Environmental Issues and World Energy Use

In the coming decades, responses to environmental issues could affect patterns of energy use around the world. Actions to limit greenhouse gas emissions could alter the level and composition of energy-related carbon dioxide emissions by energy source.

Two major environmental issues, global climate change and local or regional air pollution, could affect energy use throughout the world in the coming decades. Future actions to limit carbon dioxide emissions and global efforts to reduce the potential impacts of climate change, as well as localized policies and regulations designed to limit energy-related emissions of airborne pollutants other than carbon dioxide, are likely to affect the level, composition, and growth of global energy use.

In recent years there has been ongoing study and debate about the possible contribution of energy-related emissions of carbon dioxide and other greenhouse gases to global climate change, defined by the Intergovernmental Panel on Climate Change (IPCC) as "a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer) . . . [which] may be due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use" [***1***]. Carbon dioxide, one of the most prevalent greenhouse gases in the atmosphere, has two major anthropogenic (human-caused) sources: combustion of fossil fuels and changes in land use. Net releases of carbon dioxide from these two sources are believed to be contributing to the rapid rise in atmospheric concentrations of carbon dioxide since pre-industrial times. Because estimates indicate that approximately 80 percent of all anthropogenic carbon dioxide emissions come from fossil fuel combustion, world energy use has emerged at the center of the climate change debate [***2***].

At the same time, concern about the local environmental and air quality impacts of mobile and stationary energy consumption have resulted in increasingly stringent regulation of air pollutants such as sulfur oxides, nitrogen oxides,[31] particulate matter, and volatile organic compounds. Some countries are also considering ways to limit emissions of mercury from electric power generation to avoid the possible contamination of land surfaces, rivers, lakes, and oceans.

Global Outlook for Carbon Dioxide Emissions

The *International Energy Outlook 2003* (*IEO2003*) projects emissions of energy-related carbon dioxide, which, as noted above, account for the majority of global anthropogenic carbon dioxide emissions. Based on expectations of regional economic growth and dependence on fossil energy in the *IEO2003* reference case, global carbon dioxide emissions are expected to grow more rapidly over the projection period than they did during the 1990s. A projected increase in fossil fuel consumption, particularly in developing countries, is largely responsible for the expectation of fast-paced growth in carbon dioxide emissions. Factors such as population growth, rising personal incomes, rising standards of living, and further industrialization are expected to have a much greater influence on levels of energy consumption in developing countries than in industrialized nations. Energy-related emissions are projected to grow most rapidly in China, the country expected to have the highest rate of growth in per capita income and fossil fuel use over the forecast period.

Carbon intensity—the amount of carbon dioxide emitted per dollar of gross domestic product (GDP)—is projected to improve (decrease) throughout the world over the next two decades (Table 28). In particular, steep rates of improvement are expected among the transitional economies of Eastern Europe and the former Soviet Union (EE/FSU). In the FSU, economic recovery from the upheaval of the 1990s is expected to continue throughout the forecast. The FSU nations are also expected to replace old and inefficient capital stock and increasingly use less carbon-intensive natural gas for electricity generation and other end uses in place of more carbon-intensive oil and coal. Eastern European nations have been in economic recovery longer than has the FSU, and natural gas is expected to continue to displace coal use in the region, resulting in an average 2.8-percent annual improvement (decrease) in carbon intensity for Eastern Europe as a whole.

[31] Nitrogen oxides (NO_x) is the term used to describe the sum of nitric oxide (NO), Nitrogen dioxide (NO_2), and other oxides of nitrogen that are short-lived atmospheric gases that are produced by the burning of fossil fuels and play a major role in the formation of ozone (smog). Nitrous oxide (N_2O), discussed later in this chapter, is a long-lived atmospheric gas produced primarily as a result of nitrogen fertilization of soils, mobile source combustion, and the decomposition of solid waste from domesticated animals. Nitrous oxide is a powerful greenhouse gas.

Table 28. Carbon Intensities for Selected Countries and Regions, 2000-2025
(Metric Tons Carbon Equivalent per Thousand 1997 Dollars of GDP)

Country or Region	2001	2005	2010	2020	2025	Annual Percent Change, 2000-2025
United States	166	154	144	124	116	-1.5
Canada	209	203	190	157	146	-1.5
Mexico	213	212	193	169	161	-1.1
United Kingdom	104	95	88	77	72	-1.5
France	68	61	55	49	48	-1.4
Germany	98	90	83	70	67	-1.5
Australia/New Zealand	199	189	180	155	148	-1.2
Former Soviet Union	1,000	1,012	862	691	621	-2.0
Eastern Europe	518	430	380	291	261	-2.8
China	693	555	506	400	363	-2.7
India	480	425	386	313	285	-2.1
South Korea	217	185	169	147	137	-1.9
Turkey	270	279	270	234	220	-0.9
Brazil	109	111	110	103	97	-0.5

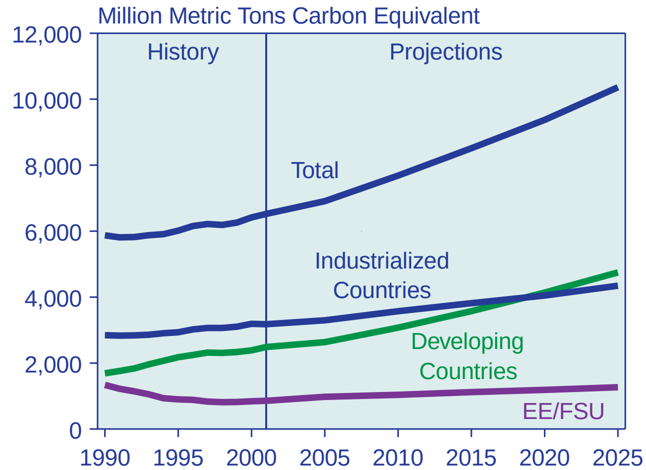
Sources: **2001:** Derived from Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/. **2005-2025:** EIA, System for the Analysis of Global Energy Markets (2003).

Fairly rapid improvement in carbon intensity is also projected for the large developing countries China and India, primarily as a result of rapid economic growth rather than a switch to less carbon-intensive fuels. Both China and India are projected to remain heavily dependent on fossil fuels, particularly coal, in the *IEO2003* reference case, but their combined annual GDP growth is projected to average 5.9 percent, compared with an expected 3.4-percent annual rate of increase in fossil fuel use from 2001 to 2025.

