REDUCING GREENHOUSE GASES AND AIR POLLUTION: A MENU OF HARMONIZED OPTIONS

by State and Territorial air Pollution Program Administrators (STAPPA) and
Association of Local Air Pollution Control Officials (ALAPCO)[1]

1. Executive summary

The State and Territorial Air Pollution Program Administrators (STAPPA) and Association of Local Air Pollution Control Officials (ALAPCO) developed *Reducing Greenhouse Gases and Air Pollution: A Menu of Harmonized Options* to assess strategies that simultaneously reduce conventional air pollution and greenhouse gases or GHGs (otherwise known as "harmonized strategies"). Utilizing this document, state and local officials can identify and assess harmonized strategies and policies to reduce air pollution and address climate change simultaneously, enhancing both the environmental and economic effectiveness of these efforts.

In recent decades, a concern has emerged that the Earth's climate is being altered by increased concentrations of GHGs into the atmosphere as a result of anthropogenic (human) activity. The concern is that activities such as the burning of fossil fuels, waste disposal and agricultural and forestry practices may be accelerating the pace of climate change to a rate that natural systems, including humans and other organisms, cannot accommodate. The growing scientific consensus notwithstanding, the United States (U.S.) Environmental Protection Agency (U.S. EPA) does not currently have clear authority to regulate CO_2, and the U.S. Senate has passed a resolution blocking the ratification of the Kyoto Protocol as currently written. Meanwhile, U.S. GHG emissions rose by over 11 per cent between 1990 and 1997. If the U.S. is to have any chance of meeting its commitment under the Kyoto Protocol (a 7 per cent GHG emission reduction from 1990 levels, on average, between the five year "budget period" 2008 to 2012), states and localities may wish to consider reducing GHG emissions now.

[1] This article is reprinted with the permission of STAPPA/ALAPCO. It is the executive summary of a longer report, of the same title, October 1999, Washington D.C. (see http://www.4cleanair.org)

In continuing to address criteria pollutant nonattainment challenges, state and local officials have the opportunity to capture significant GHG emission reductions. The most effective path for achieving this goal is to ensure that, in obtaining emission reductions needed for criteria pollutant attainment, the applied strategies are ones that also provide GHG reduction benefits, rather than measures that are ineffective or counterproductive from a GHG perspective.

STAPPA and ALAPCO believe it is important to focus on the relationship between GHG mitigation and conventional air pollutant control, because with few exceptions, strategies that mitigate GHGs will also result in reduced emissions of other air pollutants. The most widely recognized harmonized strategies relate to fossil-fueled combustion, the major source of carbon dioxide (CO_2), as well as a source for particulate matter (PM), nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO) and air toxics.

The GHGs that are of chief concern include CO_2, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride. Ozone is also a GHG; therefore, ozone precursors (i.e., NO_x and non-methane volatile organic compounds or NMVOCs) have an indirect greenhouse effect.[2] This document focuses primarily on CO_2 for two reasons. First, over half of the predicted global warming impacts are expected to result from CO_2. In 1997, CO_2 emissions constituted approximately 82 per cent of total U.S. GHG emissions.[3] Second, the primary source of this CO_2 is fossil-fuel combustion, an activity that state and local officials address by regulating categories of emission sources.

Each of the source categories that state and local officials address is discussed below, with a focus on effective harmonized strategies for reducing GHGs and other air pollutants simultaneously. A discussion of market-based approaches to implementing these strategies follows these sections. Finally, the implementation of several key harmonized strategies are examined in four case study areas in the U.S., to illustrate potential reductions in GHGs and other air pollutants.

