions*, examines these issues in detail and provides examples of their application.

To compare emission reductions achieved by different policies, the effect on warming of different greenhouse gases is evaluated on a common scale. For example, equal reductions in carbon dioxide and methane will have significantly different impacts on global warming. As Chapter 2 discusses, the International Panel on Climate Change has established a common measure, called Global Warming Potential (GWP), for comparing the relative impact of the various greenhouse gases. Although there exists some controversy as to the accuracy of GWP estimates at the current time, this scale is widely used by climate change analysts to measure the relative benefits of different emission reduction policy options. In the policy analytic framework, numbers representing emissions reductions for diverse policy options can then be presented and compared. In some cases, estimating the benefits of a greenhouse gas reduction strategy requires a more complex analysis, as illustrated in Exhibit 8-3.

8.2.2 Considering the Ancillary Environmental and Social Benefits of Emissions Reduction Policies

In addition to helping mitigate global climate change, reducing greenhouse gas emissions can provide other benefits. Policies to reduce greenhouse gas emissions from automobiles and electric utilities, for example, can improve air and water quality, with positive consequences for human health and natural systems. Similarly, policies to improve residential, commercial, and industrial energy efficiency can reduce costs and stimulate economic growth and competitiveness. Policies to recycle or reuse waste products can reduce greenhouse gas emissions and simultaneously reduce the need for costly municipal solid waste disposal.

In some cases, these benefits can outweigh the costs of policies designed to reduce greenhouse gas emissions. These approaches are often the most attractive options in the early phases of climate change program design, when program financing and political support may be low or tentative. It is important, however, that states not rely solely on these types of policies since most data indicate the total emissions reductions they can achieve, if implemented throughout the country, would not be enough to reach most climate change mitigation goals. Chapter 7 discusses the favorable and unfavorable political and organizational aspects of these types of approaches in more detail.

Exhibit 8-3: Determining the Value of Manure

When choosing between alternative policies, it may be important to quantify the benefits of a particular mitigation option before a decision can be reached. For example, using the manure from livestock, a farm can reduce its fertilizer consumption and associated greenhouse gas emissions. However, those benefits can be difficult to use to compare policy options unless they are quantified into a common unit of measurement.

Along these lines, the Soil and Plant Analysis Lab of the University of Wisconsin and the Arlington Agricultural Research Service (ARS) have developed a five-step method for determining the nutrient value of manure.

1) Determine the manure load size (volume): For a level box-end spreader, multiply the box length, the box width, and wall height together. If the load is heaped, multiply these factors by the total manure height divided by the side wall height.

2) Determine the manure density: Weigh a 5-gallon bucket of manure to obtain the manure density (weight/volume). Convert density to pounds per cubic foot.

3) Determine load weight: Multiply the load size (step 1) by the manure density (step 2).

4) Determine the pounds of nutrients per load: Multiply the load weight by the pounds of nutrient per ton of manure (which varies by animal type), based on values available from ARS.

5) Determine the total amount of nutrients spread per field or per acre: To determine the amount per field, multiply the pounds of nutrient per load (step 4) by the number of loads per field. Divide this number by the number of acres per field to get the nutrients spread per acre.

This method allows for a direct comparison between the manure and the amount of commercial fertilizer recommended. Thus, the estimated manure value can be used by policy makers in any calculatons necessary for evaluating this particular option.

Measuring and comparing diverse types of benefits across policy options can be difficult. One approach is to assess these benefits in terms of how they will reduce current and future costs for society. This may mean estimating cost savings directly for factors such as improved energy efficiency or reduced fertilizer consumption. Alternatively, it may mean estimating avoided costs of remediation or replacement. The benefits of enacting policies to prevent pollution of a water system, for example, can

be measured as the avoided cost of future clean up of that water system and the surrounding environment. Similarly, the benefits of reducing wastes can be measured as the avoided cost of depositing those wastes in landfills.

In other cases, however, society would not have chosen to remediate all damages or replace all lost services. Some benefits, for example, such as reduced emissions of air pollutants covered by the *Clean Air Act*, might not have occurred otherwise. In this case, the benefits are the improvements in human health, visibility, aesthetics, and ecosystem health that result. There are a wide array of analytic and economic techniques that policy-makers can draw from to conduct these benefit calculations. Extensive information on these topics is available in natural resource and environmental economics literature and other current literature. Topical literature assigns monetary or other quantitative values to potential benefits and costs.

However, monetizing certain kinds of benefits of climate change measures, such as ecosystem damage, is subject to considerable analytical uncertainty and often political controversy.

8.2.3 Considering the Political and Institutional Benefits of Addressing Climate Change

Some states have indicated that there can be substantial political and institutional benefits to initiating climate change mitigation programs and pursuing emissions reduction policies. Exhibit 2-3 in Chapter 2 reflects the positive attitudes of many states toward this issue. These benefits may include:

- *public visibility* as a proactive government on this issue, which may enhance the national and international image of the state, set precedents for national action, and inspire other state and national governments to act;

- *receiving special assistance*, such as receiving program support from EPA for developing climate change mitigation programs or receiving targeted aid or technical assistance for particular programs from other national and international organizations;

- *helping the United States meet national goals* and fulfill international obligations, which can be accomplished only if states take strong action; and

- *preparing for the future* by developing the foundation for programs that are likely to grow in importance over time.

As always, these and other potential benefits are only relevant relative to a state's particular goals and priorities. Each state must determine which factors are important to pursue.

8.3 ESTIMATING COSTS

Most policies encompass a range of associated costs. These include, for example, the government's costs for designing, implementing, and enforcing new policies, private sector costs linked to changes in production practices or compliance with new regulations, and costs to citizens in the form of higher prices for consumer goods or more time spent on activities such as recycling wastes. This section provides an introductory outline of how states might account for these costs during climate change policy analysis.

It is important first to distinguish the total cost of a policy option from its incremental cost. Most economists would agree that incremental costs are the appropriate focus of a cost-benefit analysis, although total costs can be important from an institutional or political perspective. Incremental costs are defined as costs that are the direct result of adopting the particular policy under consideration. Incremental costs can be determined by conceiving of a "baseline" scenario that reflects events likely to occur in the absence of a policy change and comparing it to a "policy scenario" that incorporates the likely outcome of the policy option. The difference in costs under these two scenarios reflects the incremental cost.

The incremental costs associated with climate change mitigation policies are those expenditures by individuals or organizations that would not have occurred if the policy had not been implemented. For example, public or private sector recordkeeping activities that would have been undertaken with existing resources should *not* be included in economic cost calculations. However, if the time and effort dedicated to new activities does prevent workers from carrying out tasks they used to conduct, then there is a social cost involved.

The purchase of new emissions-control equipment by industry, for example, often represents expenditures that would not have occurred without government regulation, and is an incremental cost of that regulation. Similarly, the amount of money the government spends designing, implementing, and enforcing that regulation is an incremental cost. These are the costs that policy-makers must consider when evaluating the social welfare implications of different policy options.

Economists distinguish between social costs, (costs that result from lost output or displaced resources) and costs that affect an individual sector, but do not necessarily represent losses to society. The incremental costs described above are "true" social costs. Some policies, however, induce a "transfer of wealth" between members of society but do not represent a new social expenditure. For example, taxes on fossil fuels or nitrogen based fertilizers will result in less wealth for individuals and businesses and more for the government. Because levels of fuel or fertilizer consumption changes in response to higher costs to producers or prices to consumers, there is a social cost to a tax as resources are moved to alternative uses. However, the money that is *transferred between the individuals and the government* is not considered to be a social cost. Transfers, in general, redistribute wealth but do not result in economic costs *per se*. Although, the amount of money the government spends administering the tax is a true social cost. Non-economists may refer to economics textbooks and other current literature for a more thorough explanation of how to estimate costs.

8.3.1 Process for Calculating Social Costs

Social costs that should be considered during economic evaluation of climate change policies can result from expenditures in any sector of society. For example:

- State and local governments may incur incremental costs associated with policy design, administration, monitoring, permitting, enforcement, or other activities.

- Industry may incur costs to modify production plants and equipment, alter operating practices, institute new waste disposal practices, or change their labor mix.

- Consumers may incur costs in making their homes more energy efficient, or by paying higher prices for goods and services or spending more time and effort recycling waste products.

- Product quality, innovation, or general productivity may be adversely affected; if the same resource investments yield less benefits in any of these ways, society has realized some new cost.

- Policies may displace resources such as labor or capital equipment; if resources do not find equivalent employment elsewhere in society, then their displacement also imposes a long-term cost on society. Cost also results from unemployment, because local industries that service the industry where jobs are lost may also suffer. Even if resources do become employed elsewhere, the transition between jobs, or movement of financial capital, can be unpleasant, and, at the least, imposes the transitional costs, or "transactions costs", on society.

Costs that fit these categories can be analyzed at a variety of levels or from a variety of perspectives. Exhibit 8-4 discusses some of the levels of information states may want to include in their cost analyses.

In the policy analytic framework, aggregated social costs may be a key policy evaluation criteria. A common approach for estimating social costs related to each policy option from all the sources listed above involves six basic steps:

Exhibit 8-4: **Dimensions of Costs**

Depending on the level of analytic complexity a state needs or wants to adopt, social costs can be assessed with regard to various dimensions or perspectives. These include:

- *breadth* **-** the number of affected activities;
- *depth* **-** the level of quantitative and detailed cost estimates for these activities; and
- *scope* **-** the range of the effort to locate secondary effects (and costs) of these activities (e.g., does the effort to analyze costs and economic impacts extend beyond the primary market affected).

Expanding an analysis along any of these dimensions can provide additional valuable information, but also requires more resources. In its simplest form, cost information can be presented as an inventory of activities that are sources of costs. For example, sources of costs to industry might include retooling equipment or increasing quality control, filling out reporting forms, interacting with technology transfer committees, and hiring more educated labor to use more complicated equipment. An intermediate form of analysis involves seeking to quantify, using engineering cost studies and other information, each activity and source of cost. Where significant price and output effects are expected, the analysis can be expanded to include a representation of demand and supply conditions in the relevant market(s). This is frequently called partial equilibrium analysis. The most complex form of cost analysis uses general equilibrium models that capture multi-sector interactions and subsume a variety of markets (see Section 8.7).

1. *Determine who in society will be affected by the policy.* This means identifying and listing each type of public and private sector actor that will incur new costs. This may include government agencies, small and large firms, individual consumers, and others.

2. *Separate the affected community into homogenous groups.* This means creating groupings or categories of actors that are similar to each other in terms of how they conduct their business, both before and after the policy is enacted. The point is to group together actors who are likely to react in a similar manner to the new policy. Some groupings, such as one type of small industry, will be heavily affected and will need to change their operations significantly, while a different type of small industry will only need to make small changes. These should be classified as separate groups even though each is part of the broader small-industry category.

3. *Determine the base-line costs for each group.* This means identifying the procedures or operations that will change for each group under the new policy and calculating the current pre-policy costs of those procedures. For example, if production processes, waste disposal, or record keeping will change, costs associated with these activities should be calculated before the changes take place. These calculations should be sure to incorporate both operating and capital costs.

4. *Determine new cost levels for each group.* Given the new policy, calculate the expected operating and capital costs associated with the modified procedures. This means figuring out the costs associated with conducting business if the new policy is in place.

5. *Calculate the incremental cost of the policy for each group*. For each group, subtract the pre-policy costs (the base-line from step 3) from the post-policy costs (step 4) to determine the incremental costs to the group of the new policy. In some cases, incremental costs can be

calculated directly, without first specifying the baseline in Step 4 (*i.e.*, the baseline is implicitly zero). For example, the cost of planting shade trees in residential neighborhoods can be calculated directly as the cost of labor, seedlings, etc.

6. *Calculate total cost.* Sum the incremental costs from all the affected groups into an aggregate annual cost figure for the policy in all years that the policy has costs. As Exhibit 8-5 discusses, economists and policy-makers usually include the present value of costs that will be incurred throughout future years because of the new policy.

Exhibit 8-5: Time Frames and Cost Analysis

Social costs generally fall into one of two classes: one-time, up-front costs (such as equipment purchases), and recurring annual costs (such as compliance reporting or increased equipment maintenance costs). Because costs may vary over the time-period of the analysis, cost information can be presented for decision-makers in a variety of ways. Actual annual costs are useful, for example, because the bulk of adjustments to new government policies often occur in the first few years the policy is in effect.

For comparing diverse policies, however, an aggregate measure of costs on a common scale is needed. *Present value* is one measure that transforms streams of future costs -- using a discount rate -- into a measure of comparable worth today. Section 8.5 describes alternative approaches to selecting the social discount rate to apply to projected future costs in order to calculate their current value. Comparisons of present value, however, can be complicated by questions of how to truncate the streams of costs that are compared.

A complement to calculating present values is *annualized costs*. Annualizing costs converts the stream of actual costs into a constant cost stream. Annualized costs provide a metric for comparing policies that have different lifetimes over which they would naturally be analyzed. For example, policies involving process changes at an electric utility would generally include cost analysis over 30 years, the expected lifetime of the plant. In contrast, forestry projects would naturally be analyzed for one or more tree rotation lengths, which vary widely by tree species. Annualizing costs provides one method for comparing these two options.

Annualized costs are also useful when comparing programs that involve non-monetized benefits, such as emissions reductions. In this case, annualized costs can be compared to average annual emissions reductions to calculate the cost-effectiveness of alternative policies. Present value costs can be similarly compared to cumulative annual emissions reductions, providing similar, but not identical, results.

8.3.2 Complications Associated with Social Cost Calculation

Estimates of the total costs associated with each policy option can be used for describing policies and illustrating tradeoffs within the analytical framework. States should be aware of several areas for caution, however, when conducting these calculations.

First, costs should not be double-counted. In some situations the same cost may filter its way through different groups of actors but should not be included in the aggregate cost calculations more than once. Higher costs to firms, for example, may be passed on to, and result directly in higher prices for, consumers. This cost should *not* be calculated and incorporated for both these actors, since it really represents only one net increase in total costs to society.

The second area for caution involves explicitly distinguishing wealth transfers from real resource allocation costs. As noted above, transfers of money or resources between groups of actors do not represent real costs to society. A large part of the impact of tax revenues, for example, is a transfer of wealth from citizens or private organizations to the government. While non-cost elements of these types of wealth transfers are certainly relevant in program evaluation, they should not be directly incorporated into social cost calculations. Other aspects of taxes may in fact represent true social costs, such as market distortions or potential long-run losses in productivity or competitiveness. Section 8.4 discusses this issue in more detail.

The final caution regarding social cost calculations is that apparent price impacts may actually be rooted in factors external to the new policy. While such changes may affect costs between the pre- and post-policy scenarios, they are not part of the incremental cost of the policy. For example, an external influence may cause refrigeration or air conditioning prices to rise regardless of new emission reduction policies. While these price changes may induce (or reflect) real costs to society, they are completely unrelated to climate change mitigation policies and their effects should be included in the baseline and not in the social cost calculations.

8.4 ESTIMATING OTHER IMPACTS

Greenhouse gas emission reduction policies may have a number of important impacts in addition to those quantified in standard social benefit and cost calculations. General effects on the economy, on specific sectors of the economy, and on different income classes within urban or rural populations are all similar concerns in the state policy making environment. These impacts influence the desirability of alternative policy strategies, and also affect public attitudes, the political feasibility of climate change programs, and the financial or other resources allocated to climate change mitigation efforts. While these political and administrative factors are difficult to separate or measure during policy analysis, they are critically important to long-term success in combating global climate change.

Political and organizational implications can result from financial factors, such as the wealth transfers discussed in Section 8.3, induced by policy change. These impacts may cause serious economic disruption within a region or may undermine other public policy objectives but will not appear in social cost calculations because they only represent shifts of resources among segments of society. Plant or mine closures in one region of the country, for example, may yield net benefits to society in terms of combatting damage to the environment and human health, but may undermine the region's economy. This same policy action may result in high rates of temporary unemployment and migration of people to other states. Obviously, state policy-makers must consider these factors.

Within the policy analytic framework explicit evaluative criteria can be created for each area of social concern. Including political feasibility or social equity criteria in the policy matrix, for example, ensures that these issues will be considered in evaluating every policy option. Chapter 4 presents a number of potential criteria that states might employ; the exact criteria a state defines will reflect local priorities and circumstances. The potentially important policy impacts sometime ignored by social benefit and cost calculations include:

- *Impacts on Specific Sectors of the Economy.* For example, transportation and agriculture may be most affected by some measures, while the residential sector and industry may be hit harder by others. The division of impacts between sectors may be considered favorable or unfavorable by state policy-makers depending on their priorities. If the state is trying to reduce emissions largely within one sector, for example, then a criterion that highlights how each policy affects that sector may be worth developing. On the other hand, states may wish to protect rather than target certain sectors; well-developed criteria can help account for this concern as well.

- *Impacts on Employment.* When jobs are permanently lost so that individuals remain unemployed, or if new jobs are less productive or lower paying than lost jobs, there is an economic cost since the output is lower. Labor shifting between jobs, however, is not necessarily an economic cost. Nonetheless, job loss is obviously an important social issue, as well as being politically significant. The degree to which policies induce labor shifts is, thus, usually a critical consideration in policy analysis.

- *Regressivity or Progressivity of the Policy.* Policies may extract greater payments from some income classes than from others. Taxes on household products, for example, are generally considered to impose a greater burden on low income households because these households spend a higher proportion of their annual income on such products than do households with higher incomes.