In 2001, carbon dioxide emissions from industrialized countries were 49 percent of the global total, followed by developing countries at 38 percent and the EE/FSU at 13 percent. By 2025, developing countries are projected to account for the largest share of world carbon dioxide emissions, at 46 percent, followed by the industrialized world at 42 percent and the EE/FSU at 12 percent. The *IEO2003* projections indicate that carbon dioxide emissions from developing countries could surpass those from industrialized countries by 2020 (Figure 84).

In the industrialized world, almost one-half of energy-related carbon dioxide emissions in 2001 came from oil use, followed by coal at 31 percent (Figure 85). Over the forecast period, oil is projected to remain the primary source of carbon dioxide emissions in industrialized countries because of its continued importance in the transportation sector, where there are currently few economical alternatives. Natural gas use and associated emissions are projected to increase substantially, particularly for electricity generation. By 2025, the share of natural-gas-related emissions, at 26 percent, is expected to be almost equal to that of coal.

Figure 84. World Carbon Dioxide Emissions by Region, 1990-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2003).

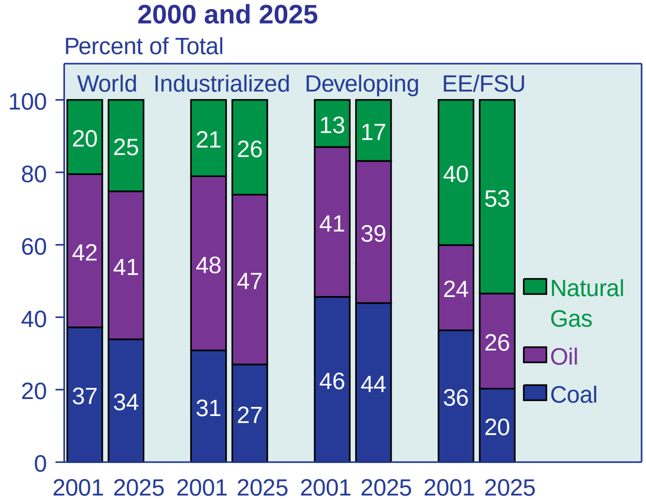
The United States is currently the largest energy consumer in the industrialized world, accounting for the majority of its energy-related carbon dioxide emissions. Natural gas and coal use for electricity generation in the United States are projected to increase over the forecast period, whereas generation from nuclear energy is expected to decline after 2010. Absent mandatory carbon reduction policies, no new nuclear plants are expected to be constructed in the United States by 2025, given the more favorable economics of competing technologies.

As a result, U.S. electricity generation is projected to become more carbon intensive over the forecast period.

With the exception of Australia, most other industrialized countries rely much less heavily on coal to meet domestic energy needs than does the United States. In Western Europe, coal consumption is projected to continue to decline over the forecast period as natural gas consumption, particularly for electricity generation, increases. The projected decline in Western Europe's carbon intensity, brought on by the continued shift in the overall energy supply toward more natural gas, is lessened somewhat by the projected decline in nuclear power generation after 2010. Germany and Sweden have committed to shutting down their nuclear power industries, and other European countries are considering similar proposals. Electricity generation from other non-emitting energy sources, such as hydroelectricity and wind power, is not expected to increase sufficiently to offset the drop in nuclear energy production in the region.

In the transitional economies of the EE/FSU region, 40 percent of energy-related carbon dioxide emissions come from natural gas combustion. Coal production and consumption in the EE/FSU declined as a result of economic reforms and industry restructuring during the 1990s, bringing about an increase in the natural gas share of the energy and emissions mix during the period. With further development of the vast natural gas reserves in Russia and the Caspian Sea region, natural gas is expected to continue to displace coal. Oil consumption is also projected to increase in the FSU, particularly for transportation and power generation, as

Figure 85. Shares of World Carbon Dioxide Emissions by Region and Fuel Type, 2000 and 2025



Sources: **2000:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/. **2025:** EIA, System for the Analysis of Global Energy Markets (2003).

Soviet-era nuclear reactors are retired in the coming years. As a result, both natural gas and oil are projected to account for increasing shares of the region's total carbon dioxide emissions, reaching 53 percent and 26 percent, respectively, by 2025.

With further restructuring of the coal mining industries in Poland and the Czech Republic, declines in coal production and consumption are expected to continue. Natural gas consumption is expected to increase significantly in Eastern European countries, in part because of the strict environmental standards required for membership in the European Union (EU). As a result of the projected changes in the energy mix, carbon intensity is expected to decline in Eastern Europe more than in any other region over the forecast period. Nevertheless, because the decline in carbon intensity is not expected to keep pace with growth in total energy consumption, annual carbon dioxide emissions in the region are expected to increase by nearly 35 percent between 2001 and 2025.

Compared with most of the industrialized countries, a much larger share of energy consumption in developing countries (particularly in Africa and Asia) comes from biomass, which includes wood, charcoal, animal waste, and agricultural residues. Because data on biomass use in developing nations are often sparse or inadequate, *IEO2003* does not include the combustion of biomass fuels in its coverage of current or projected energy consumption. For the United States, combustion of biomass is counted in energy consumption; however, because carbon dioxide emissions from biomass are considered to be part of the natural carbon cycle, they are not included in projections of anthropogenic carbon dioxide emissions.

Of the fossil fuels, oil and coal currently account for the majority of total energy-related carbon dioxide emissions in the developing world, and they are projected to remain the dominant sources of emissions throughout the forecast period. China and India are expected to continue to rely heavily on domestic coal supplies for electricity generation and industrial activities. Most other developing regions are expected to continue to depend on oil to meet the majority of their energy needs, especially in light of the projected increase in transportation energy demand.

The largest increases in energy consumption and carbon emissions are projected for China, given the expectations for continued economic expansion and population growth. Coal reserves are abundant in China, and access to other energy fuels is limited in many parts of the country. In Central and South America, carbon dioxide emissions are expected to double between 2001 and 2025 as a result of increasing energy demand and shifts in the mix of energy fuels consumed. Many countries in

Central and South America, most notably Brazil, have relied heavily on hydropower to provide the majority of their electricity in the past; but by 2025 natural gas is expected to be a larger part of the region's energy mix.

Future levels of energy-related carbon dioxide emissions in many countries are likely to differ significantly from *IEO2003* projections if measures to mitigate greenhouse gas emissions are enacted, such as those outlined under the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC). The Kyoto Protocol, which calls for limitations on greenhouse gas emissions (including carbon dioxide) for developed countries and some countries with economies in transition, could have profound effects on the future fuel use of countries that ratify the protocol. Because the Kyoto Protocol has not yet come into force, the *IEO2003* projections do not reflect the potential effects of the treaty or of any other proposed climate change policy measures.