1. Sources and associated harmonized strategies

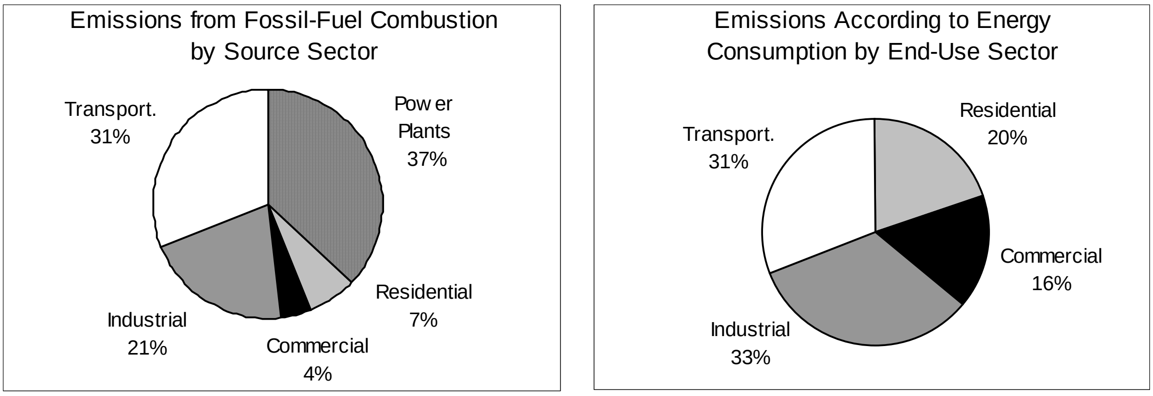
Air regulation in the U.S. targets primarily large stationary sources, area sources (groups of smaller stationary sources such as residential and commercial buildings), mobile sources (transportation) and other sources, such as municipal solid waste management and agriculture and forestry practices. There are opportunities in each of these source sectors to reduce traditional air pollutants while also achieving significant GHG reductions. In the stationary source sector, the most attractive harmonized strategies involve switching to a lower-carbon or zero-carbon fuel, increasing the efficiency of fuel use, or both. For area sources, from large commercial buildings to small homes, the key harmonized strategies are based on increasing the efficiency of fuel and electricity use. In the mobile source sector, the opportunities lie in increasing the fuel efficiency and reducing the use of motor vehicles. In the municipal solid waste sector, there are significant GHG-reduction opportunities in landfill gas to energy projects and source reduction and recycling. Finally, in the agriculture and forestry sectors, there are considerable GHG-reduction opportunities in manure management and in the sequestration of carbon, the ability of soils and plants to remove carbon from the atmosphere.

2 U.S. Environmental Protection Agency (U.S. EPA), *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-1997*, Washington, D.C., March 1999.

3 Ibid.

The generation of electricity is responsible for the largest portion—approximately 37 per cent—of the nation's CO_2 emissions. The electric industry is also the country's largest source of SO_2 and one of the largest sources of both NO_x and airborne mercury. Thus, this industry is an important point of leverage in reducing both conventional air pollution and CO_2. The transportation industry contributes the second largest share of CO_2 and is projected to be the fastest growing sector, and the other industrial sectors are third. In terms of CO_2 emissions, the primary industrial sectors are the most energy intensive: iron and steel, pulp and paper, chemicals, petroleum refining and cement manufacture. Figure 1 illustrates the portion of total 1997 emissions contributed by each source sector. In the chart at left, power plant CO_2 emissions are shown in a separate category; in the chart at right, emissions are allocated to end-use sectors based on the amount of electricity consumed in each sector.

Figure 1. **CO_2 Emissions from Fossil-Fuel Combustion, 1997**



Source: U.S. EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-1997, 1999.

1.1 Large stationary sources

Large furnaces, boilers and combustion turbines constitute the majority of large stationary sources, and in general, these sources are found at power plants and industrial facilities. In both of these sectors, there is enormous potential for reducing GHG and other air pollution emissions, sometimes at a net cost savings.

Air pollutants from large stationary sources can be controlled in familiar ways. Baghouses or electrostatic precipitators can be installed to capture PM less than ten microns in diameter (PM_{10}); sulfur emissions can be reduced by switching to lower-sulfur fuels or installing flue gas desulfurization devices (scrubbers) and post-combustion technologies like selective catalytic reduction (SCR) can lower NO_x emissions. Carbon, however, is a basic component of fossil fuels, not an impurity (like sulfur) or a by-product of combustion (like NO_x); therefore, removing carbon from flue gases after combustion is energy intensive and extremely expensive. Thus, for the foreseeable future, there are only two practical ways to reduce carbon emissions cost effectively from fossil-fueled combustion: switch to a lower-carbon or zero-carbon fuel or increase plant efficiency so that less fuel is combusted. Fortunately, these operational changes also result in significant reductions of other air pollutants. As a result, the above-mentioned operational changes are effective harmonized emission reduction strategies.