- *Impacts on Government Finances and Revenues.* Most policies will affect government finances in some way. Measures that require high levels of administration and enforcement by government agencies, for example, may demand significant dedicated budget allocations. Taxes to reduce consumption of greenhouse gas producing products and activities, on the other hand, will raise government revenues. Whether or not these issues are legitimately factored into social cost calculations, they will have certain political and administrative implications that may be important to consider during policy planning.

- *Impacts on Other Government Work.* Depending on how new programs or policies are administered, they may disrupt current government operations. If a new program in a state energy office, for example, requires staff time for administrative and other functions, current activities may be displaced or disrupted. While such impacts do represent a social cost, they are often ignored, especially if no new resources, such as budgets or employees, are allocated to help cover the new activities.

8.5 GENERAL COMPLEXITIES IN ESTIMATING POLICY IMPACTS

The above sections on benefits, costs, and other impacts highlight potentially important evaluative criteria. Impacts of climate change and of climate change policies, however, may both extend many years into the future and be highly uncertain. The policy-maker, therefore, is charged with selecting an analytical framework that adequately addresses the decision-making problem. In this context, complexities surrounding policy evaluation fall into one of two categories: 1) assumptions that underlie how states will treat social risk and social value over time; or 2) limitations on applicable policy evaluation procedures that are rooted in the uncertainty surrounding climate change.

Specific issues relating to each of these types of complexities are introduced below. These include determining social discount rates to use in policy analysis, dealing with uncertainty regarding policy impacts, and dealing with uncertainty about the impacts of climate change itself. States may wish to consider these issues and establish standards for dealing with them before conducting full-scale policy analysis.

Determining Social Discount Rates

Policy-makers must consider the future ramifications of greenhouse gas emission reduction policies. Because discount rates are generally used to calculate the present value of benefits and costs that accrue in the future, alternative discount rates and alternative methods of applying them carry significantly different implications for policy development. The information presented in this section introduces some of the foremost considerations surrounding selection and application of specific discount rates. Policy-makers interested in this issue may wish to review the extensive economic literature on discounting and environmental policy.[3]

The fundamental issue underlying the choice of a specific discount rate is that higher rates will result in lower valuation of future costs and benefits. As a result, a higher discount rate will weight future policy impacts less in current decision making. At a discount rate of 0%, for example, future costs and benefits are treated exactly the same as current costs and benefits; a $100 impact observed fifty years from now would be considered equivalent to a $100 impact felt today. At a 5% discount rate the same $100 future impact would be valued as $8.72. Similarly, at a 10% rate it would be valued at $0.85. Discounting is especially relevant to greenhouse gas emission reduction policy development and selection since climate change is such a long-term issue.

There is a considerable body of literature discussing what the appropriate discount rate is for public policy decision-making. Most economists would argue that the rate should not be zero. Rather, costs and benefits incurred in the future should be weighed less heavily than current costs and benefits; because resources today can be invested in the future, using a positive discount rate is analogous to financial decisions that firms make when comparing streams of costs and revenues. Moreover, individuals tend to weigh current costs and benefits more than future costs and benefits in their own decision-making. For example, individuals often prefer a less expensive product to a more expensive product that is more reliable and will be less costly to own and operate in the long run.

Because of ethical issues surrounding discounting, many analysts argue for the use of low discount rates. The inter-generational nature of long-range planning, for example, necessitates that some of the parties who will experience the costs and benefits of policies do not yet exist. Many individuals will not be born and organizations not formed until some time in the future. Given this situation, the irreversible nature of potential threat from climate change may require greater caution (i.e., a lower discount rate). Conversely, it has been argued that the current generation should treat future generations exactly as we would treat ourselves, potentially resulting in higher discount rates. These are issues that states should consider and evaluate in more detail.

Assuming these ethical questions are resolved, numerous practical questions remain as to the choice of an appropriate discount rate. The economic debate about what the discount rate should be examines a variety of issues, including the real resources that are displaced by the investment, riskiness, and other factors. In general, decisions by businesses and private individuals are made using private discount rates that are usually higher than social discount rates used by governments to set policy. Thus, measures that may not be implemented by individuals or industries on their own, may, nevertheless, be cost-beneficial from a social perspective.

Inherent Uncertainty in Valuing Impacts of Climate Change Policies

Social benefits are typically measured by economists as the damages avoided by taking some policy action. For example, the benefits of climate change mitigation are equal to the value to society of

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[3] For more information, see Lind, 1982. States may also want to review the U.S. Office and Management and Budget's (OMB) analyses of social discount rates as they apply to federal programs (OMB Circular A-94, Revised October 29, 1992).

avoiding any negative impacts of climate change in the future. Although available estimates suggest that the climate changes associated with a warmer planet may have significant implications for the environment, the economy, and human health, estimates of the value of avoiding these changes are incomplete and uncertain. Estimating the impacts and associated future costs of climate change is, thus, a primary focal point of current national and international research.

Because of these complications, as Section 8.2 explains, the amount of emission reductions policies achieve is most often used to measure the benefits of different policies to mitigate climate change. Since this assumes that greater benefits result from emission reductions, there are direct implications for the analytic methodologies states use to evaluate policies. As suggested later in this chapter, for example, analyzing policies based on emission reductions encourages cost-effectiveness rather than benefit-cost analyses (see Section 8.6).

States deal with the issue of uncertainty surrounding climate change impacts through the level of effort that they devote to climate change mitigation programs. States that want to wait until the uncertainties are reduced, or that do not recognize their significant potential for helping mitigate this problem, either take no action or pursue a conservative approach. Alternatively, states that believe it is worth acting amidst these uncertainties, on the other hand, often tend to be more aggressive in developing mitigation policies. In either case, however, the amount of greenhouse gas emission reductions attained through various policy options still usually serves as the proxy for the benefits of mitigating climate change since the actual "avoided damages" of not addressing climate change are impossible to quantify, though they may be significant.

Uncertainty Regarding Policy Impact

The actual impact of some policy options on greenhouse gases can also be difficult to measure and forecast. The uncertainty is especially relevant for policies that provide indirect emissions control, such as financial incentives or educational programs, for policies that span long time frames, and for policies that may interact with other emission reduction policies or with other state initiatives. Actually calculating emissions reductions may require a sophisticated understanding of the policy and the sector affected. If policy analysts do not know exactly how price changes affect fertilizer demand, for example, then the effect of a nitrogen-based fertilizer tax will be uncertain and emission reductions will be difficult to quantify. Some policies to decrease fossil fuel consumption in the residential or transportation sectors may escalate the demand for electricity, which may offset reductions in greenhouse gas emissions, depending on what type of power plants supply the additional electricity. These positive and negative interactions are most difficult to predict in the long term when other economic or social fluctuations will affect greenhouse gases and policy success as well.

Similarly, education policies are critically important but are difficult to link explicitly to components of the equations for computing emissions. Acknowledging these issues is especially important for ensuring that some critical programs, such as public education and long-term urban planning, are not dismissed or ignored because they cannot be linked to direct emission reductions.

8.6 BASIC METHODOLOGIES FOR EVALUATING CLIMATE CHANGE ISSUES

Depending on state goals, resources, and institutional capacity, policy analysis to evaluate greenhouse gas reduction options and to account for the complexities listed above can be conducted with a range of methodologies or analytic tools. The policy analytic framework highlighted in this chapter represents one way to frame the climate change issue as a whole and illustrate the tradeoffs between different options. A variety of alternative or supplemental approaches may enhance climate change policy analysis. These can range from simple computer spreadsheet approaches to complex and comprehensive modeling efforts, either of which can be supplemented by economic or engineering research. While the full range of these approaches cannot be discussed here in detail, some of the general issues and the basic structures that states might consider are worth reviewing.

The analytic approach for examining particular policy options can become increasingly complex depending on the factors and levels of information a state wishes to incorporate. A simple approach for states to follow is to rank different options based on how well they meet each criterion. More substantial information may be desirable, however, such as an understanding of the precise magnitudes of various policy impacts. In cases where benefit or cost estimation is not straightforward, states may want to use methodologies such as risk analysis, econometric evaluation, linear programming, and other analytic tools. The remainder of this section reviews decision making constructs that include benefit-cost analysis, cost-effectiveness analysis and multi-criteria decision making.

In the end, the particular methodologies and tools a state uses to conduct climate change policy analyses will depend on local circumstances, including resource and institutional constraints. It is perhaps obvious, but important, that there is a trade-off between obtaining solid and reliable information and the cost and time expended in accumulating that information. For many states, this may suggest using simpler decision guidelines unless they can work with other governments or regional coalitions on more comprehensive projects.

The types of policy analysis and decision making methodologies summarized below, as well as others not listed here, are not necessarily exclusive, but may overlap and complement each other in various ways. In addition, the risk, time frame, and discounting issues discussed above are common and fundamental to all these approaches. Extensive and more complete literature is available on all these topics; the information presented here is intended only to provide examples to state policymakers for ways to analyze policy options.

Benefit-Cost Analysis

Benefit-cost analysis offers a framework for choosing among alternative policy options that involves monetarily valuing the impacts of the policies under consideration and selecting the policies with the highest net benefits. This approach attempts to account for *all* benefits and costs, including difficult-to-monetize effects such as ecosystem damage or effects on human health.[4] This process may have limited usefulness in the current context, because of the cost and problems involved in comprehensively quantifying the value of climate change impacts at the state level. Further, many state and federal agencies, including EPA and OTA, as well as private researchers, have investigated and quantified at least a portion of these impacts, for some regions or nationally (Cline, 1992; Fankhauser, 1994; IPCC, 1992a; Nordhaus, 1994; OTA, 1993; and U.S.EPA, 1989). Extensive economic literature is available on benefit-cost procedures and different means of valuing non-quantitative factors.

Cost-Effectiveness Analysis

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[4] Typically, benefit-cost analysis involves the following steps: (1) measuring, in monetary terms, all of the costs and benefits of each policy over time; (2) for costs and benefits that occur in the future, calculating their present value by application of an appropriate discount rate; (3) calculating the net benefit of each policy by subtracting the present value of the costs from the present value of the benefits; and (4) choosing the policy option that offer the highest net benefits.

Cost-effectiveness analysis simplifies policy analysis by allowing one policy impact, such as the benefits of climate change mitigation, to be measured in non-monetary terms. If emissions of different greenhouse gases are represented on a common scale, such as 100-year estimated global warming potential (GWP), cost-effectiveness promotes calculation of a dollar-per-unit-GWP-reduced figure. This same analysis can be conducted with any other common scale, such as tons-of-carbon-equivalent emissions reduced. While cost effectiveness analysis lets policy-makers rank options on a common cost-per-unit scale, policy-makers must still determine which or how many of those policies to enact. Exhibit 8-6 illustrates these points.

Exhibit 8-6: Sample Results of Cost-Effectiveness Analysis

This table illustrates the results of cost-effectiveness analyses. While in an ideal situation data are available to generate these types of numbers with precision, in reality the cost and emissions-reduction figures are often subject to high levels of uncertainty. The data below do not represent the results of actual analyses:

Sample Policy Option	Hypothetical Associated *Cost-per-ton* of Carbon Equivalent Emissions Reduced	Total Potential Emission Reductions (tons)
1) Methane Recovery Technology Demonstration and Support	$54.00	58.4
2) Methane Emissions Tax	$31.00	123.0
3) Alternative Fuels Subsidy	$45.00	456.9
4) . . .	. . .	. . .

Given these constraints, cost-effectiveness analysis often serves as a basis for selecting a least-cost combination of policies to achieve some preset goal, such as a 20% overall emission reduction by some target year, or as a basis for selecting the combination of policies that will bring the highest level of emission reduction benefits given a certain financial or other resource constraint. For example, states can use this type of analysis to calculate the highest level of emission reductions possible given a preset budget.

Multiple Attribute Decision Analysis

A variety of analytic methodologies facilitate the structured consideration of multiple and diverse social objectives during policy evaluation, such as considering emission reductions costs, political feasibility, and social equity at the same time. By weighing evaluative criteria, assigning probabilities to certain policy outcomes, and developing utility functions to represent the value of these outcomes, these methodologies allow decision makers to consider policy impacts on diverse criteria that cannot be expressed in common units. The end product of this type of decision analysis is usually a probability-based prescription for what policy or combination of policies offers greatest expected social benefit. This analysis hinges on a well-defined set of data inputs and constraints.

Extensive literature is available on the types and different policy applications of decision analysis methodologies. The most straightforward of these methodologies allocates probabilities and payoffs to all the potential benefits and costs associated with alternative policy choices. This process, best serving decision makers and analysts who face uncertain outcomes from a set of given actions, is often incorporated into various stages of cost-effectiveness and benefit-cost analysis. It is generally used to determine the expected value of options or policy impacts by combining the probabilities of different potential outcomes with weights assigned to the social value or utility of those outcomes. Exhibit 8-7 illustrates some of the components of multi-attribute decision analysis.

A more complex but similar technique is called the Analytic Hierarchy Process (AHP).[5] This is a procedure that specifically attempts to provide structure to multi-criteria decisions involving problems of

Exhibit 8-7: Sample Multi-Attribute Decision Analysis

Due to its complexity, multi-attribute decision analysis can not be thoroughly illustrated here. This box shows the types of information that might factor into two stages of this kind of analysis. The information here is only a simplistic representation of this type of analysis and does not reflect many of the details and complexities involved.

Stage 1: Assign Probabilities and Values to Possible Policy Outcomes

Regarding a specific policy option, such as an alternative fuels subsidy, policy makers might decide that there are three possible outcomes within a five-year time frame, each carrying a certain value. The "value", developed as an earlier part of the analysis, may be derived from emissions reduction projections, costs, and other factors; extensive analytic processes exist for defining and developing both "value" and "probability" estimates. The sample below is only illustrative and does not represent an actual analyses.

Sample Possible Outcomes	Value of outcomes ($ or some other measure)		Probability		Value * Probability
1) Successful conversion to alternative fuels	$11,380	*	.25	=	$2,845
2) Partial conversion to alternative fuels	$2,385	*	.60	=	$1,431
3) Citizens reject or legislature repeals the policy	$0	*	.15	=	$0
	Sum Expected Value of this Policy Option				$4,276

Stage 2: Analyze Alternative Policies Based on Expected Values

Depending on the analytic structure chosen, policy makers may be able to compare the sum expected values of different policy options, or combinations of options, and select those with the highest expected values, given the predetermined probabilities and outcomes. Results of this analysis could look like the following:

Policy Option	Expected Value
1) Methane Recovery Technology Demonstration and Support	19,784
2) Methane Emissions Tax	7,900
3) Alternative Fuels Subsidy	4,276
4) . . .	. . .

[5] For more information on the Analytic Hierarchy Process, see Dyer, 1992.

choice and prioritization between criteria, as climate change policy formulation does. Using AHP, policy-makers develop a decision hierarchy that identifies and compares alternatives. The broad approach is to structure the complex decision first and then to focus attention on individual components of that decision, using subjective judgements (as supported by the process itself) on aspects of the problem for which no quantitative scale exists. Certain computer software tools are designed specifically to support this type of analysis. The fundamental benefits of this approach is that it structures complex decisions, provides a reliable mechanism for ranking non-quantitative issues, and focuses on objectives that policy-makers are trying to achieve rather than on the explicit alternatives. While there do not appear to be applications of AHP in the climate change field, it has been used for some renewable energy and sustainable resource analysis.[6] States may want to investigate these techniques further.

8.7 MORE COMPLEX TECHNICAL TOOLS FOR ASSESSING GREENHOUSE GAS POLICIES

Some regional, national, and international analysts are using technical tools beyond the methods described in this chapter to deal with the complexities surrounding climate change. This section illustrates a limited set of the tools that have been applied to address the following tasks:

- Demonstration of technical issues in global change;
- Policy exercises involving stabilizing of emissions, atmospheric composition, or climate;
- Risk assessment pertaining to climate change; and
- Risk management pertaining to climate change.

The information in this section is derived largely from national and international sources, and may not apply at regional and state levels, especially given local goals and agendas. If states choose to investigate complex modeling, cooperative arrangements with relevant research and federal institutions and with other states may facilitate the application of more complex methodologies to the development or implementation of state policies on greenhouse gas emissions. The tools listed here require significant investment of financial and other resources to develop.

There is currently no single tool that simultaneously addresses all of the above tasks. Some of the methodologies that are applicable to greenhouse gas policy analysis are summarized in Exhibit 8-8. An example of one of the more comprehensive methodologies is the Integrated Model to Assess the Greenhouse Effect (IMAGE), developed by the National Institute of Public Health and Environmental Protection (RIVM) of the Netherlands. Exhibit 8-9 provides a diagram of IMAGE's modular structure. Note in particular the following assessment tiers in the overall methodology, illustrated in that diagram:

- Energy/economics and land use models;
- Atmospheric composition models;
- Global and regional climate impact models; and
- Socio-economic impact models.

[6] For example, the Analytic Hierarchy Process contributed to biomass energy assessments by the Southeastern Regional Biomass Energy Program.