Issues in Energy-Related Greenhouse Gas Emissions Policy

International Climate Change Negotiations

The world community's effort to address global climate change has taken place largely under the auspices of the UNFCCC, which was adopted in May 1992 at the first Earth Summit held in Rio de Janeiro, Brazil, and entered into force in March 1994. The ultimate objective of the UNFCCC is the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" [***3***]. That objective was reinforced during the second Earth Summit held in Johannesburg, South Africa, during the summer of 2002, where the world community reaffirmed its commitment to the principles of the Framework Convention (see box on page 161). The most ambitious proposal coming out of the annual conferences held to implement the UNFCCC has been the Kyoto Protocol, which was developed in December 1997 at the Third Conference of the Parties (COP-3). The terms of the Kyoto Protocol call for Annex I countries to reduce their overall greenhouse gas emissions by at least 5 percent below 1990 levels over the 2008 to 2012 period. Quantified emissions targets are differentiated by country.[32]

In addition to any domestic emission reduction measures that Annex I parties may choose to implement in order to meet their emission targets, the Kyoto Protocol allows the use of three "flexibility mechanisms" (sometimes called "Kyoto mechanisms" or "market-based mechanisms"):

- *International emissions trading* allows Annex I countries to transfer some of their allowable emissions to other Annex I countries, beginning in 2008, for the cost of an emission credit. For example, an Annex I country that reduces its 2010 greenhouse gas emissions level by 10 million metric tons carbon equivalent more than needed to meet its target level can sell the "surplus" emission reductions to other Annex I countries.
- The *clean development mechanism* (CDM) allows Annex I countries, through governments or other legal entities, to invest in emission reduction or sink enhancement projects in non-Annex I countries, gain credit for those "foreign" emissions reductions, and then apply the credits toward their own national emission reduction commitments.
- *Joint implementation* (JI) is similar to the clean development mechanism, but the investment in emission reduction projects must occur within the Annex I countries.

The Kyoto targets refer to overall greenhouse gas emission levels, which encompass emissions of carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. Hence, a country may opt for relatively greater reductions of other greenhouse gas emissions and smaller reductions of carbon dioxide emissions, or vice versa, in order to meet its Kyoto obligation. Currently, carbon dioxide emissions account for the majority of greenhouse gas emissions in most Annex I countries, followed by methane and nitrous oxide [***4***].

Changes in emission levels resulting from human-induced actions that release carbon dioxide and other greenhouse gases or remove them from the atmosphere via "sinks" (trees, plants, and soils) are also allowed as reductions under the Protocol, subject to certain restrictions. The extent to which each Annex I party makes use of sinks and the mechanisms for counting the offsets will influence the amounts needed in domestic emission reductions needed to comply with the Protocol.

Details of the operation of the Kyoto Protocol have been the subject of several UNFCCC meetings since COP-3.

[32]The Annex I nations include Australia, Austria, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, European Community, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, the Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, and the United Kingdom. Turkey and Belarus, which are represented under Annex I of the UNFCCC, do not face quantified emission targets under the Kyoto Protocol. The Kyoto Protocol includes emission targets for 4 countries not listed under Annex I—namely, Croatia, Liechtenstein, Monaco, and Slovenia. Collectively, the 39 parties facing specific emissions targets under the Kyoto Protocol are commonly referred to as "Annex B parties," because their targets were specified in Annex B of the Protocol.

The finalized agreements reached by the end of COP-7, held in Marrakech, Morocco, in fall 2001 stipulate that forests, cropland, and grazing land management can be used to increase the amount of carbon sequestered in biologic sinks during the first commitment period (2008-2012), subject to some country-specific upper bounds; afforestation and reforestation projects can be eligible for the CDM; and no quantitative limits can be placed on JI, CDM, and emissions credit trading as means of meeting the Kyoto commitments. The Bonn

Johannesburg, South Africa, 2002 World Summit on Sustainable Development

From August 26 to September 6, 2002, the United Nations World Summit on Sustainable Development was held in Johannesburg, South Africa. Its objective was to review progress on sustainable development commitments made at earlier international meetings—such as the UN Conference on Environment and Development (Rio de Janeiro, 1992)—and to develop an action plan for protecting the environment and eradicating poverty in coming decades, which is the goal of sustainable development.[a]

The summit produced few hard targets or timetables. In particular, no further commitments were made to address the issue of climate change aside from a general reaffirmation of the principles of the UNFCCC and a statement by countries that have ratified the Kyoto Protocol strongly urging other states to follow suit. Several of the decisions that were adopted,[b] as summarized below, will have implications for future energy use in developed and developing countries.

- *Renewable Energy*: Diversify energy supply and substantially increase the global share of renewable energy sources.
- *Access to Energy*: Improve access to reliable, affordable, economically viable, socially acceptable and environmentally sound energy services and resources, sufficient to achieve the Millennium Development Goals, including the goal of halving the proportion of people in poverty by 2015.
- *Energy Markets:* Remove market distortions, including restructuring of energy taxes and phasing out harmful subsidies.

Specific funding initiatives from the summit that target the energy sector are described in the table below.

Energy-Related Funding Announcements From the Johannesburg Summit

Sponsor	Funding Initiative
Canada	By 2003, eliminate all tariffs and quotas on products from least developed countries. Double development assistance by 2010.
European Union	$700 million partnership initiative on energy. $3 billion for Global Environment Facility. Raise development assistance by 22 billion euros until 2006 and 9 billion euros annually from 2006 onward.
Germany	500 million euros over next 5 years to promote cooperation on renewable energy.
Japan	Environment-related training of 5,000 overseas people during a 5-year period.
Norway	$50 million for implementing Johannesburg commitments.
United Kingdom	Double assistance to Africa to £1 billion a year; 50-percent increase in assistance to all countries.
United States	Up to $43 million for energy partnerships and projects in 2003.
E7 Electricity Companies[a]	Agreements with the UN on technical cooperation for sustainable energy projects in developing countries.
UN Environment Programme	Launched Global Network on Energy for Sustainable Development to promote research, transfer and deployment of green and cleaner technologies to the developing world.
UN Environment Programme, UN Department of Economic and Social Affairs (DESA), U.S. Environmental Protection Agency	Partnership with DESA and U.S. EPA on cleaner fuels and vehicles, with partners from private sector, nongovernment organizations, developed and developing countries.

[a]American Electric Power (U.S.), Electricité de France (France), Enel (Italy), HydroQuébec (Canada), Ontario Power Generation (Canada), Kansai Electric Power (Japan), RWE (Germany), Scottish Power (UK), and Tokyo Electric Power (Japan).