Many of the nation's power plants and industrial facilities are powered by coal, and coal is the most carbon-intensive fuel available. Both oil and natural gas contain less carbon per unit of energy than coal; thus switching a boiler from coal to oil or gas will result in carbon reductions. The magnitude of these reductions will depend on the efficiency of the boiler before and after the alteration. Table 1 illustrates the combined effects of fuel switching and increased efficiency on CO_2 emissions at power plants.[4] Note that emissions in pounds per kilowatthour (lb/kWh) can be reduced by moving across the table (fuel switching), by moving down the table (increasing efficiency), or both.

Table 1. **Approximate CO_2 emissions from fossil fuels**

Plant Efficiency	Heat Rate (Btu/kWh)	Coal (lb/kWh)	Oil (lb/kWh)	Gas (lb/kWh)
20%	17,060	3.53	2.85	2.00
30%	11,373	2.35	1.90	1.33
40%	8,530	1.77	1.42	1.00
50%	6,824	1.41	1.14	0.80
60%	5,687	1.18	0.95	0.67

Source: STAPPA/ALAPCO, 1999.

Chapter II, *Fossil-Fueled Power Generation*, and Chapter V, *Energy-Intensive Industries*, review a number of specific areas in which fuel switching is an attractive option for both emission reductions and cost savings. Perhaps the best example of this opportunity is the gas-fired combined cycle (GFCC) power plant. While coal has historically been the dominant fuel in the electric industry (accounting for 57 per cent of U.S. generation in 1997), falling gas prices and advances in turbine technology have made gas turbines the dominant choice for new capacity in nearly all regions of the U.S.

In addition to replacing the use of coal with gas, the use of excess heat in a heat recovery generator brings the overall efficiency of new GFCC systems to approximately 50 per cent. (Existing coal-fired power plants have efficiencies in the range of 33 per cent.) Together, the fuel switch and efficiency gains offer the following reductions relative to an older coal-fired plant:

- CO_2 – 66 per cent;
- NO_x – 99 per cent; and
- SO_2 – virtually 100 per cent.

[4] This table of CO_2 emissions per unit of electrical output is derived from estimates of emissions per unit of heat input developed by the EPA and published in: U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-1993*, Washington, D.C., 1994. One figure is used in this document for CO_2 emissions from natural gas combustion (117 lb/mmBtu), and a range is given for oil combustion, reflecting different types of oil. The range is from 161 lb/mmBtu for distillate oil to 174 lb/mmBtu for residual oil. For coal, EPA provides 207 lb/mmBtu as a weighted average, reflective of the kind of coal burned in U.S. utility boilers.

Many existing coal-fired plants could be replaced with GFCC capacity at a relatively modest cost. If the entire cost increment of a new GFCC plant were loaded onto CO_2 reductions, these reductions would cost between $0 and $39 per ton. Of course, allocating some of the costs of this fuel switch to NO_x and SO_2 reductions would lower the cost of CO_2 reductions. To put these costs in perspective, estimates of the cost of complying with the Kyoto Protocol range from $25 to $150 per ton of CO_2 (see Chapter II, *Fossil-Fueled Power Generation*).

The efficiency of a power plant or industrial boiler can also be increased without simultaneously switching fuels. One of the most attractive options for achieving increased efficiency is the use of excess heat from primary combustion. Excess heat from one process can often be captured and used in another process, removing or reducing the need for a fuel source in the second process. The term "combined heat and power" or CHP is used to describe processes in which electricity and useful heat are produced in the same combustion process (see Chapter II). These CHP strategies can:

- increase overall plant efficiency by 40 to 50 per cent;
- reduce fuel use and all associated emissions considerably;. and
- result in emission reductions at a negative cost (or savings) per ton.

Overall, there is tremendous potential for reducing CO_2 emissions by utilizing waste heat in industrial facilities and power plants. The U.S. Department of Energy's (U.S. DOE's) recent "Five-Labs Study" estimates that, even without CO_2 reduction requirements in the U.S., power generation at combined heat and power systems is likely to grow to 333,000 gigawatthours per year by the year 2010.[5] If this CHP generation had a CO_2 emission rate 40 per cent below that of conventional coal-fired generation, it would result in CO_2 reductions of 102 million tons per year. This reduction is 4.6 per cent of the decrease (from 1996 levels) necessary to comply with the Kyoto Protocol.