Exhibit 8-8: Sample Methodologies for Analyzing Greenhouse Gas Policies

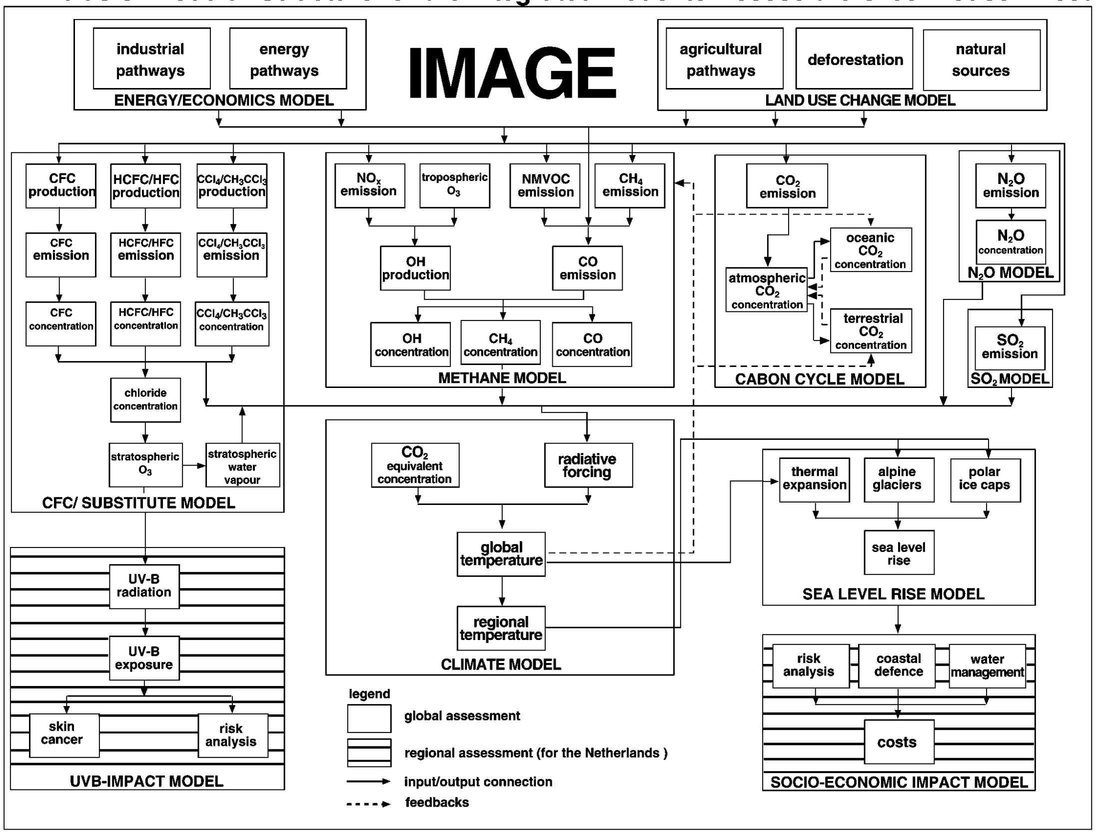
Acronym	Energy Use Model	Emissions Model	Atmospheric Composition Model	Climate Impacts Model	Socio-Economic Impacts	Scale
PC-AEO	Yes	No	No	No	No	Regional
TEMIS	Yes	Yes	No	No	No	Urban
ISAAC	Yes	Yes	No	No	No	Regional
MARKAL	Yes	Yes	No	No	No	Regional
IEA/ORAU	Yes	Yes	No	No	No	Global
DICE	Yes	Yes	Yes	Yes	Yes	Global
ASF	Yes	Yes	Yes	Yes	Yes	Global
MAGIC/	Yes	Yes	Yes	Yes	No	Global
ESCAPE	No	No	No	Yes	Yes	Regional
IMAGE	Yes	Yes	Yes	Yes	Yes	Regional
DRI/ McGraw-Hill	Yes	Yes	No	No	Yes	National/ Regional
REMI*	Yes	Yes	No	No	Yes	Regional
IDEAS (DOE)	Yes	Yes	No	No	Yes	National

* Regional Economics Models, Inc.

The regional assessment capability of IMAGE is limited to impacts specific to the Netherlands. A similar comprehensive methodology, the MAGIC and ESCAPE models of the Climate Research Unit (CRU) of the University of East Anglia, can be used to examine regional impacts in Europe. Ongoing development efforts by the U.S. Environmental Protection Agency's Office of Policy, Planning and Evaluation and at Batelle Pacific Northwest Laboratory are expected to yield comprehensive policy models that are applicable to the United States at the national and regional levels.

Policy-makers interested solely in stabilizing emissions or atmospheric concentrations of greenhouse gases, rather than in policies that address climate stabilization or the full range of socio-economic impacts, may not necessarily need to resort to a comprehensive assessment model. The Dynamic Integrated Climate-Economy (DICE) model of Nordhaus (1992), which utilizes a global, inter-temporal general-equilibrium model of economic growth and climate change, provides simpler estimates of global impacts. A more complex model used within the United States is the EPA's Atmospheric Stabilization Framework (ASF), which combines energy/economics and land use models and atmospheric composition models with a highly simplified global impacts models.

Exhibit 8-9: Modular Structure for the Integrated Model to Assess the Greenhouse Effect



The IMAGE model was developed by the National Institute of Public Health and Environmental Protection (RIVM) of the Netherlands. Details regarding its structure and application are available in the RIVM brochure, Global Change Research Programme: An Overview.

Several methodologies are solely applicable to estimating energy use and/or accompanying emissions of greenhouse gases amd have extensive economic modeling components. At the global level, there is the ORAU energy/economics model of carbon dioxide emissions developed by the International Energy Agency. A spreadsheet model that can be employed to forecast regional industrial energy use, but does not estimate greenhouse gas emissions, is the U.S. Department of Energy's PC-AEO model, which is coded in Lotus 1-2-3. An especially useful regional emissions model is MARKAL, which has been adapted to evaluate carbon dioxide emission control strategies by the New York State Energy Office. Other methodologies for forecasting CO_2 emissions are the Joint Decision Analysis Model (ISAAC), which was developed by the Bonneville Power Administration and used to examine future emissions in the Pacific Northwest by the Oregon Department of Energy, and the Total Emissions Model for Integrated Systems (TEMIS), which is a fuel cycle model developed by the OKO Institute in Germany and is best used to simulate urban emissions, when specific local data are available.

CHAPTER 9
PREPARING THE STATE ACTION PLAN

The previous chapters provided some detail on the issues with which states should deal and the processes they should go through when developing their Climate Change Action Plans. This chapter is intended to assist states in developing an organizational framework for presenting the information in their plans.

While each state bears chief responsibility for drafting its own plan, it is important to bear in mind that climate change is a global issue and that the nation has made an international commitment to reducing greenhouse gas emissions. Each state's action is part of a concerted, national effort. It is therefore possible and desirable to identify components of a State Climate Change Action Plan that should be common to all states. An action plan should contain at least the following elements:

- Executive Summary
- Background on the Science of Climate Change
- Regional and Local Risks and Vulnerabilities
- 1990 and Forecast Baseline Emissions
- Goals and Targets
- Alternative Policy Options
- Identification and Screening of Mitigation Actions
- Forecast Impacts of Mitigation Actions
- Recommendations and Strategy for Implementation

Each of these elements of the action plan will be discussed in turn, with references to the appropriate sections of this guidance document.

9.1 EXECUTIVE SUMMARY

This section summarizes the Plan's conclusions and recommendations.

9.2 BACKGROUND ON THE SCIENCE OF CLIMATE CHANGE

For some readers, the Plan will serve as their first introduction to the issues surrounding climate change, while others may already be well educated about the subject. A concise presentation on the science of climate change and the history of national and international climate change policy, as discussed in Chapter 2, will help to educate readers about the problems confronted in the Plan.

9.3 REGIONAL AND LOCAL RISKS AND VULNERABILITIES

The global phenomenon of climate change will manifest itself at the regional and local levels. To the extent possible, states should anticipate the local and regional manifestations of climate change, such as shifting patterns of agriculture, increased incidence of temperature-related diseases, and risks to water resources.

9.4 1990 AND FORECAST BASELINE EMISSIONS

As discussed in Chapter 3, identifying major sources of anthropogenic greenhouse gases will enable states to prioritize various policy initiatives. This inventory of greenhouse gas emissions will also establish a baseline against which the effectiveness of mitigation activities may be measured. For inventories developed in partnership with EPA, states are requested to use the year 1990 as their baseline year. The choice of 1990 as a baseline is consistent with the nation's international commitment under the *Framework Convention for Climate Change* to return the nation's greenhouse gas emissions to 1990 levels by the year 2000.

To evaluate the set of mitigation actions contained in the Plan, each state should also forecast a baseline set of emissions. The forecast (see sec. 3.2) baseline scenario describes a future in which a state conducts "business as usual," pursuing no initiatives specifically targeted to reduce or sequester greenhouse gases. At the same time, the baseline scenario must portray the expected economic, social, demographic, and technological developments over some future time horizon. The maximum time frame for projecting emissions is generally 15 to 20 years.

9.5 GOALS AND TARGETS

Once baseline emissions have been forecast, each state should commit to attaining realistic, measurable goals of greenhouse gas reduction or sequestration, as discussed in Chapter 4. Using the baseline forecast, states may establish reduction or sequestration goals over a given period of time (see sec. 7.1).

9.6 ALTERNATIVE POLICY OPTIONS

Although this guidance document is intended to assist states in formulating mitigation strategies, *i.e.* strategies to reduce greenhouse gas emissions, states may also choose to develop strategies that will allow them to adapt to the potential changes that climate change may generate. States should discuss these adaptation strategies in a separate section, distinct from mitigation strategies.

9.7 IDENTIFICATION AND SCREENING OF MITIGATION ACTIONS

Based on the guidance provided by Chapters 5 and 6, states can begin to identify policy options to reduce greenhouse gas emissions. These options can then be analyzed, as discussed in Chapter 8, to select mitigation actions that are economically viable, politically feasible, and technologically plausible.

When identifying and screening mitigation actions, states should also describe the process through which they arrived at their conclusions. They should discuss:

- the political infrastructure that ensured the Plan's formulation (see secs. 7.2, 7.3, and 7.4);
- the development and application of selection criteria used to screen mitigation actions (see sec. 4.3); and
- the analytical tools used to compare mitigation options (see Chapter 8).

9.8 FORECAST IMPACTS OF MITIGATION

Once a state has identified those mitigation actions that are economically viable, politically feasible, and technologically plausible, it should analyze and communicate the benefits of these actions through the use of mitigation scenarios. Mitigation scenarios are not predictions of the future. Rather, they allow policymakers and the public to imagine the future by modeling the effects of a wide range of policy initiatives.

The mitigation scenario describes a future similar to the baseline scenario with respect to underlying economic and demographic trends; however, it assumes initiatives are taken to address the issue of climate change. The mitigation scenario should take into account both the technical potential for reducing or sequestering greenhouse gases and the institutional, cultural, and political constraints that may prevent a state from exploiting all technical possibilities. States may develop several mitigation scenarios based on different assumptions that vary according to the degree to which they yield greenhouse gas reductions.

It is beyond the scope of this guidance document to go into the specifics of the various models that have been developed to generate long-term forecasts of climate-related phenomenon. Forecasting emissions relies on such uncertain variables as population growth, energy consumption and changing sources of power, number of automobiles, and changes in the agriculture and forestry sector. Section 3.2 of this guidance document provides a broad overview of forecasting methods. Whichever forecasting method a state uses, it will probably involve three essential broad types of activities: data collection and analysis; quantification of emissions/reductions/sequestration; and extrapolation.

- *Data Collection and Analysis.* Currently, greenhouse gas emissions are estimated by multiplying data that measure the level of activity that generates greenhouse gases (hereinafter referred to as *"GHG activities"*) with the appropriate greenhouse gas coefficient. It is therefore necessary to collect these data, which can be accomplished when states complete their greenhouse gas inventories (see sec. 3.1).

  Some effort must also go into collecting data on the parametric assumptions that underlie the scenarios. States should determine and define which societal indicators—such as population growth, GDP, market penetration rate for certain technologies—significantly affect GHG activities. These key parameters will be used to make extrapolations of greenhouse gas emissions in the future.

- *Quantification of Emissions/Reductions/Sequestration.* Methods currently exist to estimate greenhouse gas emissions based on data on GHG activities (*see* EPA's *State Workbook: Methodologies for Estimating Greenhouse Gas Emissions*). States should develop methodologies to quantify the greenhouse gas reduction or sequestration associated with their set of mitigation actions.

- *Extrapolation.* States should develop a model—a quantitative means to express the relationship between the key parameters and GHG activities—that permit estimates of the level of GHG activity from a given parametric value. To forecast future levels of GHG activity, projected values of the key parameters can be input into the model. These projected parametric values may be exogenous (*i.e.* external to the model) or may be based on assumptions and algorithms incorporated within the model.

9.9 RECOMMENDATIONS AND STRATEGY FOR IMPLEMENTATION

The ultimate product of a state's analytical efforts in developing a Climate Change Action Plan is a set of policy recommendations and a strategy to implement those recommendations. The implementation strategy should clearly lay out the tasks that must be accomplished, the agencies or parties responsible for accomplishing those tasks, and a timeline for implementation.

Depending on their implementation strategy, states may organize their policy recommendations in a variety of ways. States may organize recommendations by:

- targeted sector (*e.g.* utilities, transportation, agriculture);
- fuel source (*e.g.* coal, gasoline, natural gas);
- amount of greenhouse gas reductions anticipated;
- cost of implementation; or
- governmental role (*e.g.* legislative actions, regulatory actions, voluntary actions).

States who respond to the challenge of climate change face a daunting mission, but one that is critical to the world's well-being. The scientific evidence strongly suggests that increasing the concentration of greenhouse gases will alter global climate. While the effects of global climate change are uncertain, they could be substantial. Sea-level rise could inundate many coastal areas, entire species could be threatened with extinction and ecosystems lost.

This guidance document outlines procedures and strategies that states may use to implement initiatives that not only reduce greenhouse gas emissions, but that conserve energy and enhance economic efficiency as well. Hopefully, it will help to facilitate continued collaborations among the state, local, and the federal governments and to encourage states to forge innovative, creative, locally-based approaches to risks that threaten the global commons.

GLOSSARY[1]

Aerosol: Particulate material, other than water or ice, in the atmosphere. Aerosols are important in the atmosphere as nuclei for the condensation of water droplets and ice crystals, as participants in various chemical cycles, and as absorbers and scatterers of solar radiation, thereby influencing the radiation budget of the earth-atmosphere system, which in turn influences the climate on the surface of the Earth.

Afforestation: The process of establishing a forest, especially on land not previously forested.

Anaerobic Fermentation: Fermentation that occurs under conditions where oxygen is not present. For example, methane emissions from landfills result from anaerobic fermentation of the landfilled waste.

Anthropogenic: Of, relating to, or resulting from the influence of human beings on nature.

Atmosphere: The envelope of air surrounding the Earth and bound to it by the Earth's gravitational attraction.

Biomass: The total dry organic matter or stored energy content of living organisms that is present at a specific time in a defined unit (ecosystem, crop, etc.) of the Earth's surface.

Biosphere: The portion of Earth and its atmosphere that can support life.

Carbon Sink: A pool (reservoir) that absorbs or takes up released carbon from another part of the carbon cycle. For example, if the net exchange between the biosphere and the atmosphere is toward the atmosphere, the biosphere is the source, and the atmosphere is the sink.

Carbon Dioxide (CO_2): Carbon dioxide is an abundant greenhouse gas, accounting for about 66 percent of the total contribution in 1990 of all greenhouse gases to radiative forcing. Atmospheric concentrations have risen 25% since the beginning of the Industrial Revolution. Anthropogenic source of carbon dioxide emissions include combustion of solid, liquid, and gases fuels, (e.g., coal, oil, and natural gas, respectively), deforestation, and non-energy production processes such as cement-production.

Carbon Monoxide (CO): Carbon monoxide is an odorless, invisible gas created when carbon-containing fuels are burned incompletely. Participating in various chemical reactions in the atmosphere, CO contributes to smog formation, acid rain, and the buildup of methane (CH_4). CO elevates concentrations of CH_4 and tropospheric ozone (O_3) by chemical reactions with the atmospheric constituents (i.e., the hydroxyl radical) that would otherwise assist in destroying CH_4 and O_3.

Chlorofluorocarbons (CFCs): A family of inert non-toxic and easily liquified chemicals used in refrigeration, air conditioning, packaging, and insulation or as solvents or aerosol propellants.

[1] Some of the definitions shown here are taken from the *Carbon Dioxide and Climate Glossary* produced by the Carbon Dioxide Information Analysis Center of Oak Ridge National Laboratory.

Because they are not destroyed in the lower atmosphere, they drift into the upper atmosphere where their chlorine components destroy ozone.

Climate Change: The long-term fluctuations in temperature, precipitation, wind, and all other aspects of the Earth's climate.

Deforestation: The removal of forest stands by cutting and burning to provide land for agricultural purposes, residential or industrial building sites, roads, etc. or by harvesting trees for building materials or fuel.

Enteric Fermentation: Fermentation that occurs in the intestines. For example, methane emissions produced as part of the normal digestive processes of ruminant animals is referred to as "enteric fermentation."

Flux: Rate of substance flowing into the atmosphere (e.g. $lbs/ft^2/second$).