Note: Funding initiatives targeting such other issues as water, poverty reduction, health, and natural resources are not included in this table.

Source: United Nations Department of Economic and Social Affairs, Division for Sustainable Development, "Johannesburg Summit 2002: Key Outcomes of the Summit" (September 2002), web site www.johannesburgsummit.org/html/documents/summit_docs/2009_keyoutcomes_commitments.pdf.

[a]United Nations Department of Economic and Social Affairs (DESA), Division for Sustainable Development, "World Summit on Sustainable Development: Plan of Implementation," web site www.johannesburgsummit.org/html/documents/summit_docs/2309_planfinal.htm.

[b]United Nations Department of Economic and Social Affairs (DESA), Division for Sustainable Development, "Johannesburg Summit 2002: Key Outcomes of the Summit" (September 2002), web site www.johannesburgsummit.org/html/documents/summit_docs/2009_keyoutcomes_commitments.pdf.

agreement also calls for 2 percent of the revenues raised from certified emission reductions issued for any CDM project to go toward a fund for climate change adaptation projects in developing countries.

A few Kyoto Protocol issues remain unresolved, some of which can be finalized only when the Protocol has entered into force. They include targets and procedures for subsequent commitment periods, accounting rules for carbon sink projects, and whether the consequences for noncompliance in meeting national emission reduction targets should be legally binding. A new debate over next steps in the development of a climate change regime was introduced during the 2002 COP-8 meeting in New Delhi, India, including discussion of binding commitments for developing countries (see box below).

The Kyoto Protocol enters into force 90 days after it has been ratified by at least 55 Parties to the UNFCCC, including a representation of Annex I countries accounting for at least 55 percent of the total 1990 carbon dioxide emissions from the Annex I group. As of February 2003, 104 countries had ratified the Protocol, including Canada, China, India, Japan, Mexico, New Zealand, South Korea, and the European Union. A total of 30 Annex I countries, representing 43.9 percent of total 1990 carbon dioxide emissions, have signed on to the treaty (Figure 86). Two major Annex I countries, Australia and the United States, have announced that they will not adopt the Kyoto Protocol, leaving Russia as the deciding factor for entry into force. With its 17.4 percent of 1990 Annex I carbon dioxide emissions, Russia's ratification of the Protocol would bring the total to 61.3 percent and enable the Kyoto Protocol to enter into force—regardless of the American and Australian decision not to participate. The Russian President has announced Russia's intention to ratify the treaty, but the timing of such action is still uncertain [***5***].

Although the United States has announced that it will not participate in the Kyoto Protocol, the government has introduced a series of alternative measures to reduce greenhouse gas emissions. In 2001, President Bush committed the U.S. government to the pursuit of a broad

COP-8 Climate Change Negotiations in New Delhi, India

The Eighth Session of the Conference of Parties (COP-8) to the UNFCCC was held in New Delhi, India, from October 23 to November 1, 2002, to continue discussion on the Kyoto Protocol and implementation of the UNFCCC. With the Kyoto Protocol not yet in force, agenda items focused mostly on technical issues that had been left out of the Kyoto agreements of COP-6.5 and COP-7. Notable decisions include:

Kyoto Protocol:

- Rules for small-scale CDM projects and accreditation procedures for operational entities.
- Guidelines for tracking emission transfers in a uniform format to allow linkage of JI, CDM, and emissions trading activities in national emission registries.
- Procedures for expert review of registries to assess compliance with requirements on "commitment period reserves" to avoid overselling of allowances.

UNFCCC:

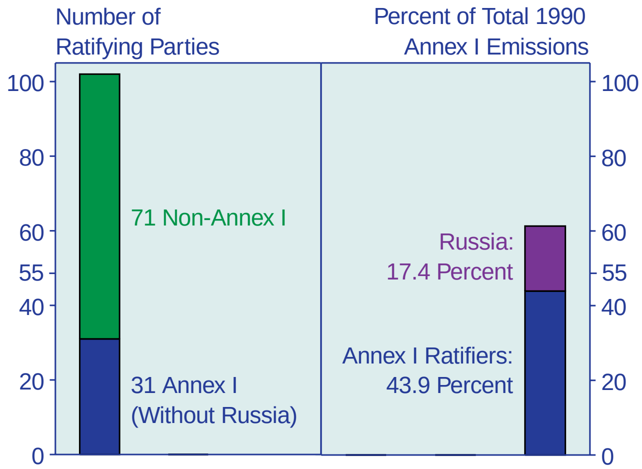
- Guidance for two of the three new developing country funds (the least developed countries fund and the special climate change fund) established at COP-7.
- Invitation to the IPCC and the Montreal Protocol's Technology and Economic Assessment Panel to undertake a special report on hydrofluorocarbons and perfluorocarbons.

Political discussions also focused on potential next steps in the development of a climate change regime, including a debate on the proposed Delhi Ministerial Declaration designed to shape the direction of future negotiations. While the Indian government focused negotiations around developing country concerns, such as vulnerability and adaptation to the effects of climate change, developed countries, led by the EU, focused on the need to develop longer term commitments beyond the first Kyoto commitment period.

In particular, the EU proposed the development of a broader, more inclusive, and balanced process for commitments after 2012, opening the door for inclusion of developing countries in future commitments. This suggestion was met with strong resistance by developing countries. The final Delhi Ministerial Declaration on Climate Change thus excludes references to forward-looking strategies and instead reaffirms and highlights the need for sustainable economic and social development in the developing countries and increased support for adaptation measures.

Sources: Pew Center on Global Climate Change, "Climate Talks in Delhi - COP8: Summary (November 1, 2002), web site www.pewclimate.org/cop8/summary.cfm; Baker & McKenzie, "Climate Change Negotiations: COP8 Outcomes" (December 2002), web site www.ieta.org/Documents/New_Documents/COP8_Outcomes_and_Implications_v3.PDF.

Figure 86. Progress Toward Ratification of the Kyoto Protocol, as of January 1, 2003



Sources: United Nations Framework Convention on Climate Change, web site www.unfccc.int; and S. Ruth and A. Retyum, "CERA Decision Brief: Russia: Holding the Kyoto Trump Card" (Cambridge, MA: Cambridge Energy Research Associates, September 2002).

range of strategies to address the issues of global climate change, launching three initiatives: the Climate Change Research Initiative to accelerate science-based climate change policy development; the National Climate Change Technology Initiative to advance energy and sequestration technology development; and increased international cooperation to engage and support other nations on climate change research and clean technologies [***6***].