Policies to support fuel switching and increased efficiencies from power plants and other industrial sources include fuel-neutral, output-based emissions standards and comparable emission standards for all facilities.

The move to output-based emission standards, expressed in terms of the amount of pollutant emitted per unit of energy produced, usually pounds of pollution per megawatt-hour (lb/MWh) for CO_2, NO_x and possibly SO_2, would incent efficiency enhancements and the use of lower-carbon fuels by making it easier for efficient and cleaner facilities and more difficult for inefficient and more polluting facilities to meet emission limits. These incentives would make it more difficult to operate older, inefficient units and would enhance the value of units with very low emission rates.

5 U.S. Department of Energy, *Potential Impacts of Energy-Efficient and Low-Carbon Technologies by 2010 and Beyond*, Interlaboratory Working Group on Energy-Efficient and Low-Carbon Technologies, Energy Efficiency and Renewable Energy Program, Washington, D.C., September 1997.

1.2 Area sources

Increasing the efficiency and reducing the use of end-use equipment (demand side management) in the residential and commercial sectors—in contrast to increasing the efficiency of electricity generating units—can vastly reduce GHGs and air pollution emissions. Over one-third of fossil-fuel energy in the U.S. is consumed by the residential and commercial building sectors via lighting, heating, cooling and the operation of appliances. Therefore, the most effective way to reduce air pollution and GHGs from these sectors is to increase end-use efficiency, thereby reducing the amount of fuel consumed directly at the building site and indirectly at the electric generating plant.

The residential and commercial sectors are characterized by a diverse array of energy uses and varying sizes and types of buildings in a wide range of climates. As a result, there is no single method to improve efficiency. Rather, a broad array of technologies are available to reduce GHGs and criteria pollutants through increasing end-use efficiency. These technologies could potentially reduce GHG emissions by approximately 20 per cent, and SO_x and NO_x emissions by 20 to 30 per cent in both the residential and commercial building sectors.[6]

The residential sector uses approximately 20 per cent of the fossil fuel consumed in the U.S. Water heating is a main area where energy efficiency can be improved. For instance:

- new low-flow showerheads have a maximum flow rate of half that of older showerheads, and installing one can reduce hot water consumption for bathing by 30 per cent. A new top-quality, low-flow showerhead costs between $10 and $20 and will pay for itself within four months;

- leaky faucets and showerheads can be repaired; a leak of one drip per second can cost $1 per month;

- high-efficiency clothes washers now on the market can reduce hot water use by 60 per cent or more compared with today's average new washer, and by almost 75 per cent compared to an older washer; and

- high efficiency dishwashers can cut hot-water use by about 20 per cent, compared to new machines that are already using about 30 per cent less water than older, existing products.

Also, new lighting technologies and the employment of existing technologies that are intelligently matched to the appropriate lighting needs can achieve significant emission reductions. High-efficiency fluorescent lamps, for example, use less than one-half the energy of incandescent fixtures. Compact fluorescent lamps are another alternative that similarly results in a reduction of energy use in the residential sector. In addition, automatic lighting controls can serve as a supplement or replacement for manual controls.

These strategies have the potential to mitigate GHGs significantly, and as the Five-Labs Study results suggest, most of the strategies will also reduce SO_x and NO_x.

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6 Ibid.

Similar multiple reductions are also possible within the commercial sector. In the commercial sector, the largest potential for reducing energy use lies in motor drive systems. Motor systems include motor equipment, fans and pumps and transmissions or drivetrains. These systems consume approximately two-thirds of the total electricity in the U.S., and much of this electricity is used very inefficiently. For example, motors are often oversized for their applications, reducing their efficiency. Surveys suggest that about one-fifth of motors above five horsepower are running at or below 40 per cent of rated load. Replacing these oversized motors with smaller, more efficient motors allows the new motors to maintain higher efficiency levels over a wider operating range. In general, optimizing system design, rather than simply choosing individual components, can lead to improvements of 60 per cent using existing technology.[7]