Global Warming Potential (GWP): Gases can exert a radiative forcing both directly and indirectly: direct forcing occurs when the gas itself is a greenhouse gas; indirect forcing occurs when chemical transformation of the original gas produces a gas or gases which themselves are greenhouse gases. The concept of the Global Warming Potential has been developed for policy-makers as a measure of the possible warming effect on the surface-troposphere system arising from the emissions of each gas relative to CO_2.

Greenhouse Effect: A popular term used to describe the roles of water vapor, carbon dioxide, and other trace gases in keeping the Earth's surface warmer than it would be otherwise.

Greenhouse Gases: Those gases, such as water vapor, carbon dioxide, tropospheric ozone, nitrous oxide, and methane that are transparent to solar radiation but opaque to infrared or longwave radiation. Their action is similar to that of glass in a greenhouse.

Hydrofluorocarbons (HFCs): HFCs are substitutes for CFCs and HCFCs which are being phased-out under the *Montreal Protocol on Substances that Deplete the Ozone Layer*. HFCs may have an ozone depletion potential (ODP) of zero, however, they are very powerful greenhouse gases. For example, HFC-23 and HFC-134a have a GWPs of 10,000 and 1,200 respectively.

Methane (CH_4): Following carbon dioxide, methane is the most important greenhouse gas in terms of global contribution to radiative forcing (18 percent). Anthropogenic sources of methane include wetland rice cultivation, enteric fermentation by domestic livestock, anaerobic fermentation of organic wastes, coal mining, biomass burning, and the production, transportation, and distribution of natural gas.

Nitrous Oxide (N_2O): Nitrous oxide is responsible for about 5 percent of the total contribution in 1990 of all greenhouse gases to radiative forcing. Nitrous oxide is produced from a wide variety of biological and anthropogenic sources. Activities as diverse as the applications of nitrogen fertilizers and the consumption of fuel emit N_2O.

Nitrogen Oxides ($NO_{x)}$: One form of odd-nitrogen, denoted as NO_x is defined as the sum of two species, NO and NO_2. NO_x is created in lighting, in natural fires, in fossil-fuel combustion, and in the stratosphere from N_2O. It plays an important role in the global warming process due to its contribution to the formation of ozone (O_3).

Nonmethane Volatile Organic Compounds (NMVOCs): NMVOCs are frequently divided into methane and non-methane compounds. NMVOCs include compounds such as propane, butane, and ethane (see also discussion on Volatile Organic Compounds).

Ozone (O_3): A molecule made up of three atoms of oxygen. In the stratosphere, it occurs naturally and it provides a protective layer shielding the Earth from ultraviolet radiation and subsequent harmful health effects on humans and the environment. In the troposphere, it is a chemical oxidant and major component of photochemical smog.

Perfluorinated Carbons (PFCs): PFCs are powerful greenhouse gases that are emitted during the reduction of alumina in the primary smelting process. Eventually, PFCs are to be used as substitutes for CFCs and HCFCs. PFCs have a GWP of 5,400.

Radiative Forcing: The measure used to determine the extent to which the atmosphere is trapping heat due to emissions of greenhouse gases.

Radiatively Active Gases: Gases that absorb incoming solar radiation or outgoing infrared radiation, thus affecting the vertical temperature profile of the atmosphere. Most frequently cited as being radiatively active gases are water vapor, carbon dioxide, nitrous oxide, chlorofluorocarbons, and ozone.

Stratosphere: Region of the upper atmosphere extending from the tropopause (about 5 to 9 miles altitude) to about 30 miles.

Trace Gas: A minor constituent of the atmosphere. The most important trace gases contributing to the greenhouse effect include water vapor, carbon dioxide, ozone, methane, ammonia, nitric acid, nitrous oxide, and sulfur dioxide.

Troposphere: The inner layer of the atmosphere below about 15 km, within which there is normally a steady decrease of temperature with increasing altitude. Nearly all clouds form and weather conditions manifest themselves within this region, and its thermal structure is caused primarily by the heating of the Earth's surface by solar radiation, followed by heat transfer by turbulent mixing and convection.

Volatile Organic Compounds (VOCs): Volatile organic compounds along with nitrogen oxides are participants in atmospheric chemical and physical processes that result in the formation of ozone and other photochemical oxidants. The largest sources of reactive VOC emissions are transportation sources and industrial processes. Miscellaneous sources, primarily forest wildfires and non-industrial consumption of organic solvents, also contribute significantly to total VOC emissions.

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CLIMATE CHANGE ACTION PLANS

CLIMATE CHANGE ACTION PLAN FOR ILLINOIS

STATE OVERVIEW

Illinois completed the *Climate Change Action Plan for Illinois* in June 1994 as part two of a three-step program. During step one (development of emissions inventory), Illinois calculated the state's greenhouse gas (GHG) emissions and identified the largest sources of these emissions. The third step will be to implement the actions articulated in the state's plan.

Total emissions in 1990 were 242 million metric tons of carbon dioxide equivalent (MMTCDE). The greatest sources were fossil fuel combustion in the transportation and utility sectors with 58 MMTCDE each, and in the industrial sector with 53 MMTCDE.[1] The Action Plan for Illinois presents strategies for reducing emissions in these sectors as well as in the commercial energy and land use sectors. Strategies addressing sources with the highest emissions are shown in Table 1. Overall, the objective of Illinois' Action Plan is to reduce GHG emissions by 10 MMTCDE compared to a "business as usual" scenario, in order to reduce emissions to 1990 levels by the year 2000.

Table 1. Highest Emission Sources and Associated Mitigation Strategies

Source of Emissions	Mitigation Strategy
Transportation Fossil Fuel Combustion	CAFE (Corporate Average Fuel Economy) Standards (30, 35, and 45 mpg) Powering vehicles with gasohol, ethanol (E-100), or compressed natural gas
Utility Fossil Fuel Combustion	Natural gas switching
Industrial Sector Fossil Fuel Combustion	CO_2 scrubbers More efficient industrial motors More efficient industrial lighting

The Action Plan also identified the effects that climate change could have on Illinois. State officials are primarily concerned with potential effects on the state's agriculture, infrastructure, water resources, water and highway transportation, cooling energy, natural ecosystems, and human health.

STATE MITIGATION STRATEGIES

Illinois evaluated over 20 greenhouse gas mitigation actions for the fossil fuel and land use sectors, as well as one cross-sectoral action, as outlined in Table 2. Possible GHG reductions and associated costs are also shown in this table. The measures are summarized below.

[1] These values are from the summary of the Illinois greenhouse gas inventory.

Table 2. Greenhouse Gas Mitigation Strategies[a]

Sector	Strategy	Projected Annual Emission Reductions in year 2000 (MTCDE)	Cost of Reduction ($/MTCDE)
Fossil Fuel Combustion			
Residential	Residential A/C	130,637	-80
	New Housing Efficiency	1,769,947	-72
	Hot Water Heaters	582,422	-32
	Refrigerators	113,400	17
	Residential Furnaces	514,382	14
	Subtotal	**3,110,789**	**-47**
Commercial	Commercial A/C	136,080	-139
	Commercial Refrigeration	36,288	-37
	Commercial Lighting	518,011	13
	Subtotal	**690,379**	**-19**
Industrial	Industrial Motors	110,678	-36
	Industrial Lighting	163,296	-33
	CO_2 Scrubbers	44,772,134	33-110
	Subtotal[b]	**45,046,109**	**71**
Transportation	CAFE Standards (30 mpg)	409,147	0
	CAFE Standards (35 mpg)	1,696,464	63
	CAFE Standards (40 mpg)	2,969,266	116
	Gasohol	1,407,067	22-64
	Ethanol Vehicles (E-100)	8,364,384	30-82
	CNG Vehicles	2,489,357	51-67
	Subtotal[b]	**17,335,685**	**65**
Utility	Utility Transformers	54,432	-3
	Natural Gas Switching	21,954,240	42-57
	Subtotal[b]	**22,008,672**	**49**
Forestry	Pasture	6.85/acre	1.08
	Grazed Forest	7.65/acre	0.97
	Eroding Cropland	8.78/acre	0.76
	Subtotal	**not estimated**	**not estimated**
Cross-sectoral	Joint Implementation	**not estimated**	**not estimated**
Total		**88,191,634**	**60**

[a] Please note that the estimates in the table are given in metric tons of carbon dioxide equivalent.

[b] This subtotal was calculated based on the midpoint of the range of costs for each measure in this sector.

Fossil Fuel Combustion

Most of the measures evaluated by Illinois involve energy efficiency. Improved efficiency in the residential, commercial, transportation, and utility sectors were all estimated to offer cost savings as well as greenhouse gas reductions. Use of biofuels (gasohol and ethanol vehicles) offer possible reductions of more than 10 MMTCDE per year. The two actions with the greatest potential reductions are use of CO_2 scrubbers (45 MMTCDE) and switching from coal to natural gas for power generation (22 MMTCDE). Both of these options would require significant expenditures — costs per MTCDE are on the order of $27 to $91 for scrubbers and $34 to $47 for fuel switching.

Land Use

Afforestation is presented in the Illinois Action Plan as a low-cost, “no regrets” option that provides benefits beyond emission reductions. Tree seedlings are supplied by the state’s nursery program and planted by landowners on marginal land. The 40 year levelized cost of sequestering CO_2 in Illinois is between $0.69-0.89 per metric ton, while the CO_2 offset ranges from 6.8-8.8 metric tons/acre/year. Currently, the demand for tree seedlings exceeds the supply; expansion of the state’s nursery program could yield higher CO_2 sequestration at a very low cost.

Cross-sectoral

Joint implementation projects (i.e., projects whereby one country assists another in reducing greenhouse gas emissions through technology transfer or other means, and in return receives emission reduction credits) are presented in Illinois’ Action Plan. These projects may be more cost-effective than domestic reductions. The Action Plan provides an example of the potential benefits of joint implementation: reducing emissions in China by 18 million short tons of carbon dioxide through *cost saving* measures is compared to spending $500 million dollars annually to achieve the same reductions in Illinois.

RECOMMENDATIONS

The *Climate Change Action Plan for Illinois* recommends the following framework for the state’s policy-makers for developing a response to global climate change:

1. Make energy efficiency and forestation, which are relatively low-cost and have other environmental, social and economic benefits, the centerpiece of Illinois’ climate change policy.

2. Expand the state’s rural and urban tree planting programs and increase forest management assistance to private forest landowners.

3. Provide cost sharing and technical assistance to landowners and communities for tree planting and management.

4. Assist Illinois companies in meeting their commitments under the Climate Wise and Climate Challenge programs.

5. Partner with the federal government to implement energy efficiency programs under the U.S. Climate Change Action Plan.

6. Test joint implementation as an option for cost effective emissions reductions and, where efficient, promote the option for meeting long term emissions reduction requirements by utilities and industry.

7. Partner with the federal government to capture and use methane gas from landfills.

8. Promote research, development, and adoption of renewable fuels and biomass including ethanol fuel and soy-based fuel.

CLIMATE CHANGE ACTION PLAN FOR IOWA

STATE OVERVIEW

Iowa completed the *Iowa Greenhouse Gas Action Plan* (the Action Plan) in December 1996 as part two of a three-step program. During step one (development of emissions inventory), Iowa calculated the state's greenhouse gas (GHG) emissions and identified the largest sources of emissions. The third step will be to implement the actions specified in the state's plan.

Total GHG emissions in 1990 were 70.7 million metric tons of carbon dioxide equivalent (MMTCDE). The greatest sources were electric utilities with 25 MMTCDE, and agriculture with 15 MMTCDE.[2] The Action Plan for Iowa presents options for (1) reducing emissions from these sources (as shown in Table 1), as well as in the residential, commercial, industrial, and transportation sectors, and (2) increasing forest carbon sequestration. Overall, the objectives of Iowa's Action Plan are to reduce GHG emissions to 1990 levels by the year 2000 — which will require a reduction of 5.7 MMTCDE below projected baseline emissions, and to achieve further reductions by 2010.

Table 1. Highest Emission Sources and Associated Mitigation Strategies

Source of Emissions	Mitigation Strategy
Electric utilities	State & Federal voluntary programs for end users of electricity Growing energy crops Developing wind power Emissions trading (i.e., financing emission reductions in other sectors, or outside Iowa) Reporting facility-level GHG emissions
Agriculture	Reducing N_2O from fertilizers Improved manure management Continued improvement of farm efficiency

The Action Plan also identified the effects that climate change could have on Iowa. State officials are primarily concerned with the potential effects on the state's agriculture, water supply, and energy demand.

STATE MITIGATION STRATEGIES

Iowa has identified greenhouse gas mitigation measures for 7 sectors, as described below. The Action Plan discusses 34 options, and selects 16 as the most cost-effective and easily achievable. If the 16 options are implemented, the state projects that GHG emissions would be

[2] These values are from the summary of the Iowa greenhouse gas inventory.

reduced to 1990 levels by 2000.[3] The GHG reductions expected from each option are shown in Table 2.

Fossil Fuel Combustion

Residential

State and Federal programs: Residential energy efficiency options include (1) ongoing energy efficiency education programs for builders and building officials to improve compliance with requirements to construct new homes in conformance with the Model Energy Code (MEC), and (2) using Iowa's Home Energy Rating System (HERS) to indicate which homes merit energy efficient mortgages (EEMs).

Transportation

Improve vehicle fleet efficiency: The emission reduction estimates in this sector rely on implementing a revenue-neutral rebate system whereby there is a rebate for vehicles with a relatively high fuel efficiency and a fee for those that achieve fewer miles per gallon.

Discourage single occupancy trips: Options include cashing out employer provided parking in urban areas, and promoting transit use and telecommuting.The emission reduction estimates in this sector rely on implementing a revenue-neutral rebate system whereby there is a rebate for vehicles with a relatively high fuel efficiency and a fee for those that achieve fewer miles per gallon.

Commercial

State and Federal energy efficiency measures: Several programs are in force or are to be implemented in Iowa. These programs, described below, include (1)Rebuild Iowa, (2) Building Energy Management Programs (includes Iowa Energy Bank program and the Iowa Facilities Improvement Corporation), (3) Energy Star Buildings, and (4) Green Lights.

(1) The Rebuild Iowa program is an opportunity for communities to invest in cost-effective energy improvements in their schools, hospitals, local governments, colleges, commercial and industrial facilities, and multi-family dwellings. At present, with the help of a federal grant, five communities have been selected to participate in the program. As buildings become more efficient through the program, they will serve as examples for managers of similar facilities in other communities.

(2) The Building Energy Management Program provides advice, and helps identify and finance the installation of energy improvement measures for state facilities, schools, hospitals, private colleges, and local governments. Financing is structured so that energy savings cover the cost of lease or loan payments for the measures, and the payback is six years or less.

(3) Energy Star Buildings is a federal program designed to improve efficiency in heating, cooling, and air handling equipment.

(4) Green Lights, another federal program, promotes efficiency in facility lighting.

[3] The Action Plan also specifies the maximum feasible extent to which these policy options could be implemented. At the maximum feasible levels, additional GHG reductions of 19 MMTCDE would be achieved by 2010.

Table 2. Greenhouse Gas Mitigation Strategies

Sector	Strategy/Action	Annual Emissions Reductions (MTCDE) in 2010 (Priority Options)	Cost Per MTCDE
Fossil Fuel Combustion			
Residential	Improved Efficiency Measures		
	State and Federal voluntary programs	610,000	not estimated
	Sub-total	**610,000**	
Industrial & Commercial			
	Improved Efficiency Measures		
	State voluntary programs	70,000	not estimated
	Federal voluntary programs	1,900,000	not estimated
	Emissions Trading	1,810,000	not estimated
	Reporting Facility GHG Emissions	1,270,000	not estimated
	Sub-total	**5,050,000**	
Transportation			
	Improved Efficiency Measures		
	Revenue neutral fee/rebate	2,630,000	not estimated
	Economic Incentives		
	Discourage single occupancy trips	160,000	not estimated
	Sub-total	**2,790,000**	
Electricity Generation			
	Improved Efficiency Measures		
	Demand side management	180,000	not estimated
	Production of energy crops	80,000	not estimated
	Wind power development	250,000	not estimated
	Emissions trading	1,810,000	not estimated
	Reporting Facility GHG Emissions	1,270,000	not estimated
	Sub-total	**3,590,000**	not estimated
Forestry			
	Tree Planting Program	2,450,000	not estimated
	Sub-total	**2,450,000**	not estimated
Agriculture			
	Reducing N_2O from Fertilizers	360,000	cost savings
	Improved Manure Management	90,000	not estimated
	Continued Improvement of farm efficiency	90,000	not estimated
	Sub-total	**540,000**	not estimated
TOTAL		**15 million**	**Annual cost saving of $300 million**

Please note that the estimates in the table are given in metric tons of carbon dioxide equivalent (MTCDE).

Industrial

State and Federal energy efficiency measures : Voluntary programs that are currently in place include (1) Climate Wise, (2) Total Assessment Audit (TAA), and (3) Motor Challenge. These programs are explained in turn:

(1) The Climate Wise program provides information and assistance on a range of emission reduction opportunities. Companies are encouraged to reduce emissions by measures such as altering production processes, switching to lower carbon content fuels and renewable energy, implementing employee mass transit, and tracking energy use for efficiency improvements.

(2)The TAA works in conjunction with the Climate Wise Program by analyzing waste and productivity operations. The audits help firms enhance their competitive position and improve their economic success.