On February 14, 2002, President Bush announced the Administration's Global Climate Change Initiative, which calls on the United States to reduce greenhouse gas intensity (total greenhouse gas emissions per unit of gross domestic product) by 18 percent between 2002 and 2012, primarily through voluntary measures (**see box below**). Under the Global Climate Change Initiative, the President directed the Secretary of Energy to propose improvements in the Department of Energy's Voluntary Reporting of Greenhouse Gases Program to enhance the accuracy, reliability, and verifiability of emission reduction measurements reported to the program. Reforms to the program are to ensure that businesses and individuals registering reductions will not be penalized under a future climate policy, and to give transferable credits to companies that can show real emission reductions [***7***, ***8***].

On February 12, 2003, the U.S. Department of Energy, on behalf of President Bush, launched the President's "Climate VISION" (Voluntary Innovative Sector Initiatives: Opportunities Now). Climate VISION is a voluntary, public-private partnership to pursue cost-effective initiatives to reduce the projected growth in U.S. greenhouse gas emissions. The program, to be administered through the Department of Energy, is intended to help meet the President's goal of reducing U.S. greenhouse gas intensity by 18 percent between 2002 and 2012. It involves Federal agencies, including the Department of Energy, Environmental Protection Agency, Department of Agriculture, and Department of Transportation, working with industrial partners to reduce greenhouse gas emissions voluntarily over the next decade. Industry groups making commitments include the Alliance of Automobile Manufacturers, Aluminum Association, American Chemistry Council, American Forest and Paper Association, American Iron and Steel Institute, American Petroleum Institute, American Public Power Association, Association of American Railroads, Business Roundtable, Edison Electric Institute, Electric Power Supply Association, Magnesium Coalition and the International Magnesium Association, National Mining Association, National Rural Electric Cooperative Association, Nuclear Energy Institute, Portland

U.S. Greenhouse Gas Intensity Target

In February 2002, President Bush introduced the Climate Change Initiative to address the issue of global warming. As a cornerstone of the initiative, the President set a target of reducing the greenhouse gas intensity of the U.S. economy by 18 percent over the next 10 years.[a] Greenhouse gas intensity measures the ratio of greenhouse gas emissions (carbon dioxide equivalent) to economic output (dollars of gross domestic product). The intensity-based greenhouse gas reduction target can be met without reducing or stabilizing annual U.S. emissions of carbon dioxide, so long as annual economic growth is greater than the increase in emissions.

The greenhouse gas intensity of the U.S. economy has declined steadily in past decades, and continued declines are expected in the future. The Bush Administration's proposal assumes that, with business-as-usual emissions rates, greenhouse gas intensity will decline by 14 percent between 2002 and 2012. Measures included in the Climate Change Initiative are expected to reduce the intensity by an additional 4 percent, by producing an absolute reduction in emissions of 100 million metric tons carbon equivalent in 2012 and more than 500 million metric tons cumulatively over the 2002-2012 period.

[a]"President Announces Clear Skies & Global Climate Change Initiatives," web site www.whitehouse.gov/news/releases/2002/02/20020214-5.html (February 14, 2002).

Cement Association, and Semiconductor Industry Association.

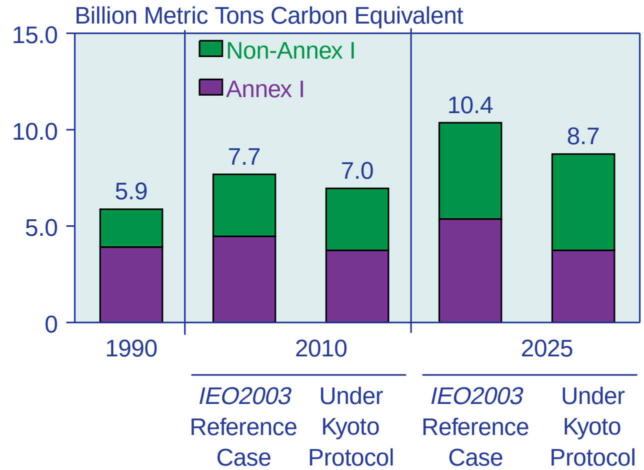
Many other Annex I countries have initiated measures to reduce greenhouse gas emissions and meet projected emissions targets. Policies target all areas of energy use in industry, energy production, transportation, and buildings. Table 29 highlights some of the measures taken by individual countries.

The *IEO2003* reference case projections indicate that energy-related carbon dioxide emissions from the entire Annex I group of countries will exceed the group's 1990 emissions level by 14 percent in 2010 (Figure 87). Taking the prescribed Kyoto emission reduction targets on the basis of energy-related carbon dioxide emissions alone, the industrialized Annex I countries would face an emission limit of 2,575 million metric tons carbon dioxide equivalent in 2010, or 25 percent less than their projected baseline emissions. On the other hand, energy-related carbon dioxide emissions from the group of transitional Annex I countries have been decreasing since 1990 as a result of economic and political crises in the EE/FSU. The combined Kyoto Protocol reduction target for the transitional Annex I countries is 10 percent below their projected 2010 baseline emissions. Of the industrialized Annex I countries, Finland, Germany, Luxembourg, Sweden, and the United Kingdom had reduced energy-related carbon dioxide emissions below their 1990 levels in 2000.

Greenhouse Gas Emissions Trading

At COP-7 in Marrakech, it was established that international emissions trading under the Kyoto Protocol could start as of 2008. In advance of any international emissions trading under the Protocol, however, some Annex I parties have established or are in the process of establishing their own internal greenhouse gas emissions trading programs. The economic rationale behind emissions trading is to reduce the costs associated with achieving a set reduction in greenhouse gases. Trading works by encouraging the covered participants with low-cost options to reduce their emission levels to below their allotted share and to make the surplus reductions

Figure 87. Carbon Dioxide Emissions in Annex I and Non-Annex I Nations Under the Kyoto Protocol, 2010 and 2025



Sources: **1990:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/. **2010 and 2025:** EIA, System for the Analysis of Global Energy Markets (2003).