Policies to support increased end-use efficiency include revised building codes and subsidies designed to help overcome market barriers to the adoption of new technologies. Many state and municipal building codes have incorporated more stringent energy requirements in their building codes as a means to reduce energy use. For example, California, Florida, Minnesota and Oregon have developed codes 5 to 30 per cent more stringent than the national Model Energy Code, developed by the Council of American Building Officials.[8] California's Title 24 program is among the nation's most innovative and successful; since 1977, building and appliance efficiency programs administered by the state have saved more than $11 billion in energy costs.[9]

In addition, most states currently subsidize efficiency upgrades via a surcharge on electricity sales, and in general, these subsidies are being maintained as states move to competitive electric industries.

1.3 Mobile sources

The mobile source sector is responsible for more than a quarter of all GHG emissions in the U.S. High levels of motor vehicle ownership, sprawling land use patterns, limited public transit service, subsidies to the oil industry and low gasoline prices have been major factors in increasing vehicle miles traveled (VMT), and as a result, GHG emissions over the past decade. Since 1990, GHG emissions from transportation have grown by almost 9 per cent. In 1996, the sector was responsible for more than 30 per cent of the CO_2, more than 40 per cent of NMVOC, 50 per cent of the NO_x and 80 per cent of the CO emitted in the U.S.

Significant GHG reductions in the transportation sector will require a comprehensive approach that unites technology- and policy-based strategies. In spite of rising GHG emissions from the transportation sector in recent years, there are several reasons to be optimistic. Aggressive efforts are underway at the state and federal levels to reduce urban sprawl and constrain, if not eventually reverse, the steady growth in the use of vehicles. Fuel-efficient and advanced technologies under development by major auto manufacturers and other researchers have the potential to reduce fossil-fuel consumption considerably over time.

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7 Esource, *Technology Atlas Series* (Boulder, CO, 1997).

8 Alliance to Save Energy, *Report Card on State Residential Building Codes* (Washington, D.C., 1995).

9 California Energy Commission (*Title 24: California Energy Efficiency Standards for Residential and Non-Residential Buildings*) 1998. The regulations are available at *http://www.energy.ca.gov/title24/index.html.*

Strategies to reduce transportation-related GHG emissions can address either vehicle emissions per mile driven or the demand for mobility in general. Strategies to reduce emissions per mile driven are generally technology-based. Examples include improvements in fuel efficiency and shifts to new technologies that rely on lower- and zero-carbon fuels. In contrast, strategies to reduce the use of vehicles are generally policy based, such as policies to:

- limit urban sprawl;
- manage traffic; and
- promote use of public transportation.

When the distance traveled per unit of fuel is increased, CO_2 emissions decrease. The U.S. has mandatory fuel-efficiency standards for automobiles, called "Corporate Average Fuel Economy" (CAFE) standards, which require auto manufacturers to maintain a minimum fleet average fuel efficiency for all cars and light trucks sold in a given year. The average fuel economy of the total light-duty fleet has actually declined over the past decade as a result of increasing sales of light-duty trucks and sport utility vehicles, which are held to a lower CAFE standard. Largely as a result of this trend, the overall efficiency of the total light-duty fleet has deteriorated over the past decade.

The U.S. DOE and the Big Three automakers have been involved in the Partnership for a New Generation of Vehicles (PNGV), a cooperative effort to develop a car with a fuel efficiency of 80 miles per gallon. In January 1998, the PNGV selected hybrid-electric vehicles, direct-injection engines, fuel cells and lightweight materials as the most promising technologies to achieve their fuel-efficiency goal.

Another opportunity to lower mobile-sector GHG emissions lies in the use of alternative fuels and advanced technologies, rather than traditional fossil-fueled internal combustion. Of the advanced vehicle technologies, the most promising for near-term commercialization are hybrid electric vehicles (HEVs). HEVs utilize two power sources, and one or both can be used depending on the amount of energy needed. Vehicles combining electric drives with fuel cells or diesel engines hold particular promise.