(3) Motor Challenge promotes energy efficient electric motor systems; motor systems account for 75 percent of the electricity used in industry. The aims of the program are to increase the use of efficient motors and drive systems, improve industrial competitiveness and productivity, save energy, and decrease industrial waste and pollution.

Electricity Generation (Wind Power, Demand Side Management, and Production of Energy Crops)

Wind Power: Iowa has good potential for wind power, but at present it is not cost-effective compared to conventional energy sources, because coal fired power plants can produce electricity at less than $0.02/kW-hr. A state program developed under the 1991 Energy Efficiency Act requires utilities to purchase 105 megawatts (MW) of alternate-energy which will be provided by wind power or other sources. The Iowa Utilities Board has given investor-owned utilities a 1997 deadline for meeting this goal; the Action Plan anticipates that wind power will supply the majority of this energy supply.

Demand Side Management: Utilities are investing millions of dollars in programs to improve their customers' energy efficiency; these programs will continue and may expand by the year 2010. Spending on energy efficiency programs by Iowa utilities topped $76 million in 1994. Outreach efforts targeted 226,000 residential and business customers and encouraged improved lighting efficiency and installation of more efficient heating, ventilation, and air conditioning (HVAC) equipment.

Production of Energy Crops: Programs are underway to determine the feasibility of growing switchgrass in Iowa as a renewable biofuel that would also sequester carbon dioxide. One study has indicated that co-firing switchgrass with coal would be the most practical and economical way to establish a biomass energy industry. It further projected that with relatively low cost modifications at an existing utility, a biomass capacity of 35 MW could be achieved. This would require an estimated 200,000 tons of biomass annually.

Cross-sectoral (Commercial, Industrial and Electricity Generation)

Emissions Trading: A global, national, or regional CO_2 trading system could be used effectively to reduce overall GHG emissions while making pollution control a less expensive effort. Iowa estimated its emission reduction potential on the basis of a system similar to the sulfur dioxide allowance system in which allowances are allocated to each emitter based on their baseline CO_2 emissions.

CO_2 Emission Inventory: Under this strategy, a reporting system is proposed for greenhouse gas emissions. Like the 1986 Toxic Release Inventory (TRI) reporting program, the top ten emitters of GHGs within the state would be published. The state hopes that, as in the case of the TRI, most industries would take actions to reduce emissions to get their facilities off the list and to improve public relations. Because the program could only be implemented a few years prior to 2000, annual reductions of only 1 percent have been estimated for this strategy in the industrial and utility sectors.

Agriculture (Fertilizer Use, Manure Management, and Improvement of Farm Energy Efficiency)

Reducing N_2O from Fertilizers: A number of programs have been in effect in Iowa since 1982 to improve nitrogen management on Iowa farms. The programs include the Big Spring Demonstration project, the Integrated Farm Management Demonstration Project, the Integrated Crop Management Project, and the Model Farms Demonstration project. The education programs were funded by oil overcharge revenues at a cost of $26 million, with savings to farmers of $363 million.

Improved Manure Management: Iowa has the largest number of hogs of any state (14 million). Under the priority option, state legislation would require large producers (those with more than 5,000 animals) to have methane capture facilities by the year 2000.This will reduce emissions by 0.02 MMTCDE per year after the year 2000.

Continued Improvement of Farm Energy Efficiency: Total farm energy consumption in 1989 was only 60 percent of 1975 consumption, despite little change in acreage farmed. For this strategy it is assumed that further efficiency gains will be made, without the need for state action.

Forestry

Tree Planting Program: As a priority option, a total of 200,000 acres should be reforested with poplar and native trees by the year 2015. This would be accomplished by voluntary efforts, “free-trees” programs, Conservation Reserve Program conversion to permanent forest land, and land purchases.

RECOMMENDATIONS

The options summarized in the Action Plan are largely voluntary in nature and many have already been underway for several years. To help implement additional options that are not currently underway, the Iowa Greenhouse Gas Action Plan also recommends actions at the federal level. These are:

- Beyond adopting public policies that directly affect those within its borders, Iowa can work with other states to influence the adoption of federal policies to conserve energy and reduce CO_2 emissions.
- Emissions trading is a difficult program for Iowa to enact alone. Rather, the state should encourage the federal government to adopt an innovative CO_2 emission allowance system

that would reduce CO_2 emissions equitably and efficiently.

CLIMATE CHANGE ACTION PLAN FOR OREGON

STATE OVERVIEW

Oregon completed the *Report on Reducing Oregon's Greenhouse Gas Emissions* (the Action Plan) in March 1995, as part two of a three-step program. During step one (development of emissions inventory), Oregon calculated the state's greenhouse gas (GHG) emissions and identified the largest sources of emissions. The third step will be to implement the actions specified in the state's plan. The Action Plan describes Oregon's strategy, which consists of near-term actions (i.e., a five year action plan) and longer term actions, as well as a scenario of what it might take to stabilize Oregon's greenhouse gas emissions at 1990 levels. This scenario is presented in Appendix A of the Action Plan, and is summarized at the end of this Action Plan summary. The Oregon Department Of Energy (ODOE) does not propose that Oregon stabilize GHG emissions, because of the economic losses the state would incur in doing so. Nonetheless, the Action Plan evaluates the type and magnitude of measures required to meet a stabilization goal.

Total GHG emissions in 1990 were 56 million metric tons of carbon dioxide equivalent (MMTCDE). The greatest sources were fossil fuel combustion for transportation with 20 million MMTCDE, and electric utilities with 16 MMTCDE.[4] Oregon's strategy presents options for (1) reducing emissions from these sectors (as shown in Table 1), (2) reducing emissions from fossil fuel combustion in the residential, commercial, and industrial sectors, (3) reducing emissions from solid waste management, and (4) increasing forest carbon sequestration. Oregon predicts that its GHG strategy will reduce GHG emissions by "at least 2 million tons" (presumably, 2 million short tons of carbon dioxide equivalent) in 2015, compared to a "business as usual" scenario.

Table 1. Highest Emission Sources and Associated Mitigation Strategies

Source of Emissions	**Mitigation Strategy**
Transportation	Implement the Oregon Transportation Plan (including telecommuting)
Electric utilities	Consider GHG emissions in integrated resource plans. Find new ways to fund and achieve energy efficiency.

The Action Plan also identified the effects that climate change could have on Oregon. State officials are primarily concerned with the potential effects of sea-level rise on Oregon's coast.

STATE MITIGATION STRATEGIES

Oregon has identified greenhouse gas mitigation strategies for six sectors, as described below. The Action Plan does not project the GHG reductions that will be achieved by each strategy, nor the cost of the various strategies.

[4] These values are from the summary of the Oregon greenhouse gas inventory.

Residential

If extended, the Residential Tax Credit program will continue to provide loans, rebates and tax credits to households to fund energy effficiency improvements, while the Home Oil Weatherization Program will continue to fund home weatherization. In addition, the Oregon Department Of Energy (ODOE) (1) has developed standards for homes and appliances; (2) provides technical information to consumers on ways to save energy; and (3) supports pricing strategies and environmental costing policies that signal to consumers the need to conserve energy and reduce GHG emissions.

Industrial and Commercial

The ODOE has a range of energy efficiency programs for this sector, including (1) codes and standards for appliances, (2) training for building operators to run their equipment efficiently, and (3) demonstration projects for new energy saving technologies. The Oregon Resource Efficiency and Waste Prevention Program helps businesses, schools, industry, and cities use energy efficiency measures to save money and reduce GHG emissions. The program helps reduce costs by proposing ways to increase energy efficiency and decrease the production of solid waste. The state also provides incentives for the recycling of waste.

Transportation

The five year action plan calls for implementing the Oregon Transportation Plan (OTP), which would result in construction of more bike lanes and walkways. However, additional sources of state, federal, and local funding will be needed to implement this plan. As part of the OTP and in harmony with the state's "20 x 2000" executive order (which directs Oregon state government to reduce its energy use in facilities and transportation 20 percent by 2000), the ODOE is also collaborating with public and private employers to implement telecommuting; particularly in the Portland area, to meet federal air quality standards. The Business Energy Tax Credit program offers an incentive for purchasing telecommuting equipment.

The Plan also calls for the Oregon Department Of Transportation (ODOT) to develop an integrated management system that guarantees compatibility of intermodal facilities and systems. For example, it calls for rail mainlines to have convenient ramp, terminal, and reload facilities for transfers from truck to rail for longhaul movement of freight.

In addition to the OTP, the Action Plan suggests educational efforts to inform state residents about ways to save fuel when maintaining and operating their cars and trucks. The Action Plan also calls for study of the potential for encouraging the purchase of efficient cars and trucks through market-based incentives.

Utility

The Oregon Public Utility Commission requires utilities to consider CO_2 emissions as they design their integrated resource plans. Oregon recognizes that the most efficient way to limit damage is to ensure that prices signal the full costs of energy. The state continues to seek ways to incorporate environmental consequences into energy decisions. As a result of electric utility deregulation, it is hard for utilities to finance efficiency measures; because of this, the Action Plan calls for finding new ways to fund energy efficiency.

Forestry

The Oregon Forest Resources Trust (FRT), administered by the Oregon Department of Forestry, aims to plant trees in 250,000 acres of damaged, non-productive and under-productive forest lands over 15 years. Within the next five years, the state plans to fulfill a substantial portion of the goals of the FRT. The state makes low interest loans to private, non-industrial landowners for initial reforestation and rehabilitation costs. The landowners then repay the loans by paying a percentage of the after-tax receipts when they harvest the timber.

Municipal (Recycling and Solid Waste Management)

The five year action plan seeks to implement the Oregon State Integrated Resource and Solid Waste Management Plan. The solid waste plan calls for a continuous decrease in per-capita solid waste disposal, and for using recycled materials in production and manufacturing. It has a goal of a 50 percent recovery rate. As an incentive, the State's Business Energy Tax Credit program offers a 35% tax credit for purchasing equipment to recycle materials and to incorporate recycled materials into new products. By reducing the amount of waste that goes into landfills and capturing or flaring landfill gases, methane emissions from landfills will be reduced by 0.04 million tons by 2015 (beyond the reductions from the capture or flaring of methane from large landfills due to EPA's landfill gas regulation).

Cross-sectoral

Additional aims of the five year action plan include helping the Portland metropolitan area achieve the goals of its CO_2 reduction strategy. The Action Plan also calls for research on (1) the effects of climate change on water, fisheries, agricultural and forestry resources; (2) sea level rise on Oregon's coast; and (3) climate change adaptation and mitigation.

Recommendations

The five year action plan includes existing plans and regulations that are in the early stages of implementation as well as supplementary actions that could be implemented in the near term. Because of the scope of the changes and the economic consequences for a state acting alone, ODOE does not recommend actions that would stabilize emissions. In particular, ODOE found no way to achieve sufficient reductions from transportation emissions through state actions alone. Also, the state could not find a way to meet new demand in the electricity sector solely with energy efficiency and renewable energy.

In light of this, the Action Plan suggests that the following national actions should be implemented:

- Focus federal research and development, standards, incentives, collaborations, and promotion activities to give priority to reducing greenhouse gas emissions, and use pricing mechanisms to incorporate climate change externalities into the marketplace.

- Take leadership in areas where the federal government has pre-empted the states from acting (e.g., vehicle and appliance efficiency standards). Leadership would involve (1) setting standards, (2) sponsoring collaborative efforts with industry, states and other parties, and (3) achieving significant advances in research and development.

- Institute pricing mechanisms such as a carbon tax or tradable permits for carbon emissions, which would be most effective as part of a national, and probably international, effort.
- Institute a national gas-guzzler fee / gas-sipper rebate ("feebate") program. This would be an incentive to consumers to purchase efficient vehicles, and a disincentive to purchase inefficient ones. A national program could have a greater impact than a state program in that it could influence manufacturers to provide more choices for efficient vehicles.

- Support research, development, and demonstration (RD&D) of new renewable resource technologies and efficient energy conversion technologies such as fuel cells, and re-direct RD&D funds away from fossil fuels and nuclear power and toward renewable resources and efficient technologies.

- Collaborate with other stakeholders to develop an overall appliance and equipment efficiency strategy to link new standards to RD&D and commercialization efforts.

- Revise alternative fuels policy for vehicles, to develop and promote only those fuels that reduce greenhouses gas emissions.

Additional strategies, beyond those specified in Oregon's Climate Change Strategy, that would need to be implemented to stabilize GHG emissions in Oregon include the following:

<u>Pay-as-you-drive insurance</u> - This would involve charging an extra 50 cents per gallon of gasoline for insurance, instead of the driver paying monthly or annually. Ideally this would have to be a federal program so that people living near the state border did not have an incentive to buy fuel in other states.

<u>Corporate Average Fuel Economy standards (CAFE)</u> The GHG reductions projected for this measure assume that cars achieve 50 miles per gallon (MPG) by 2015 and light trucks 40 MPG. At present the federal government forbids states from setting energy efficiency standards. The current federal CAFE standard for cars is 27.5 MPG and for light trucks is 20.5 MPG.

<u>Feebates</u> - This is a cash incentive for consumers of efficient vehicles, combined with a surcharge to discourage consumers from buying inefficient vehicles.

<u>Better tires</u> - Driving with under-inflated tires increases fuel consumption and makes the tires wear out faster. The Action Plan relies on the US Department of Transportation to establish tire standards. An education campaign could also alert the public to the potential savings.

<u>Electric cars</u> - The scenario forecasts the potential CO_2 emission reductions from having up to 15% of new car purchases being electric cars by 2010. It further assumes that the increase in electric load will be met by renewable-based generation.

<u>Gasohol</u> - As an alternative fuel, the scenario assumes that low CO_2 gasohol will provide 20% of the gasoline market by 2000, increasing to 65% by 2010. It also assumes that gasohol will only be used in the winter months because of air quality concerns about using it in the summer.

Non-transportation petroleum fuels efficiencies - efficiency measures for commercial and industrial equipment, such as improved operations and maintenance, and boiler efficiency improvements, could reduce CO_2 emissions from such equipment by 10 percent.

SUMMARY OF APPENDIX A OF OREGON'S CLIMATE CHANGE ACTION PLAN

Hypothetical Greenhouse Gas Mitigation Strategies and Associated Emission Reductions in 2000 and 2010 (for Oregon's Stabilization Scenario)

Sector	Strategy / action	Potential annual emission reductions (MTCDE) in 2000	Potential annual emission reductions (MTCDE) in 2010
Residential	**Subtotal**	**-**	**-**
Commercial	**Subtotal**	**0**	**0**
Industrial	Improved efficiency measures		
	non-transportation petroleum efficiencies	97,070	317,520
	natural gas efficiencies	199,584	654,998
	Improved industrial processes		
	Inert anodes for alumina reduction	0	73,483
	Subtotal	**296,654**	**1,046,001**
Transportation	Improved efficiency measures		
	Freight hauling efficiency improvements	229,522	554,299
	Fuel switching		
	Cellulose and waste biomass based gasoh	213,192	509,393
	New regulations		
	Oregon transportation plan	0	684,936
	Economic incentives		
	Pay-as-you-drive insurance, High MPG cars and light trucks (CAFE), Feebates, better tires & electric cars.	1,075,939	4,093,286
	Subtotal	**1,518,653**	**5,841,914**
Electricity generation	Renewables / nuclear		
	Renewable resources and energy efficiency	233,150	2,747,909
	Subtotal	**233,150**	**2,747,909**
Forestry	Tree planting program		
	Forest Trust resources timber offsets	54,432	296,654
	Additional In state timber offsets	0	766,584
	Subtotal	**54,432**	**1,063,238**
Agriculture	***Subtotal***	**0**	**0**
Municipal	***Subtotal***	**-**	**-**
Cross - sectoral	***Subtotal***	**-**	**-**
TOTAL		2,102,890	10,114,243

Please note that the estimates in the table are given in metric tons of carbon dioxide equivalent. No cost data are provided in Oregon's Action Plan.

A dash indicates that the data are not available. Oregon also provides emission reduction estimates for 2005 and 2015*.*

Timber offsets - the stabilization plan reflects an additional 400,000 acres of Douglas fir and 350,000 acres of ponderosa pine. The cost would be about $25 - $45 per ton of carbon sequestered.

Inert anodes for alumina reduction - Technology is available to reduce perfluorocarbon emissions in the aluminum industry by 30 to 60 percent. Using an inert anode would reduce both carbon and perfluorocarbon emissions. The US Department of Energy and EPA are supporting research in this area.

Natural gas efficiencies - the stabilization scenario reflects a decrease in natural gas consumption of 10 percent as a result of new equipment standards and better design of equipment for space conditioning, water heating, cooking and commercial and industrial processes. The reductions could be greater if the federal government introduced more stringent standards for new furnaces and water heaters.

Freight hauling - reductions in diesel fuel emissions could be achieved by more aerodynamic designs; improved tires, transmissions, and engines; electronic engine controls; scheduling improvements; and reductions in empty back hauling. The stabilization scenario assumes that diesel is used mostly for freight hauling by truck and train, and that there would be a 10 percent reduction in GHG emissions as a result of the above measures.

Even with all these measures in force, Oregon would still have excess CO_2 emissions of 5 million tons above the target in 2000, and excess CO_2 emissions of 2.6 million tons in 2015. To achieve these additional GHG reductions, Oregon states that a national carbon tax or tradable emission allowances would be needed.