Table 29. Sample Policies and Measures To Reduce Greenhouse Gas Emissions in Annex I Countries

Regulatory Instruments	Policy Processes	Fiscal Instruments	Voluntary Agreements	Tradable Permits
United States (California): Carbon dioxide emission reductions for cars and light-duty vehicles (2002)	Australia: Campaign for energy efficiency awareness	Denmark, Finland, Italy, Netherlands, New Zealand, Norway, and Sweden: Carbon tax	Australia: Industry-owned green electricity market	United Kingdom: Emissions trading system (2002)
Norway: Energy labels for household appliances	France: Mass media climate change campaign	Luxembourg: Grants for purchase of efficient vehicles (2001)	Japan: Industry (Keidanren) action plan to reduce emissions	Austria: Green certificate trading (2000)
Finland: Replacing coal-fired power generation	United Kingdom: The Carbon Trust, a nonprofit organization to promote energy efficiency in nondomestic sectors	United Kingdom: Road taxation linked to carbon dioxide emissions	European Union: Agreement with European/Korean/Japanese car manufacturers to increase vehicle efficiency of new models (2000)	Denmark: Carbon dioxide emission trading
Australia: Fuel consumption labels on cars (2001)	Belgium: Planning to increase rail transport by 15 percent	Canada: Subsidies for commercial and institutional building retrofits	Germany: Industrial and energy sector promotion of combined heat and power generation	Belgium: Combined heat and power certificate market
United Kingdom: Renewables obligation on electricity supply		Netherlands: "Eco-tax" exemptions for green electricity use		

Notes: Regulatory instruments include mandates, standards, and regulations. Policy processes include planning, information, and consultation. Fiscal instruments include taxes, tax exemptions/credits, incentives, and subsidies. Voluntary agreements are with industry/consumer groups.

Source: Energy information Administration, Office of Integrated Analysis and Forecasting.

available to participants whose reduction options are more costly.

One framework for emissions trading is "cap and trade," whereby a regulatory authority would establish a permanent cap on aggregate emissions for a group of emitters. The cap could, for example, be set at a fraction of the historic emissions from the group of participants. The cap would be divided into a set number of allowances, each of which would give the holder the right to emit a specified quantity of the regulated pollutant in a given compliance period. In the case of greenhouse gas emissions, each allowance could grant the holder the right to emit 1 metric ton carbon dioxide equivalent. Once distributed among the participants, the allowances could be bought, sold, or (possibly) banked for future use. At the end of each compliance period, each participant would be required to hold allowances equal to its actual emissions or else face a penalty. Although it has not been used to achieve a mandatory large-scale reduction of greenhouse gas emissions, the cap and trade system is not new, having been used in the United States since the 1990s to achieve reductions in stationary-source emissions of sulfur dioxide and in the fisheries industry. In the late 1980s New Zealand introduced an individual transferable quota (ITQ) system for managing fisheries, setting a total allowable catch and allocating tradable shares to individual fishermen. The system has since been emulated in more than 75 countries [***9***].

Emissions trading could also be based on concepts other than cap and trade. For example, a "credit-based" emissions trading system would include both capped and non-capped industries and entities that would trade voluntarily created, permanent emission reductions legally recognized by a regulator. This system would allow entities with emissions increases to obtain offsetting reductions from other entities. Other trading variants include "baseline" emissions trading systems, which would allow entities to reduce emissions below a level that would otherwise occur under business as usual, and then trade the emission reductions. "Rate-based" emissions trading would focus on emissions per unit of output rather than absolute emissions, allowing entities that improved their efficiency beyond target levels to trade the excess improvement with other entities.

In October 2001, the European Commission of the EU released a final proposal for establishing its own internal greenhouse gas emissions trading system [***10***]. The first trial phase of the scheme would run from 2005 through 2007, regulating carbon dioxide emissions from all heat and electricity generators over 20 megawatts of rated thermal input capacity and from all refineries, coke ovens, iron and steel production processes, pulp and paper plants, and mineral industry installations. The proposal would require operators of such installations to hold permits as a condition for emitting greenhouse gases. The second phase of the scheme would be concurrent with the first compliance period under the Kyoto Protocol (2008-2012), should it come into force, and each subsequent phase would last for 5 years.

The EU member states would determine the quantity of allowances to be issued in each phase. Noncompliance sanctions would be applied to any installation that did not have enough allowances to cover actual emissions each year. The allowances, which would be tradable across the entire EU, could be banked from year to year within each phase, and across phases if individual member states decided to do so.

In fall 2002, the European Parliament and the Council of Ministers separately approved the Commission's proposal, adding a number of amendments to the scheme [***11***]. For example, the Council of Ministers voted for mandatory participation by Member States from 2005, but inserted the provision that Member States should have limited rights to exempt individual sectors, activities, or installations until 2008 if comparable emission reductions were already being undertaken. Moreover, the Council would allow Member States to include additional sectors and other greenhouse gases only after 2008, contradicting an earlier Parliamentary amendment to do so by 2005. On the issue of permit allocation, the Parliament introduced a "hybrid scheme" whereby—for the whole of the 2005-2012 period—15 percent of the permits should be auctioned and the rest allocated for free. However, the Council of Ministers would limit auctioning to 10 percent, and only during the second phase. The directive is pending final approval by the European Parliament and could be delayed until 2004 if the Council and Parliament have difficulties reaching an agreement.

The EU proposal was designed to be compatible with international emissions trading under the Kyoto framework; however, any other agreements recognizing third countries' emission trading schemes must be subject to ratification of the Protocol, effectively excluding participation by non-Kyoto countries (such as Australia and the United States). Moreover, the proposal is open to the use of the Kyoto Protocol's project mechanisms, perhaps as early as the first phase, although the use of carbon "sinks" or nuclear projects may be excluded.

In conjunction with the introduction of the EU trading program, several EU member countries, including Denmark, France, Germany, Ireland, the Netherlands, Sweden, and the United Kingdom, are considering development of their own national trading programs. Non-EU countries, including Japan, Norway, and Slovakia, have also announced that they intend to establish trading systems. Currently, Denmark is the only country that has instituted a mandatory cap and trade system to reduce carbon dioxide emissions from electricity producers [***12***]. A cap of 22 million metric tons of carbon dioxide was set for 2001, with reductions of 1 million metric tons per year during the 3-year life of the program. The trading system became operational in April 2001 and will run through 2003. Free allowances were allocated to eight firms, based on their fuel consumption and actual emissions during the 1994-1998 period, excluding emissions from puchased power. If the program is extended, its allowances are likely to be compatible with the proposed EU trading scheme.

The compatibility of the EU proposal with the United Kingdom's voluntary emissions trading program, which entered into effect in April 2002, is more questionable. The programs differ in several respects, including rules for participation, generation of allowances, and sectoral coverage. Under the British program, any company can opt to enter the trading scheme by negotiating energy efficiency targets or absolute emission reduction targets in return for incentive payments offered by the government. Companies can report on direct emissions and indirect emissions from imported energy and will earn tradable allowances for carbon dioxide equivalent reductions computed against their targets. Also in contrast to the EU proposal, the UK scheme is based on voluntary targets, includes all six Protocol gases, and excludes combined heat and power generators, except for emissions from electricity usage that is generated and used on-site.