Progressive vehicle emission requirements at the state level can promote the development of fuel-efficient and advanced vehicle technology by increasing the pressure on automobile manufacturers to develop advanced technology vehicles. California was granted the authority to establish its own vehicle emission requirements by the Clean Air Act. As a result, since 1994, the California Low-Emission Vehicle (LEV) Program has required successively lower average annual emission rates from new vehicles sold in the state and has promoted the introduction of zero-emission vehicles (ZEVs). Other states have aggressively pursued adoption of the California LEV program. The California ZEV sales requirement has spurred tremendous technological advances in electric vehicles and hybrid drive vehicles. The ZEV mandate will require ZEVs to potentially comprise up to 10 per cent of the sales of the major car companies.

Finally, policy-based strategies that reduce the use of motor vehicles are crucial to an overall GHG reduction strategy for the transportation sector. These strategies can focus on:

- land use patterns—encouraging people to live near their workplaces;
- shifting the cost of driving from indirect costs, like annual taxes, to direct costs incurred by actually driving;
- managing traffic to reduce idling time; and
- enhancing public transportation systems.

1.4 Municipal solid waste

Municipal solid waste (MSW) management in the U.S. is responsible for a substantial portion of the nation's anthropogenic emissions of methane, a potent GHG. However, the emissions of criteria air pollutants from the MSW sector are relatively small. As a consequence, while there are many options for reducing GHG emissions from this sector, there are few opportunities for harmonizing these reductions with criteria air pollutant reductions. Opportunities are available, however, for co-control of other pollutants (e.g., hazardous air pollutants from landfills).

The methane emissions from MSW come from landfills, which are the largest single anthropogenic source of methane emissions in the U.S. Municipal solid waste landfills account for over 95 per cent of landfill methane emissions, with industrial landfills accounting for the remainder.

There are two basic approaches for reducing emissions of methane and other gases from landfills.

- Landfill gas can be recovered and either flared or used as an energy source. A system to collect and flare landfill gas will convert virtually all of the methane in landfill gas to CO_2. Alternatively, the landfill gas may be collected and used for energy recovery. Because methane's global warming potential is 21 times higher than CO_2, most of the benefits of those systems are associated with destroying the methane emissions. Simply collecting and flaring landfill gas achieves about 95 per cent of the GHG reductions that are possible by collecting landfill gas and using it for energy recovery. Energy recovery reduces GHG emissions by an additional 5 per cent by displacing higher-carbon fossil-fuel combustion (i.e., oil or coal).
- The quantity of degradable organic waste that is disposed in landfills can be reduced either by limiting the quantity of waste through source reduction or recycling, or by managing the waste in other ways, notably composting. Source reduction and recycling reduces GHG emissions mainly by reducing the use of energy at the manufacturing stage. Composting of organic materials is an aerobic process that avoids the methane emissions associated with anaerobic landfills.

Policy-based strategies in the municipal solid waste sector should be designed to promote recycling, source reduction, composting and other GHG reduction strategies, such as emission trading.

1.5 Agriculture and forestry

Although the emissions from the agriculture and forestry sectors are relatively low, there are tremendous opportunities in these two sectors to reduce GHGs. Altering farming practices and enhancing carbon sequestration provide two opportunities to reduce GHG concentrations in the atmosphere. Many sequestration opportunities represent "win–win" situations that need only to be identified, publicized and officially encouraged to make significant contributions to both climate change and pollution control efforts. As Chapters VIII, *Agriculture and Forestry* and IX, *Carbon Sequestration* discuss, carbon is constantly moving through the carbon cycle and changes in human activities can increase net storage of carbon in terrestrial systems (thereby delaying or preventing its return to the atmosphere). In many cases it is less expensive to sequester a ton of carbon in biomass than to reduce a ton of carbon emissions. Carbon sequestration can be accomplished in either of two ways:

- increase the rate and amount which carbon is sequestered by living plants; and
- decrease the rate and quantity of decomposition or combustion of existing carbon stocks in soils and forests.

Many industries convert biological waste into usable energy. The same practice can be applied to the agricultural sector. For example, biomass can be converted into gaseous fuel by covering a lagoon filled with animal waste and capturing the gas, primarily methane, as it is produced by the decomposition process. In fact, employing one of these strategies has the potential to reduce methane emissions by 80 per cent on large farms (over 500 dairy cows or 2,000 hogs) in warm climates (see Chapter VIII, *Agriculture and Forestry*). Additionally, using a combination of chemicals and enzymes to break down plant cellulose to sugars that ferment into ethanol can produce liquid fuel. Biomass can also be burned directly to produce electricity, process heat or both. If the energy generated displaces fossil-fuel combustion, emissions of all pollutants, GHGs and conventional pollutants are reduced.