CLIMATE CHANGE ACTION PLAN FOR PENNSYLVANIA

STATE OVERVIEW

Pennsylvania completed *Phase II of the Greenhouse Gas Inventory: Reducing Pennsylvania's Anthropogenic Greenhouse Gas Emissions* (the Action Plan) in January 1995 as the second phase of a three-phase program. During step one (development of an emissions inventory), Pennsylvania calculated the state's greenhouse gas (GHG) emissions and identified the largest sources of these emissions. The third step will be to implement the actions specified in the state's plan.

Total GHG emissions in 1990 were 278 million metric tons of carbon dioxide equivalent (MMTCDE). The greatest sources of emissions were fossil fuel combustion in (1) the utility sector with 89 MMTCDE, (2) the industrial sector with 62 MMTCDE, and (3) the transportation sector with 57 MMTCDE.[5] The Action Plan for Pennsylvania presents strategies for reducing emissions from these sources as well as from commercial and residential fossil fuel combustion, mining and extraction, landfills, agriculture, and land use. Strategies addressing two of Pennsylvania's three highest emission sources are shown in Table 1. Overall, the objective of the Action Plan is to reduce GHG emissions "through viable mechanisms that do not inhibit the state's economy." The Pennsylvania Energy Office (PEO) did not set a target emissions level in the Action Plan, nor a target date for implementing the plan. The Action Plan does not address the effects that climate change could have on the state.

Table 1. Highest Emission Sources and Associated Mitigation Strategies

Source of Emissions	Mitigation Strategy
Utility Fossil Fuel Combustion	Clean Coal Projects Demand Side Management
Transportation Fossil Fuel Combustion	Employer Trip Reduction Enhanced Vehicle Inspection and Maintenance Program

STATE MITIGATION STRATEGIES

Pennsylvania identified more than 15 GHG mitigation strategies in the areas of fossil fuel combustion, mining and extraction, landfills, agriculture, and land use sectors, as well as five cross-sectoral actions, as outlined in Table 2. The plan identified programs currently in place as well as proposed actions to further reduce GHG emissions. The Action Plan does not provide specific emission reduction potentials for most actions, nor does it estimate costs for individual actions. The GHG reduction measures are summarized below.

[5] These values are from the summary of the Pennsylvania greenhouse gas inventory.

Table 2. Greenhouse Gas Mitigation Strategies

Sector	Strategy	Projected Annual Emission Reductions in 2010 (MTCDE)
Fossil Fuel Combustion		
Residential	Building Energy Conservation Act	not estimated
	Community Action and Resources for Energy Savings	not estimated
	Subtotal	**not estimated**
Commercial	Green Lights Program	not estimated
	Building Energy Conservation Act	not estimated
	Subtotal	**not estimated**
Transportation	Enhanced Vehicle Inspection and Maintenance Program	not estimated
	Employer Trip Reduction	not estimated
	Subtotal	**not estimated**
Utility	Clean Coal Projects	not estimated
	Demand Side Management	2,721,600
	Subtotal	**not estimated**
Mining/Extraction	Coalbed Methane Recovery and Use	**not estimated**
Landfills	Landfill Gas Recovery	not estimated
	Grants for Landfill Gas Capture	not estimated
	Subtotal	**not estimated**
Agriculture	Nutrient Management Program	not estimated
	Deep-Pit Manure Systems	not estimated
	Information Dissemination	not estimated
	Subtotal	**not estimated**
Land Use	Cool Communities	not estimated
	Stabilization of Forest Lands	not estimated
	Subtotal	**not estimated**
Cross-Sectoral	State Agency Task Force	not estimated
	PEO Partnerships	not estimated
	PEO Educational Outreach	not estimated
	Grant Programs	not estimated
	Extension of Cool Communities Program (outreach to local officials)	not estimated
	Subtotal	**not estimated**
Total		**not estimated**

Fossil Fuel Combustion

Residential

Building Energy Conservation Act (BECA) - Pennsylvania enacted BECA, Pennsylvania's Act 222, to require that design and construction of new residential buildings meet minimum energy conservation standards. This also applies to additions and renovations to existing buildings.

Community Action and Resources for Energy Savings (CARES) - Project CARES is designed to implement various energy efficiency measures in specific communities. One such activity involved weatherization improvements in a low to moderate income apartment complex.

Commercial

Green Lights Program - PEO encourages small businesses to participate in EPA's ongoing *Green Lights* Program, which promotes energy efficiency in lighting.

Building Energy Conservation Act (BECA) - BECA, described above for the residential sector, also applies to commercial buildings.

Transportation

Enhanced Vehicle Inspection and Maintenance Program - This program requires automobiles to operate at "standardized efficiencies" that reduce emissions.

Employer Trip Reduction Program - This program reduces the number of vehicles traveling to and from employment sites by promoting measures such as "high occupancy vehicles, enhanced transit services, and improved parking management measures for companies [with more than 100 employees] in areas of severe ozone nonattainment." In addition, "each large employer in the five-county area around Philadelphia is required to achieve a commuting employee passenger occupancy of approximately 25% more than that of the area-wide average occupancy per commuting vehicle."

Utility

Clean Coal Projects - The Pennsylvania Energy Authority has designated nearly $13 million dollars for research projects focused on environmental enhancement, energy efficiency, and conservation. To date, 58 Clean Coal Projects have been supported.

Demand Side Management Plans - These plans will evolve into programs that prevent emissions of carbon dioxide by over 2.7 MMTCDE per year by 2010. All Pennsylvania utilities are required to submit demand side management plans to the Pennsylvania Public Utility Commission.

Mining/Extraction

Coalbed Methane Recovery and Use - The plan proposes that PEO and the Department of Environmental Quality should work collaboratively to implement a program to encourage the capture and use of coalbed methane.

Landfills

Landfill Gas Recovery - Seven of the landfills in Pennsylvania are already recovering landfill methane or are planning to do so. The PEO and the Department of Environmental Regulation (DER) participate in EPA's Landfill Methane Outreach Program as State Allies.

Grants for Landfill Gas Capture - The Pennsylvania Economic Development Financing Authority (PEDFA) makes low-interest loans for landfill gas recovery projects. PEDFA makes loans for up to 100% of project costs, at 75 percent of the prime interest rate, for a term of up to 30 years.

Agriculture: Manure Management

Nutrient Management Program - the Department of Agriculture operates a Nutrient Management Program that provides information to farmers and others, and sponsors programs on issues such as alternative uses for manure.

Deep-Pit Manure Systems - The Pennsylvania Department of Agriculture and the Pennsylvania Department of Environmental Resources are actively pursuing the enhancement of deep-pit manure systems to collect methane for use in near-site electricity generation.

Information Dissemination - The plan proposes that the PEO and the Department of Agriculture should provide farmers with information about energy-efficient sustainable farming practices.

Land Use

Cool Communities - This program, organized by PEO and the DER, creates local partnerships to reduce the urban heat island effect through strategic tree planting and surface color lightening.

Forest Lands - Pennsylvania forest growth exceeds harvests; as a result, the state's 17,000,000 acres of forest lands sequester approximately 141 MMTCDE a year.

Cross-sectoral

State Agency Task Force - Pennsylvania established a task force of state agencies (PEO, Public Utilities Commission, Department of Agriculture, Department of Transportation, and Department of Commerce) to formulate state policies to reduce greenhouse gas emissions.

PEO Partnerships - PEO will continue to engage in partnerships with private sector firms and local governments to establish energy conservation practices and promote the use of alternative sources of energy.

PEO Educational Outreach Programs - The plan proposes that the PEO should perform more education and outreach activities in order to make state residents more energy- and environmentally-literate. PEO staff have met with various interest groups, including the Council of Boroughs, to make progress towards achieving this goal.

Grant Programs - Pennsylvania has a number of grant programs that could reduce the emissions of greenhouse gases. These programs include the Energy and Environmental Grants Program, the Recycling Grants Program, and the Alternative Fuels Program.

Expansion of the Cool Communities Program - The plan proposes an expansion of the Cool Communities program to include an educational and technical assistance program for local officials and also an improved training program for urban foresters.

RECOMMENDATIONS

The Pennsylvania Action Plan suggests future actions concentrated on education and technical assistance, the adoption of environmentally sound technologies, and the establishment of a cooperative public-private approach to addressing GHG emissions. These recommendations, taken verbatim from the Action Plan, are listed below:

1. Community Action Programs, consisting of direct technical assistance, public information programs, and the development of tailored energy and environmental programs, have been proposed. These multi-phased community energy efficiency programs would focus the attention of local leaders on the greenhouse gas issue and provide these leaders with information and assistance on energy and environmental issues.

2. Expansion of the Cool Communities Program to include an educational and technical assistance program for local officials and also an enhanced training program for urban foresters. This enhanced training in cool community concepts will better equip urban foresters to provide on-site assistance to communities interested in implementing the program.

3. As an extension of the Cool Communities Program, the Commonwealth should organize and implement a program of outreach and technical assistance to local governments in the area of energy efficiency. This type of program could be developed by the PEO and delivered to local governments through existing training and outreach services conducted by the Pennsylvania Department of Community Affairs.

4. The PEO and the DER should work together to implement a program to facilitate the capture and use of coalbed methane. Such a program could be modeled after the Landfill Gas Outreach Program. A potential mechanism for this program may involve the DER which, through its Bureau of Oil and Gas Management, has held a series of meetings to pursue a coalbed methane program.

5. The Commonwealth, through the PEO and the Department of Agriculture, should expand information to farmers about sustainable farming practices which not only are energy efficient, but which are also beneficial to the local environment. This could be accomplished through the use of existing mechanisms such as the Nutrient Management Program. This could also include developing a joint strategy to develop cost effective designs for small scale on-farm digesters that would collect methane and turn it into a usable energy source for the farm. A mechanism of this could be financial assistance for the design of such systems offered through the Commonwealth programs, such as the Agricultural Technology Loan program in the Department of Agriculture or from other sources, such as the Center for Rural Development. In addition, the Department of Agriculture, in conjunction with the PEO, should develop Pennsylvania’s electrofarming potential through use of crops like C-4 switchgrass.

CLIMATE CHANGE ACTION PLAN FOR WASHINGTON STATE

STATE OVERVIEW

Washington State completed the *Greenhouse Gas Mitigation Options for Washington State* (the Action Plan) in April 1996 as part two of a three-step program. During step one (development of emissions inventory), Washington calculated the state's greenhouse gas (GHG) emissions and identified the largest sources of emissions. The third step will be to implement the actions specified in the state's plan.

Total GHG emissions in 1990 were 61 million metric tons of carbon dioxide equivalent (MMTCDE).[6] The greatest sources were fossil fuel combustion for transportation with 42 MMTCDE; land use (especially forest changes including land conversion and slash burns) with 38.1 MMTCDE;[7] and industrial processes (especially aluminum production) with 6 MMTCDE. The Action Plan presents strategies for reducing emissions from these sources as well as from fossil fuel combustion in the residential, commercial, and utility sectors. Strategies addressing sectors with the highest emissions are shown in Table 1. In order to reach the goal of returning GHG emissions to 1990 levels, Washington would need to reduce emissions by 16.3 MMTCDE by the year 2010 (the target year for the Action Plan), in comparison with emissions under a "business as usual" scenario.

Table 1. Highest Emission Sources and Associated Mitigation Strategies

Source of Emissions	Mitigation Strategy
Fossil Fuel Combustion for Transportation	Increased Parking Fees Tire Pressure Check Gasoline Tax Feebate More Efficient Airplane Engines
Land Use: Forest Changes	Afforestation
Industrial Processes: Aluminum Production	Aluminum Manufacturing Process Improvements

The Action Plan also identified the effects that climate change could have on Washington. State officials are primarily concerned with potential effects of sea-level rise, especially for the central-south Puget Sound and central coastal areas.

STATE MITIGATION STRATEGIES

Washington evaluated more than 35 GHG mitigation strategies for fossil fuel combustion, industrial processing, and land use sectors, as outlined in Table 2. It should be noted that the potential programs identified in this report did not undergo highly detailed review and the

[6] This value is from the summary of the Washington greenhouse gas inventory.
[7] These land use emissions are offset by 46.4 MMTCDE sequestered through Washington's net annual forest growth.

estimated emission reductions and costs only identify the most promising programs. Flexibility, economic efficiency, and feasibility were considered in determining promising programs. One of the criteria for selecting mitigation strategies was cost-effectiveness: actions with costs higher than $100 per metric ton of GHG controlled were rejected. The GHG reductions expected from each strategy, and associated costs, are shown in Table 2. It is very important to note that in terms of greenhouse gas emissions, there is often overlap between sectors. For example, little is gained from reduced residential electricity use if the electricity displaced is from a renewable resource. Therefore, the emission reduction estimates presented herein can not be added across sectors. Washington's GHG strategies are summarized below.

Fossil Fuel Combustion

Residential

Existing Home Retrofits: Potentially, large reductions of GHG emissions may result from efficiency measures, conservation, and fuel switching in existing homes. Washington has a large inventory of homes built before 1970 which lack adequate insulation. These homes provide a great opportunity for energy savings; it is cost effective to retrofit insulation in the ceiling and crawl space to an R-19 level and in exterior walls to an R-11 level. Other possibilities for reductions include: converting to electric space and/or water heating to natural gas, installing low-flow shower heads, and installing compact fluorescent light bulbs. A program aimed at replacing incandescent bulbs with fluorescent bulbs could result in as much as a 130 megawatt reduction in the state's average electricity demand.

New Building Practices: Upgrading the residential energy codes to class 35 windows (e.g., windows with an insulation value of U-3.5) for new construction is one cost-effective option to reduce GHG emissions through energy conservation, because the energy savings exceed the cost of the upgraded windows. In addition, emission reductions can be obtained through upgrading the residential energy codes for insulation used in new construction (see Table 2).

Commercial

Food Refrigeration Efficiency Improvements: Several measures for commercial food refrigeration systems offer large energy savings. For example, multiple compressors in parallel reduce energy use 13 to 27 percent, and glass doors for supermarket display cases lower energy use 30 to 60 percent.

Fluorescent Lighting Retrofits: Implementing commercially available lighting technologies could lower lighting electrical use by 40 percent. Potential efficiency improvements include: fluorescent lamps, ballasts, lighting fixtures, and lighting control switches.

Improvements for Public Buildings: There is the potential for improving the energy efficiency of many public buildings, such as schools, recreational facilities, prisons, etc. Conservation measures would include lighting (e.g., controls that reduce hours of operation), heating, ventilating and air conditioning systems (e.g., improved controls and operation), building envelopes (higher insulating windows), and improved appliances (e.g., low-flow faucets).

Transportation

More Efficient Airplane Engines: Commercial jet fuel is one of the fastest growing areas of fossil fuel consumption. Between 1990 and 2010 consumption in Washington is projected to almost double and carbon dioxide emissions are estimated at over 17.2 MMTCDE. The *Ultrahigh* bypass high-efficiency, unducted fan engine is one way to reduce these emissions.

Table 2. Greenhouse Gas Mitigation Strategies[a]

Sector	Strategy/Action	Potential Annual Emission Reductions (MTCDE) in 2010	Cost per MTCDE
Fossil Fuel			
Residential	Existing Home Retrofits		
	Install Fluorescent Lighting	417,312	not estimated
	Hot Water Tank Upgrade	3,629	$3
	Direct Use of Natural Gas	226,800	cost savings
	R-19 Attic Insulation, Electrically Heated Homes	189,605	cost savings
	R-11 Wall Insulation	102,514	cost savings
	R-19 Floor Insulation for Natural Gas Homes	105,000	cost savings
	R-30 Attic Insulation for Natural Gas Homes	13,608	cost savings
	Low Flow Shower Heads	6,350	cost savings
	R-11 Duct Insulation for Natural Gas Homes	9,979	$18
	Caulking Joints in Natural Gas Homes	4,536	$3
	New Building Practices		
	Class 35 Windows Code	96,163	cost savings
	R-30 Floor Insulation Code for Natural Gas Homes	15,422	$65
	R-38 Attic Insulation Code for Natural Gas Homes	5,443	$82
	R-21 Wall Insulation Code	22,680	$86
	Subtotal	**1,219,042**	**insufficient data**
Commercial	Fluorescent Lighting Retrofits	4,898,880	cost savings
	Food Refrigeration Efficiency Improvements	498,960	cost savings
	Improvements for Public Buildings	397,354	cost savings
	Subtotal	**5,795,194**	**cost savings**
Transportation	More Efficient Airplane Engines	725,760	cost savings
	Tire Pressure Check	31,752	cost savings
	Parking Restrictions	not estimated	not estimated
	FeeBate ($100/MPG off baseline)	3,991,680	$0
	Gas Tax ($1.00/gallon)	7,711,200	$17
	Vehicle Mileage Tax (0.04/mile)	7,439,040	$50
	Diesel to Electric Train Conversion	199,584	not estimated
	Truck to Train Mode Shift	1,524,096	not estimated
	Subtotal	**21,623,112**	**insufficient data**
Utility	Chemical Boiler Cogeneration	371,952	cost savings
	Landfill Gas Combustion	448,157	$0
	Animal Manure	9,979	$2
	Wood Waste Combustion	136,080	$88
	Agricultural Waste Combustion	255,830	$103
	Wind	408,240	not estimated
	Nuclear Power	2,685,312	$28
	Subtotal	**4,315,550**	**insufficient data**
Industrial	Petroleum Refining Process Improvements	121,565	not estimated
	Pulp and Paper Process Improvements	95,165	not estimated
	Aluminum Process Improvements	1,074,125	not estimated
	Subtotal	**1,290,855**	**not estimated**
Land Use - Forest	Afforestation	**4,989,600**	**$4**
Total[b]		**39,233,352**	**insufficient data**

[a] Please note that the estimates in the table are given in metric tons of carbon dioxide equivalent.
[b] Please note that the emission reduction estimates are not additive. See text for further explanation.