In anticipation of entry into force of the Kyoto Protocol, private firms and national governments have started investing in greenhouse gas reduction projects and trading in greenhouse gas offset credits, contributing to the emergence of a nascent market in the credits. Since 1996, more than 280 carbon transactions have taken place, amounting to some 335 million metric tons of carbon dioxide equivalent emission reductions [***13***]. About half of the trades were negotiated in 2002. Major market drivers include the UK emissions trading scheme, the World Bank's Prototype Carbon Fund, and the Dutch government's ERUPT and CERUPT programs to purchase JI and CDM credits. As illustrated in Table 30, emission reductions purchased by the Prototype Carbon Fund range between $3 and $4 per metric ton carbon dioxide equivalent, and credits purchased by the Dutch government range between $4 and $5 per metric ton [***14***]. As of fall 2002, credits traded in the British system were valued at about $18 per metric ton.

In general, the focus in the market is shifting from North America toward Europe, largely because of the U.S. decision not to ratify the Kyoto Protocol, the startup of the UK emissions trading system, and the proposed directive for a European-wide trading scheme. In 1996, 100 percent of carbon emissions trades took place in the United States; in 2002, more than one-half of the 150 carbon deals negotiated in 2002 took place in Europe. Emissions trading activity in the United States could increase, however, with the expected opening of the Chicago Climate Exchange (CCX) in spring 2003. CCX is a voluntary cap and trade program. Participating members will be able to buy and sell greenhouse gas credits to assist in achieving their emission reduction commitments.

Abating Other Energy-Related Emissions

Many countries currently have policies or regulations in place that limit energy-related emissions other than carbon dioxide. Energy-related air pollutants that have received particular attention include nitrogen oxides, sulfur dioxide, particulate matter, and volatile organic compounds, because of their contribution to ozone and smog formation, acid rain, and various human health problems (see **Table 31** for a summary of the possible health and environmental effects of these pollutants). Moreover, in some countries regulation of mercury emissions associated with energy combustion has recently become an issue. Countries also regulate the management of spent fuel from nuclear power generation facilities, but in most of the countries with active nuclear power programs there is no permanent disposal system for highly radioactive waste. How countries limit energy-related emissions by legislation and/or regulation can have significant impacts on energy technology choices and energy use.

Regulated air pollutants can be attributed to a mix of mobile and stationary energy uses. Nitrogen oxide emissions come from high-temperature combustion processes, such as those that occur in motor vehicles and power plants; road transportation is generally the single largest source. Sulfur dioxide is formed during the burning of high-sulfur fuels for electricity generation, metal

Table 30. Greenhouse Gas Credit Prices by Trading Program

Greenhouse Gas Trading System	Credit Price (2002 Dollars per Metric ton Carbon Dioxide Equivalent)
United Kingdom, Auction System	23
United Kingdom, Emissions Trading System	7-18
Dutch Government, ERUPT and CERUPT	4-5
World Bank, Prototype Carbon Fund	3-4
Denmark, Emissions Trading System	2-4
North America, Private Transactions	1-2
Other	0.5-5

Sources: A.C. Christiansen, "Overview of European Emissions Trading Programs," Point Carbon Presentation at EMA 6th Annual Fall Meeting and International Conference (Toronto, Canada, September 29-October 1, 2002); F. Lecocq and K. Capoor, "State and Trends of the Carbon Market," PowerPoint Presentation Prepared for PCF*plus* Research (October 2002); Point Carbon, "ViewPoint: The UK ETS Quieting Down," *Europe Weekly* (February 21, 2003), web site www.pointcarbon.com.

smelting, refining, and other industrial processes; coal-fired power plants account for the preponderance of sulfur dioxide emissions. Volatile organic compounds are emitted from a variety of sources, including motor vehicles, chemical plants, refineries, factories, consumer products, and other industrial sources. Particulate matter can be emitted directly or can be formed indirectly in the atmosphere: "primary" particles, such as dust from roads or elemental carbon (soot) from wood combustion, are emitted directly into the atmosphere; "secondary" particles are formed in the atmosphere from primary gaseous emissions. Emissions of mercury can be attributed to coal-fired boilers, municipal waste combustors, medical waste incinerators, and manufacturing processes that use mercury as an ingredient or raw material. Coal-fired boilers contribute the largest share of mercury emissions [***15***].

With the tightening of emissions limits on combustion plants during the 1990s, sulfur dioxide emissions declined in many industrialized countries. In Europe, the shift from coal to natural gas for electricity production (most notably, in the United Kingdom and Germany) also contributed to a reduction in the region's sulfur dioxide emissions. Many industrialized countries have scheduled further restrictions on sulfur dioxide emissions from stationary sources to take effect over the next 10 years.

With the decrease in atmospheric concentrations of sulfur dioxide in industrialized countries, attention has shifted to ozone, nitrogen oxides, and particulates. Despite the imposition of emissions regulations, nitrogen oxide emissions rose during the 1990s in many industrialized countries as a result of continued increases in consumption of transportation fuels. In Europe, however, the decrease in coal-fired electricity generation and the introduction of catalytic converters on vehicles led to a gradual drop in nitrogen oxide emissions [***16***]. In contrast to the generally rising trend in nitrogen oxide emissions, emissions of volatile organic compounds have declined [***17***]. To continue combating ground-level ozone formation, several countries plan to tighten emissions standards for new vehicles over the coming years (Table 32). Limits on the sulfur content of gasoline and diesel fuel also are being imposed in order to ensure the effectiveness of emission control technologies used to meet new vehicle standards (Table 33).

The regulation of mercury emissions from energy use has recently become an area of particular interest in industrialized countries. Over the past decade, many nations have begun to evaluate the potential adverse effects of mercury on human health and the environment. Major anthropogenic sources of mercury emissions include stationary energy combustion, nonferrous metal production, pig iron and steel production, cement production, oil and gas processing, and waste disposal. Of these, only electricity generation, municipal solid waste combustion, and oil and gas processing are related to energy use. In the past, energy-related mercury regulations have focused on municipal solid waste combustion. However, as coal-fired boilers contribute the single largest share of both energy-related and non-energy-related mercury emissions, countries that rely heavily on coal-fired power generation are beginning to consider limits on mercury emissions from power plants [***18***] (see box on page 169).