Forests can also be managed to maximize carbon sequestration. One study estimates that between 131 and 200 million metric tons of carbon equivalent (MMTCE) could be offset each year in the U.S. by:

- selecting trees that increase timber growth;
- encouraging longer rotations between harvest cycles;
- ensuring harvesting practices preserve carbon stored in the soil and remaining trees;
- managing forest wastes especially from forest harvests; and
- selecting appropriate uses of prescribed fire.

Policies to reduce emissions of GHGs and conventional air pollutants are only one part of a more complex mix of regulations designed to protect ecosystems. Currently, the areas of environmental regulation that could have an impact on the speed at which carbon is sequestered on U.S. lands include:

- forest management laws;
- water quality programs such as best management practices;
- land use regulation; and
- wetland protection programs.

If emission trading becomes an approved part of the implementation of the Kyoto Protocol, and mitigation credits can be earned by the creation of sequestration projects, the result could be significant financial incentives that would dramatically increase mitigation on the land. Since many sequestration projects result in reductions of both GHGs and other air pollution emissions, the development of these programs is also an important issue for air quality programs.

In order for these trading systems to be successfully adapted to agriculture and forestry programs, several challenges need to be resolved, including:

- development of acceptable methods for measuring the emission reduction values of agriculture and forestry activities; and
- creation of local institutional structures that can work with landowners to install and monitor approved practices, and assemble portfolios of project credits that will be sufficiently large, diverse and credible to attract investors.

Some of these issues will be addressed by the *Intergovernmental Panel on Climate Change Special Report on Forestry and Land Use Change*, due to be released in mid-2000. Decisions based on that report will be very important in establishing the technical framework for implementing any emissions trading or mitigation scheme in both the agriculture and forestry sectors.

1.6 Market-based strategies

Market-based strategies will play a key role in cost-effectively reducing GHG emissions at the local, state, national and international levels. Many state and local agencies are involved with EPA’s State and Local Climate Change Program to 1) inventory their GHG emissions; 2) create State Action Plans that identify policy options to reduce those emissions; and 3) implement their state’s Action Plan. The policy options recommended so far in these plans are focused on the creation of market incentives to increase energy efficiency, promote alternative fuel and renewable energy use, reduce VMT and internalize the environmental cost of CO_2 emissions.

Market strategies, for the most part, are not sector-specific. Rather, these mechanisms are typically viewed as “cross-cutting” strategies; that is, they can be applied to a variety of sectors, although with varying degrees of effectiveness. There is not a single “one-size-fits-all” market mechanism to reduce GHG that can be applied to every local area and state. Each area has a unique combination of sources contributing to its emissions inventory. As a result, a different mix of market-based strategies will be optimal in different areas. For instance, allowance trading is generally viewed as an effective form of emission trading to reduce GHG emissions from the electricity sector. However, it is less well suited for smaller sources, such as personal vehicles. A better market-based mechanism for smaller, disperse sources might include subsidies for alternative fuels and rebates for the purchase of low emitting vehicles.

Because GHG reductions have not been required in the U.S., little actual experience exists in applying market mechanisms towards the achievement of GHG reduction goals. However, experience with the application of market-based strategies to criteria pollutants provides a useful indication of the issues that are relevant to the application of each mechanism to GHGs.

From a domestic perspective, major source sectors such as electric generators are likely to be targeted with a cap-and-trade mechanism. For example, if the U.S. reduction goal for the electric generating sector were proportional to the reduction obligation under the Kyoto Protocol, then electric generators would have average annual caps for the first budget period (2008 through 2012) set at approximately 450.68 million metric tons carbon equivalent (MMTCE), which is 7 per cent below the sector's 1990 GHG emissions (484.6 MMTCE). If GHG emission levels from the generating sector continued as projected and, by 2010, were to reach a 34 per cent increase over 1990 levels (or approximately 649.36 MMTCE),[10] the emission cap would represent an annual reduction of 198.68 MMTCE or a total of 993.42 MMTCE for the first five-year budget period.