Given the mobile nature of airplanes and interstate commerce issues, the Action Plan noted that an individual state can do little to promote acquisition and use of these engines. Progress will depend upon federal action.

Increased Parking Fees: Many commuters do not bear the full costs of parking and, as a result, drive more frequently than is socially optimal. Increasing the cost of employee parking to reflect its full costs would correct this inefficiency. However, it will be difficult to persuade commuters who currently receive free parking to accept this change. Unless other salary or benefit adjustments were made, commuters would bear the costs while employers would reap the benefits. Under one option, the state could require employers to pay a parking fee for every employee using a single occupant vehicle to get to work.

Tire Pressure Check: A slight modification of the Inspection and Maintenance (I&M) program could improve automobile efficiency. At any given time, approximately half the motor vehicles have under-inflated tires. These vehicles suffer an efficiency loss of about one mile per gallon. Incorporating tire check/inflation into the I&M procedure would reduce gasoline consumption and carbon dioxide emissions.

Gasoline Tax: Higher fuel prices due to a gasoline tax would result in improved vehicle efficiency and lower vehicle miles traveled. Commuters would acquire more fuel efficient vehicles and adopt behaviors which lower transportation demand, such as moving closer to work or using alternatives to single occupancy vehicles. The reduction in travel and the improvement in fuel efficiency could save 900 million gallons of gasoline.

FeeBate: A feebate system sets a standard level of motor vehicle efficiency against which each new motor vehicle is compared. A fee is charged to purchasers of vehicles below the efficiency standard and a rebate is awarded to those who purchase vehicles above the standard.

Vehicle Mileage Tax: A vehicle mileage tax raises travel costs in order to reduce vehicle miles traveled. Data from the Washington State Department of Transportation suggest that a $0.04 per mile tax could lower vehicle travel by approximately 18.6 billion miles in the year 2010. This would result in a reduction of 866 million gallons of gasoline and thus would lower GHG emissions.

Diesel to Electric Train Conversion: In Washington, trains consume significant quantities of energy. Electric trains emit 15 percent less carbon dioxide per ton-mile than do diesel trains. Thus, conversion of diesel trains to electric trains would reduce GHG emissions.

Truck to Train Mode Shifts: Trains consume much less energy per ton-mile than trucks. Assuming a conservative in-use energy consumption truck-to-train ratio of 3:1, approximately 330 pounds of carbon dioxide emissions are reduced for every 1,000 ton-miles of freight diverted from trucks to trains. The feasibility of such a shift depends on both the proximity of current rail facilities to cargo origination and destination points, and the capacity of rail facilities to absorb the new load. Absorbing the new load does not appear to pose a problem because the national rail network operates at about 20-25 percent of capacity. However, the extent to which truck cargo may be diverted to trains is uncertain.

Utility

Chemical Boiler Cogeneration: Washington has 19 paper mills, nine of which have chemical recovery boilers. Chemical recovery boilers recycle chemicals used to pulp wood into fiber, reduce wastewater discharges, and create excess steam which is used to produce electricity. Washington State Energy Office (WSEO) estimates that upgrades to four boilers along with new generating equipment at five other boilers would increase the electricity generating capacity in this sector to over 203 aMW (average megawatt).

Landfill Gas Combustion: Landfills in Washington are projected to produce 369,775 metric tons of methane in 2010. WSEO projects that a collection system will capture about 75 percent or 277,331 metric tons of methane. At a conversion rate of 9.4 MW/trillion Btu for internal combustion engines, landfill methane could produce about 140 aMW of electricity in 2010.

Animal Manure: Dairy cows provide the major recoverable animal manure resource in Washington. In 1992, the manure generated by about 242,000 dairy cows had the potential to produce 26 aMW of electric power. A cost per kWh of 0.039 and 0.041 is estimated for herd sizes of 1500 and 750 head, respectively. Assuming a size cut off of 750 head, a 5.5 aMW generation potential exists from manure methane recovery and electricity generation. The climate change benefits of this strategy not only include the displacement of electricity from other generating sources, but also includes a reduction in methane emissions.

Wood Waste Combustion: Woody residues include two potential biomass fuels — forest residues and mill residues. Forest residues include material left after a timber harvest, stagnant and dying timber, hardwood stand conversions, and pre-commercial thinnings. Washington projects that 2,350 Mbtu of forest residues will be economically available for energy production each year beginning in 2010. Mill residues are generated when timber is converted into lumber and plywood. A projected 5,500 Mbtu of mill residues are assumed to be economically available to produce electricity in 2010. Alternative wood-fired power plants could supply approximately 43.5 aMW of electricity in 2010.

Agricultural Waste Combustion: Crop residue burning as a source of electricity generation in Washington has the potential to offer important GHG reduction benefits. Approximately 50,000 MBtu of residues are annually left on Washington fields. Washington does not currently practice agricultural waste combustion to produce power, however other areas such as California do utilize this resource.

Wind: Using current wind turbines, Washington's estimated wind resources are approximately 900 MW. The potential for wind energy in Washington State is limited by the windiness of an area, competing land uses, and the cost of project development. The intermittent nature of wind gives rise to concerns about its ability to supply base-load needs. However, for Washington, it is an attractive complement to the regional hydroelectric energy system.

Nuclear Power: There is one nuclear powered electricity generation facility operating in Washington, WNP-2. In 1994, it operated at a capacity factor of 71.8 percent and generated about 840 aMW of electricity. Because no fossil fuel was combusted, the 840 megawatts generated by WNP-2 reduced GHG emissions by 2.69 MMTCDE.[8]

Industrial Processes

Petroleum Refining Process Improvements: The adoption of available state-of-the-art technologies can reduce energy consumption in the petroleum sector by about one-third. For example, improvements could be made to the distillation method which is one of the most energy-intensive steps in the refining process. Distillation is the primary process for breaking down crude oil into its constituent hydrocarbons. Technologies such as vapor recompression, staged crude preheating, and air condensers can reduce energy use in distillation by 55 percent.

[8] Note that the Action Plan takes no position on the environmental issues surrounding nuclear power.

Pulp and Paper Process Improvements: The adoption of state-of-the-art technologies by the pulp and paper industry could reduce energy consumption by 29 percent below that of current average practices. For example, improvements could be made to drying and stock preparation which are the most energy-intensive activities of paper production. Modern technologies such as top-wire formers and improved mechanical and thermal water removal techniques can reduce the energy use of this stage by approximately 32 percent.

Aluminum Process Improvements: The adoption of state-of-the-art technologies in the aluminum industry would reduce energy consumption by 16 percent below that of current average practices. Smelting consumes about 65 percent of the energy used in aluminum production. Using the latest technology for smelters would result in a 11 to 18 percent efficiency improvement.

Land Use

Forest Changes

Afforestation: This strategy will sequester carbon dioxide by planting idle cropland with trees. The 1992 Department of Commerce Agricultural Census reports approximately 450,000 acres of idle cropland in Washington. A study cited in the Action Plan estimates that newly planted Pacific coast forests sequester 12.2 tons of carbon dioxide per acre.

Recommendations for Federal Action

Washington's Action Plan emphasized that major progress in reducing GHG emissions in many of the areas of the transportation sector depends on action by the federal government. Several of the state's recommendations for federal action follow.

- Washington suggested that the federal government implement more stringent standards for motor vehicle fuel efficiency. The U.S. government is the sole regulator of motor vehicle fuel efficiency and federal statutes prohibit states from establishing motor vehicle efficiency standards. Federal regulation began in 1976 through Corporate Average Fuel Efficiency (CAFE) standards. Proponents of fuel efficiency standards argue that currently available technologies could markedly improve motor vehicle efficiency. The Congressional Office of Technology Assessment (OTA) projected that regulatory pressure could raise average new car fuel efficiency by about 13 percent in 2000 and 22 percent by 2005.
- The federal government could support FeeBate programs. The U.S. Department of Transportation (DOT) blocked Maryland's effort to enact a FeeBate program. DOT held that fuel economy incentive programs are preempted by federal statute. Maryland's Attorney General, while conceding that certain aspects of the Maryland law violated the federal preemption, otherwise affirmed the state's right to enact a FeeBate. Presently, the legality of a feebate based on fuel efficiency is uncertain.
- Washington can do little to promote acquisition and use of the *Ultrahigh* bypass high-efficiency airplane engine because of the mobile nature of airplanes and interstate commerce issues. Progress in the adoption of this engine technology depends upon federal action.
- Federal government policies could directly promote rail transportation in the form of subsidies or tax breaks.

RECOMMENDATIONS

The Washington Action Plan offers the following framework for policy-makers developing a response to global climate change:

1. Actively pursue those mitigation strategies that are cost effective for reasons other than their greenhouse gas reduction benefits.

2. Efforts to reduce greenhouse gas emissions are investments in the future of the state and nation. As an investment, the mitigation program must compete with other claims on state resources (e.g., education, welfare programs, police and fire protection, etc.).

3. The use of cost effectiveness criteria to develop a mitigation program is essential. The cost of changing energy, industrial, land use, agriculture, and forestry practices range from cost savings to very expensive. Obtaining the largest emission reduction at the lowest cost is sensible.

4. The expected consequences of global climate change should drive the scope and stringency of a mitigation program.

5. Any mitigation program should consist of a diverse portfolio of programs to protect against unexpected economic and emission effects.

6. Given the uncertainties surrounding climate change, the state should consider carbon dioxide controls as insurance against as yet unknown consequences.

7. The state should commit to better understand the effects of climate change and to further develop greenhouse gas mitigation options. A better understanding of climate change reduces the need to hedge against the uncertainty and improved GHG mitigation technologies will enhance our ability to deal with surprises should they occur.

8. With regard to specific concerns within Washington, perhaps the best policy-makers can do is to identify and develop response plans for those activities/environments most sensitive to climate change. In this way the state can help minimize adverse climate change consequences should they occur.

Estimating GHG Reductions From State Actions to Improve Solid Waste Management Practices

This appendix contains three sections: (1) Background, (2) A Life Cycle Approach: Evaluating and Incorporating Solid Waste Management Actions in a Statewide GHG Mitigation Plan, and (3) Example Plan for Waste Management Mitigation Actions. The background section sketches some national trends in solid waste management actions, identifies solid waste management actions which may yield GHG reductions, and discusses the importance of integrating solid waste management actions into a statewide GHG mitigation action plan. The next section discusses the importance of using a life cycle approach for evaluating the GHG impacts of current and future solid waste management actions. In the last section of this appendix, an example MSW management scenario is presented for a hypothetical state looking to evaluate its current and future solid waste management actions from a GHG perspective. The example establishes a baseline scenario of solid waste management actions and compares it to a future scenario; the future scenario uses solid waste management as part a statewide GHG mitigation action plan.

Background

To achieve statewide source reduction and recycling goals, many states and municipalities develop municipal solid waste (MSW) management plans which include a variety of measures such as curbside collection and recycling programs, recycling drop-off centers, and yard trimmings composting facilities. According to a recent nationwide survey, 45 states have waste reduction and/or recycling goals in place.[1] Nationwide, approximately 51% of the US population has access to curbside recycling, and the number of drop-off recycling programs continues to grow.[2]

Additional MSW management measures provide opportunities for states to meet and exceed their source reduction and recycling goals. Such measures include introducing "Pay As You Throw" (PAYT) pricing for waste collection, increasing the service area or improving collection efficiency of curbside recycling programs, increasing commercial sector recycling, and banning landfilling of organic wastes such as yard trimmings. Note that in most states, the role of state government is to develop plans and standards; local governments implement solid waste policy. Thus, any state actions addressing solid waste should start with full coordination and consultation with local officials.

Many states are in the process of reevaluating their MSW management goals. This reevaluation process provides the opportunity for state and local authorities to consider the GHG reduction benefits of different MSW management strategies currently in place, and identify opportunities to further achieve GHG reductions in the MSW sector. Viewing MSW management actions from a GHG perspective provides the basis for including and integrating these management actions into a statewide GHG mitigation action plan.

A Life Cycle Approach: Evaluating and Incorporating MSW Management Actions in a Statewide GHG Mitigation Plan

To incorporate MSW management actions into a statewide GHG mitigation action plan, one must first identify the impacts of MSW management actions on GHG emissions. Heretofore, most of the focus on GHG emissions associated with waste management has been on methane emissions from landfills.

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[1] BioCycle, *The state of garbage in America*, April, 1997.
[2] Ibid.

There are, however, many emissions and sinks upstream of the point of disposal that are affected by MSW management. A life cycle approach provides an analytic framework for evaluating the full range of GHG emissions and sinks. Major GHG sources associated with MSW include carbon dioxide from fossil fuel burning associated with raw material extraction manufacturing processes, and transportation; process non-energy emissions; landfill methane; and waste combustion. These emissions are offset to some degree by energy recovery at municipal waste combustors and landfill gas collection systems, and enhanced carbon sequestration by forests and landfills.

For MSW management, EPA has conducted a streamlined life cycle inventory (LCI) focusing on the GHG impacts of ten MSW components (e.g., paper, plastics, metals) in various ways. The EPA draft working paper *Greenhouse Gas Emissions from Municipal and Solid Waste Management*[3] and the EPA's Waste Reduction Model (WARM)[4] provide GHG emission factors, for waste stream components, that are based on an LCI framework. EPA's research indicates that for many materials, the effect of recycling or source reduction on net GHG emissions is more closely related to upstream energy emissions and forest carbon sinks than to landfill methane emissions, and so a life cycle approach is able to capture the benefits of solid waste management options in a more holistic way.

EPA recognizes that LCIs have limitations. Data vary with respect to quality, quantity, validity, and robustness. For example, data may vary seasonally, regionally, and locally as a result of changes in economic activity, demographics, different state and local waste regulations, or different waste accounting practices. When state or local data are not available, it is possible to use averaged national data. Application of averaged national data may not accurately reflect state or local conditions. However, in the absence of state or local data, averaged national data are a good proxy. The EPA research to date, has very wide error bounds and is based on average national conditions; nevertheless, the information it provides on GHG emissions from waste management is suitable for estimating the impacts of voluntary GHG reduction activities.

Example Plan for Waste Management Mitigation Actions

The objective of this example is to demonstrate to developers of State Action Plans the value of incorporating waste management activities in their plans. This example uses averaged national data to estimate GHG emissions resulting from the baseline and future MSW management scenarios for a hypothetical state. The initial (baseline) scenario is based on some simple assumptions about MSW management activities in the current year. This baseline scenario provides the starting point from which to consider future changes in MSW management actions. The future scenario is based on the successful implementation of a variety of waste management activities which result in increases in overall recovery and a reduction in GHG emissions.

The hypothetical scenarios focus on a set of ten materials[5] present in the MSW stream for which EPA has estimated GHG emission factors. EPA is conducting research to develop emission factors for additional materials such as glass and wood.

[3] EPA 530-R-97-010. March 1997. USEPA Office of Solid Waste and Emergency Response.
[4] Available through the USEPA Office of Solid Waste.
[5] These materials include paper (office paper, newsprint, corrugated cardboard), metals (aluminum cans, steel cans), plastics (HDPE, LDPE, and PET), food scraps, and yard trimmings.

Methodological Approach and Assumptions

To establish a baseline and future scenario for the hypothetical state, the following assumptions were made.

Waste Generation:

Total waste generation is the product of the per-capita waste generation rate and the state population. In both the baseline and future scenarios, this analysis assumes a state population of 5 million people and a per-capita waste generation rate of 4.3 pounds of waste/person/day.[6]

Baseline Scenario Assumptions:

The baseline scenario assumes the state currently landfills most of its waste, and also uses waste-to-energy as a management option. Recycling actions include curbside recycling programs in major residential areas, some recycling collection centers, some yard waste composting facilities, and a limited industrial/commercial recycling program. These assumptions are based largely on *BioCycle's* "The State of Garbage In America" which reported the number and types of MSW management programs in place for each state (April, 1997).[7]

The baseline scenario assumes these programs reflect common MSW management actions at the state and local level within the US, and that these actions result in a recovery rate of 27 percent, a combustion rate of 15 percent and a landfill rate of 58 percent.[8] The baseline data are presented in Table 1.

The baseline scenario assumes 20 percent of the waste destined for landfills is managed in landfills with landfill gas (LFG) recovery systems, and that these systems have a LFG collection efficiency of 75 percent. In addition, the baseline scenario assumes an overall waste-to-energy (WTE) efficiency rate (i.e., electrical energy output divided by energy value of waste inputs) of 17 percent.

Future Scenario Assumptions:

The future scenario assumes the state implements a set of MSW management activities designed to achieve a higher total recovery rate by the year 2005 in response to state solid waste recovery goals (see Exhibit 1). The future scenario assumes these MSW management activities result in a waste recovery rate of 50 percent, a combustion rate of 15 percent, and a landfill rate of 35 percent. The future scenario data are presented in Table 2.

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[6] Calculated based on an estimated total US population of 260 million and a total amount of waste generated as reported in *Characterization of MSW in the United States 1996 Update*, EPA530-R-97-015.

[7] *BioCycle* reported approximately 49 of 51 states have curbside recycling programs, 40 of 51 states have recycling drop-off sites, and 48 of 51 states have yard waste composting facilities (for reporting purposes the District of Columbia was counted as a state).

[8] The total and material specific generation, recovery, and disposal rates are comparable to the national average rates for 1995 reported in EPA's *Characterization of Municipal Solid Waste in the United States: 1996 Update*.

Exhibit 1
Example of Future Scenario MSW Management Goals and Activities

Future Goals	Future Activities
Increase newspaper recovery rate to 67 percent.	Increase collection efficiency of curbside collection.
Increase office paper and corrugated cardboard recovery rates to 67 percent.	Expand the commercial collection of mixed paper and corrugated cardboard.
Increase yard trimmings recovery rate to 40 percent.	Promote the benefits of composting. Create yard waste drop-off centers in addition to offering seasonal curbside collection of yard waste. Ban yard waste from landfills.
Increase food waste diversion rate to 25 percent.	Expand the commercial and institutional collection of food waste discards.

Specifically, the future scenario assumes a statewide recovery rate of 67 percent for newspaper, office paper, and corrugated cardboard; 25 percent for food scraps; and a landfill ban on yard trimmings. The material-specific recovery rates for the remaining materials were adjusted upward to achieve a total recovery rate of 50 percent.

The future scenario assumes 60 percent of the waste destined for landfills is managed in landfills with landfill gas (LFG) recovery systems, and that these systems have a LFG collection efficiency of 85 percent. In addition, the future scenario assumes the overall waste-to-energy (WTE) efficiency rate improves to 19 percent.

In an actual state report, the future scenario for the total and material-specific recovery, combustion, and landfill rates would be based on the state's MSW management goals and activities.

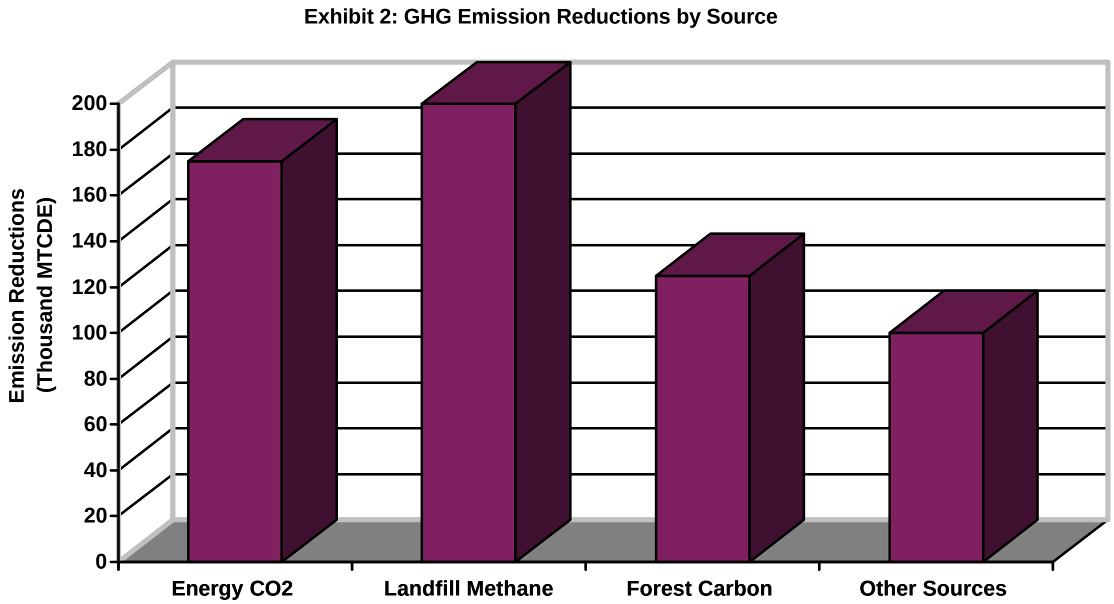
The Waste Reduction Model (WARM)

WARM, an EPA software model for estimating GHG emissions from the waste management sector, was used to estimate GHG emissions for this analysis. Table 3 presents the GHG emission estimates for the baseline scenario, and Table 4 presents the GHG emissions for the future scenario. Table 5 compares the estimates from the two scenarios.

Results of Example Analysis and Relationship to Other Mitigation Activities

WARM estimates of annual GHG emissions in the baseline and future scenarios are summarized in columns "b", "c", and "d" of Table 5. The estimated GHG emissions are 1.5 million MTCDE per year in the baseline scenario and 930,000 MTCDE per year in the future scenario. The future scenario thus reduces emissions by about 600,000 MTCDE per year.

The largest reductions in GHG emissions were for office paper (224,000 MTCDE per year), corrugated boxes (153,000 MTCDE per year), newspaper (114,000 MTCDE per year), and food waste (103,000 MTCDE per year). Most of the reductions are attributable to reduced energy-related carbon dioxide emissions, reduced landfill methane emissions, and increased forest carbon sequestration. (Exhibit 2)[9]



The estimated 600,000 MTCDE emission reduction predicted in this exercise is comparable in magnitude to some of the most significant tools available to states for reducing GHG emissions. For comparison, examples of policy and technology options that reduce GHG emissions by similar levels are found in several state action plans. One such option can be found in Illinois' action plan, which estimated that efficiency improvements to hot water heaters and residential furnaces have the potential to reduce GHG emissions by approximately 582,000 and 514,000 MTCDE, respectively, by the year 2000. In Oregon, improved natural gas efficiencies have the potential to reduce GHG emissions by approximately 655,000 MTCDE by the year 2010. Washington estimates that improved food refrigeration may reduce GHG emissions by approximately 500,000 MTCDE by the year 2010.

MSW management options thus represent significant opportunities for states to further reduce their GHG emissions. Because these options have other environmental benefits as well, they deserve careful consideration in Action Plans.

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[9] Potential exhibit comparing the "breakout" by source for the baseline and future scenarios.

Table 1
Baseline Scenario for the Management of Municipal Solid Waste in the Current Year for a State "Mock-Up"

Baseline Scenario Assumptions

State's Population	Annual MSW Generation[1] (tons)	Percent of Total MSW Recovered	Percent of Total MSW Combusted	Percent of Total MSW Landfilled	Percent of Landfilled Waste Managed at Landfills with LFG Systems	Collection Efficiency of LFG Systems	Conversion Efficiency of Waste-to-Energy (WTE) Systems
5,000,000	4,015,000	27%	15%	58%	20%	75%	17%

Generation and Management of MSW in Current Year

	Current Waste Generation		Current Waste Recovery					
(a) Material	(b) Percentage of MSW Generation[2] (by weight)	(c) Amount of Waste Generated[3] (tons)	(d) Percentage of Waste Recovered[4] (by weight)	(e) Amount of Waste Recovered (tons)	(f) Amount of Waste Discarded[5] (tons)	(g) Amount of Waste Combusted (tons)	(h) Amount of Waste Landfilled with no LFG System (tons)	(i) Amount of Waste Landfilled with LFG System (tons)
Newspaper	6.3%	252,945	53.0%	134,061	118,884	24,428	75,565	18,891
Office Paper	3.3%	132,495	44.3%	58,695	73,800	15,164	46,908	11,727
Corrugated Cardboard	13.8%	554,070	64.2%	355,713	198,357	40,758	126,079	31,520
Aluminum Cans	0.8%	32,120	62.7%	20,139	11,981	2,462	7,615	1,904
Steel Cans	1.3%	52,195	56.8%	29,647	22,548	4,633	14,332	3,583
HDPE	1.9%	76,285	10.8%	8,239	68,046	13,982	43,251	10,813
LDPE	2.7%	108,405	1.7%	1,843	106,562	21,896	67,733	16,933
PET	0.5%	20,075	22.7%	4,557	15,518	3,189	9,863	2,466
Food Scraps	6.7%	269,005	4.1%	11,029	257,976	53,009	163,974	40,993
Yard Trimmings	14.3%	574,145	30.3%	173,966	400,179	82,229	254,360	63,590
SUBTOTAL	51.6%	2,071,740	38.5%	797,889	1,273,851	261,750	809,681	202,420
Other Materials	48.4%	1,943,260	14.7%	286,161	1,657,099	340,500	1,053,279	263,320
TOTAL	100.0%	4,015,000	27.0%	1,084,050	2,930,950	602,250	1,862,960	465,740

[1] Assuming 5 million people generate 4.4 lbs of waste/person/day.

[2] Franklin Associates, Ltd. *Characterization of Municipal Solid Waste in the United States: 1996 Update* , EPA 530-R-97-015.

[3] The product of total MSW generation and percent of MSW generation for each material. For example, 4,015,000 tons/yr x 0.063 = 252,945 tons/yr of newspaper.

[4] Percentage recovery for each material based on national average from Franklin Associates, Ltd., EPA 530-R-97-015. Yard waste recovery means back yard composting.

[5] The difference between the amount of waste generated and the amount of waste recovered.

Table 2

Future Scenario for the Management of Municipal Solid Waste by Year 2005 for a State "Mock-Up": Assuming Increased Material Recovery

Future Scenario Assumptions

State's Population	Annual MSW Generation[1] (tons)	Percent of Total MSW Recovered	Percent of Total MSW Combusted	Percent of Total MSW Landfilled	Percent of Landfilled Waste Managed at Landfills with LFG Systems	Collection Efficiency of LFG Systems	Conversion Efficiency of Waste-to-Energy (WTE) Systems
5,000,000	4,015,000	50%	15%	35%	60%	85%	19%

Generation and Management of MSW in Year 2005

	Future Waste Generation		**Future Waste Recovery**					
(a) Material	**(b) Percentage of MSW Generation[2] (by weight)**	**(c) Amount of Waste Generated[3] (tons)**	**(d) Percentage of Waste Recovered[4] (by weight)**	**(e) Amount of Waste Recovered (tons)**	**(f) Amount of Waste Discarded[5] (tons)**	**(g) Amount of Waste Combusted (tons)**	**(h) Amount of Waste Landfilled with no LFG System (tons)**	**(i) Amount of Waste Landfilled with LFG System (tons)**
Newspaper	6.3%	252,945	67.0%	169,473	83,472	25,042	23,372	35,058
Office Paper	3.3%	132,495	67.0%	88,772	43,723	13,117	12,243	18,364
Corrugated Cardboard	13.8%	554,070	67.0%	371,227	182,843	54,853	51,196	76,794
Aluminum Cans	0.8%	32,120	65.0%	20,878	11,242	3,373	3,148	4,722
Steel Cans	1.3%	52,195	60.0%	31,317	20,878	6,263	5,846	8,769
HDPE	1.9%	76,285	15.0%	11,443	64,842	19,453	18,156	27,234
LDPE	2.7%	108,405	5.0%	5,420	102,985	30,895	28,836	43,254
PET	0.5%	20,075	25.0%	5,019	15,056	4,517	4,216	6,324
Food Scraps	6.7%	269,005	25.0%	67,251	201,754	60,526	56,491	84,737
Yard Trimmings	14.3%	574,145	40.0%	229,658	344,487	51,673	9,646	14,468
SUBTOTAL	51.6%	2,071,740	48.3%	1,000,458	1,071,282	321,385	299,959	449,939
Other Materials	48.4%	1,943,260	51.8%	1,007,042	936,218	280,865	262,141	393,211
TOTAL	100.0%	4,015,000	50.0%	2,007,500	2,007,500	602,250	562,100	843,150

[1] Assuming the state population of 5 million people and the waste generation rate of 4.4 lbs of waste/person/day have not changed by the year 2005.

[2] Franklin Associates, Ltd. *Characterization of Municipal Solid Waste in the United States: 1996 Update* , EPA 530-R-97-015.

[3] The product of total MSW generation and percent of MSW generation for each material. For example, 4,015,000 tons/yr x 0.063 = 252,945 tons/yr of newspaper.

[4] Assuming these are the recovery rate goals achieved by the year 2005. Yard waste recovered includes back yard and centralized composting.

[5]The difference between the amount of waste generated and the amount of waste recovered.

Table 3
Estimated GHG Emissions from MSW Management Actions in the Baseline Scenario
(Estimated Using WARM)

(a)	(b)	(c)	(d)	(e)	(f)			(g)	(h)	(i)	(j)	(k)
Material	**Baseline Generation of Material (Tons)**	**Estimated Recycling (Tons)**	**Annual GHG Emissions from Recycling (MTCDE)**	**Estimated Landfilling (Tons)**	**Annual GHG Emissions from Landfilling (MTCDE)**			**Estimated Combustion (Tons)**	**Annual GHG Emissions from Combustion (MTCDE)**	**Estimated Composting (Tons)**	**Annual GHG Emissions from Composting (MTCDE)**	**Total Annual GHG Emissions (MTCDE)**
					LFs without LFG recovery	**LFs with LFG recovery**	**Total**					
Newspaper	252,945	134,061	-185,829	94,456	107,922	11,639	119,561	24,428	33,254	0	0	-33,014
Office Paper	132,495	58,695	-52,950	58,635	280,253	25,656	305,908	15,164	26,154	0	0	279,113
Corrugated Box	554,070	355,713	-405,678	157,599	301,554	22,292	323,846	40,758	42,499	0	0	-39,334
Aluminum Cans	32,120	20,139	112,359	9,519	153,774	38,444	192,218	2,462	49,764	0	0	354,341
Steel Cans	52,195	29,647	59,380	17,915	59,866	14,967	74,833	4,633	19,416	0	0	153,629
HDPE	76,285	8,239	10,230	54,064	116,933	29,233	146,166	13,982	59,954	0	0	216,351
LDPE	108,405	1,843	2,705	84,666	230,652	57,663	288,315	21,896	109,256	0	0	400,275
PET	20,075	4,557	9,087	12,329	43,149	10,787	53,937	3,189	18,023	0	0	81,047
Food Waste	269,005	0	0	204,967	142,889	-7,334	135,555	53,009	-2,212	11,029	0	133,343
Yard Waste	574,145	0	0	317,950	22,122	-32,603	-10,480	82,229	-5,694	173,966	0	-16,175
Total	2,071,740	612,894	-450,696	1,012,101	1,459,114	170,744	1,629,858	261,750	350,414	184,995	0	1,529,576

Table 4
Estimated GHG Emissions from MSW Management Actions in the Future Scenario
(Estimated Using WARMl)

(a) Material	(b) Baseline Generation of Material (Tons)	(c) Projected Recycling (Tons)	(d) Annual GHG Emissions from Recycling (MTCDE)	(e) Projected Landfilling (Tons)	(f) Annual GHG Emissions from Landfilling (MTCDE)			(g) Projected Combustion (Tons)	(h) Annual GHG Emissions from Combustion (MTCDE)	(i) Projected Composting (Tons)	(j) Annual GHG Emissions from Composting (MTCDE)	(k) Total Annual GHG Emissions (MTCDE)
					LFs without LFG recovery	LFs with LFG recovery	Total					
Newspaper	252,945	169,473	-234,916	58,430	33,380	21,435	54,815	25,042	32919	0	0	-147,183
Office Paper	132,495	88,772	-80,082	30,606	73,143	39,770	112,913	13,117	22098	0	0	54,930
Corrugated Box	554,070	371,227	-423,372	127,990	122,450	53,558	176,008	54,853	54924	0	0	-192,439
Aluminum Cans	32,120	20,878	116,481	7,869	63,563	95,345	158,908	3,373	68182	0	0	343,571
Steel Cans	52,195	31,317	62,726	14,615	24,419	36,628	61,046	6,263	26255	0	0	150,027
HDPE	76,285	11,443	14,208	45,390	49,086	73,628	122,714	19,453	81274	0	0	218,196
LDPE	108,405	5,420	7,956	72,089	98,195	147,293	245,488	30,895	150763	0	0	404,207
PET	20,075	5,019	10,008	10,539	18,442	27,664	46,106	4,517	25273	0	0	81,387
Food Waste	269,005	0	0	141,228	49,227	-15,677	33,550	60,526	-3369	67,251	0	30,181
Yard Waste	574,145	0	0	24,114	839	-8,676	-7,837	51,673	-4429	498,358	0	-12,266
Total	2,071,740	703,548	-526,991	532,871	532,744	470,968	1,003,711	269,712	453,890	565,609	0	930,610

Table 5
Comparison of Total Estimated GHG Emissions For the Baseline and Future Scenarios

(a) Material	(b) Baseline Scenario: Estimated Total Annual GHG Emissions* (MTCDE)	(c) Future Scenario: Estimated Total Annual GHG Emissions** (MTCDE)	(d) Difference Between Baseline and Future Scenario Estimates of Annual GHG Emissions (MTCDE)
Newspaper	-33,014	-147,183	-114,169
Office Paper	279,113	54,930	-224,183
Corrugated Boxes	-39,334	-192,439	-153,106
Aluminum Cans	354,341	343,571	-10,770
Steel Cans	153,629	150,027	-3,602
HDPE	216,351	218,196	1,846
LDPE	400,275	404,207	3,932
PET	81,047	81,387	340
Food Waste	133,343	30,181	-103,162
Yard Waste	-16,175	-12,266	3,909
Total	1,529,576	930,610	-598,966

* These data were copied directly from Table 3, column k.
** These data were copied directly from Table 4, column k.