Market incentives have also been used successfully to encourage energy efficiency. The federal government has sponsored energy-efficiency programs for industry and utilities have designed energy-efficiency incentives for potential commercial or industrial energy-efficiency clients.

An excellent example of this concept has been demonstrated by the Indiana Department of Commerce, Office of Energy Policy, which coordinated the design and implementation of a Home Energy Rating System/Energy-Efficient Mortgage (HERS/EEM) program. The HERS/EEM mechanism has two components. The first is a rating system that will classify new and existing homes according to their energy efficiency. This efficiency rating provides 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 homebuyers to make informed decisions regarding the costs of operating a home.

- By giving regulated sources flexibility in choosing the means of compliance, market mechanisms can allow the target environmental goals to be realized at lower costs, and can encourage innovation as well.

1.7 Harmonized measures – Reducing criteria pollutants and greenhouse gases

As this document details and this summary has highlighted, there is an important relationship between GHG mitigation and conventional air pollutant control. To evaluate the emission impacts of harmonized strategies, an assessment model has been developed to estimate reductions of criteria pollutants and GHGs in the electricity, commercial and residential, transportation and industrial sectors. It is important to note that the assessment model has been designed to compare the relative magnitudes of emission reductions that can be expected from source sectors in different regions by implementing these strategies.

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[10] U.S. Energy Information Administration, *Annual Energy Outlook 1999*, Washington, D.C., December 1998.

Four areas of the U.S., the state of New Hampshire; Atlanta, Georgia; Louisville, Kentucky and Ventura County, California, serve as case studies for the assessment of selected harmonized strategies. The areas that participated in these case studies are not currently implementing the strategies identified, nor have they committed to implement these strategies. The purpose of these case studies is to begin to evaluate the potential carbon reductions available from comprehensive harmonized strategies.

In most areas, the electric or transportation sector is the largest aggregate emitter of GHGs, with each one typically accounting for 35 per cent to 40 per cent of total emissions. Industrial sources are usually the third largest emitters, followed by the commercial/residential sector. Therefore, harmonized strategies focused on these source sectors. Each area chose its own mix of harmonized strategies, which included:

- switching to natural gas-fired steam generation at an existing coal- or oil-fired unit;
- replacing existing fossil-fueled steam cycle capacity with natural gas-fired combined-cycle capacity;
- replacing fossil-fueled power generation with renewable generation (e.g., wind, solar, hydro and biomass);
- replacing fossil-fueled power generation with primary or distributed fuel cell generation;
- reducing electricity consumption via improved end-use efficiency;
- establishing cogeneration systems at power plants and industrial sources;
- improving transportation fuel efficiency; and
- reducing vehicle use, by increasing such alternatives as carpooling, mass transit and telecommuting.

In aggregate, the results of the model for the four case study areas demonstrate that a range of effective strategies exist that can reduce GHG emissions and also contribute to criteria pollutant reduction goals. The distribution of emission reduction impacts among the four areas is a result of their different emission inventory profiles, their respective nonattainment status for criteria pollutants and the control strategies already adopted or to which the area has already committed.

This analysis indicates that the 7-percent reduction in GHG emissions targeted for the U.S. in the Kyoto Protocol is well within reach of most states and localities. The harmonized control strategies also provide additional criteria pollutant reductions required to meet current and future clean air mandates. Table 2 summarizes the total per cent reductions from baseline emissions that each area would realize with its package of harmonized control strategies.

Table 2. **Percent reduction from baseline emissions in four case study areas**

Area	SO_2	NO_x	PM	VOC	CO	CO_2
New Hampshire	41%	17%	12%	3%	4%	12%
Atlanta, GA area	40%	6%	1%	3%	4%	7%
Louisville, KY area	26%	14%	3%	3%	4%	15%
Ventura County, CA	2%	4%	1%	4%	4%	11%

Source: STAPPA/ALAPCO, 1999.

2. Conclusion

Many effective opportunities exist at the federal, state and local levels to reduce GHG emissions and, at the same time, achieve substantial criteria pollutant reductions. These strategies are generally technically feasible and cost-effective and can play a substantial role in meeting current and future clean air mandates, including the Kyoto Protocol.