Table 31. Possible Health and Environmental Effects of Major Air Pollutants

Air Pollutant	Nature of Pollutant	Possible Health and Environmental Effects
Nitrogen Oxides (NO_x)	Includes nitric oxide, nitrogen dioxide, and other oxides. Precursor of ozone and particulate matter.	Respiratory illnesses, haze, acid rain, and deterioration of water and soil quality.
Sulfur Dioxide (SO_2)	Family of sulfur oxides gases. Precursor of particulate matter.	Asthma, heart disease, respiratory problems, and acid rain.
Volatile Organic Compounds (VOC)	Precursor of ozone and particulate matter.	Respiratory and heart problems, acid rain, and haze.
Particulate Matter (PM)	Mixture of solid particles and liquid droplets formed by sulfur dioxide, nitrogen oxides, ammonia, volatile organic compounds, and direct particle emissions.	Respiratory and heart problems, acid rain, and haze.
Mercury (Hg)	Metallic element, which when it enters a body of water, is transformed by biological processes into a toxic form of mercury (methylmercury).	Mercury in ambient air is deposited on land surfaces or into rivers, lakes, and oceans, where it can concentrate in fish and other organisms. Exposure to methylmercury from eating contaminated fish and seafood may cause neurological and developmental damage.

Sources: U.S. Environmental Protection Agency, *Latest Findings on National Air Quality: 2001 Status and Trends*, EPA 454/K-02-001 (Washington, DC, September 2002); National Research Council, *Toxicological Effects of Methylmercury* (Washington, DC, 2000); C.L. French, W.H. Maxwell, W.D. Peters, G.E. Rice, O.R. Bullock, A.B. Vasu, R. Hetes, A. Colli, C. Nelson, and B.F. Lyons, *Study of Hazardous Air Pollutant Emissions from Electric Utility Steam Generating Units: Final Report to Congress, Volumes 1-2*, EPA-453/R-98-004a and b (Research Triangle Park, NC. February 1998).

United States

In the United States, the main initiatives to reduce air pollution stem from the 1970 Clean Air Act—the comprehensive Federal law that regulates air emissions from stationary and mobile sources—and the subsequent Clean Air Act Amendments of 1990 (CAAA90), which designate stricter emissions goals and standards across a wider range of pollutants.

In the sections related to stationary energy use, the Clean Air Act and its amendments address all the major air quality issues, such as acid rain, ground level ozone, and visibility. The Acid Rain Program, introduced under Title IV of CAAA90, regulates both sulfur dioxide and nitrogen oxides. The program sets a goal of reducing annual sulfur dioxide emissions by 10 million tons below 1980 levels and annual nitrogen oxide emissions by 2 million tons below 1980 levels. The program also specifies a two-phase reduction in emissions from fossil-fired electric power plants greater than 25 megawatts capacity and from all new power plants. Phase II of the program, which began in January 2000, lowered the total allowable level of sulfur dioxide emissions from all electricity generators, capping annual U.S. emissions at 8.95 million metric tons by 2010.[33] The sulfur dioxide regulations include a highly successful market-based regulatory program, which allows individual plant operators to reduce their emissions through any combination of strategies, including installation of scrubbers, switching to low-sulfur fuels, and emissions allowance trading

Table 32. Current and Future Nitrogen Oxide Emission Standards for New Vehicles in Selected Countries

Vehicle Type	Vehicle Class	United States		European Union		Australia	
		Limit	Date	Limit	Date	Limit	Date
Gasoline . .	Light Duty	0.60-1.53 g/mile	Current standard	0.15-0.21 g/km	Current standard	0.63-1.40 g/km	Current standard
		0.07 g/mile	Phase-in 2004-2007	0.08 g/km[b]	Starting 2005	0.22 g/km	Starting 2003
				0.1-0.11 g/km[c]	Starting 2006	0.15-0.21 g/km	Starting 2005
	Heavy Duty	4.0 g/bhp-hr	Current standard				
		1.0 g/bhp-hr[a]	Starting 2004				
		0.2 g/bhp-hr	Phase-in 2008-2009				
Diesel	Light Duty	0.97-1.53 g/mile	Current standard	0.50-0.78 g/km	Current standard	0.78-1.20 g/km	Current standard
		0.07 g/mile	Starting 2004	0.25-0.39 g/km	Starting 2005	0.50-0.78 g/km	Starting 2003
	Heavy Duty	4.0 g/bhp-hr	Current standard	5.0 g/kWh	Current standard	8.0 g/kWh	Current standard
		1.0 g/bhp-hr[a]	Starting 2004	3.5 g/kWh	Starting 2005	5.0 g/kWh	Starting 2002
		0.2 g/bhp-hr	Phase-in 2007-2010	2.0 g/kWh	Starting 2008	3.5 g/kWh	Starting 2006

[a]Combined nitrogen oxide and hydrocarbon emissions limit.
[b]For passenger cars and class I light commercial vehicles.
[c]For other light commerical vehicles.
Note: The mix of vehicle types varies by region.
Sources: **United States:** U.S. Environmental Protection Agency, Office of Mobile Sources, *Emission Facts*, EPA-420-F-99-017 (Washington, DC, May 1999). **European Union:** European Parliament, Directive 98/69/EC, Official Journal L 350 (December 28, 1998), and Directive 99/96/EC, Official Journal L 44 (February 16, 2000). **Australia:** Department of Transport and Regional Services, "Vehicle Emission Australian Design Rules (ADRs)" (August 7, 2001).

Table 33. Future Sulfur Content Limits on Motor Fuels in Selected Countries

Fuel	United States		European Union		Australia	
	Limit	Date	Limit	Date	Limit	Date
Gasoline	30 ppm	Phase-in 2004-2006	50 ppm	As of 1/1/2005	500 ppm[a]	Current Standard
					150 ppm[b]	Current Standard
					150 ppm[c]	As of 1/1/2005
Diesel	15 ppm	As of 6/1/2006	50 ppm	As of 1/1/2005	500 ppm	As of 12/31/2002
			10 ppm	As of 1/1/2009	50 ppm	As of 1/1/2006

[a]For unleaded gasoline and lead replacement gasoline.
[b]For premium unleaded gasoline.
[c]For all grades.
Sources: **United States:** U.S. Environmental Protection Agency, "Control of Air Pollution from New Motor Vehicles: Tier 2 Motor Vehicle Emission Standards and Gasoline Control Requirements," *Federal Register* (February 10, 2000). **European Union:** European Parliament, Directive 98/70/EC, Official Journal L 350 (December 28, 1998); and "E.U. Slashes Sulphur Content in Road Fuels from 2005," Reuters News Service Planet Ark (February 3, 2003), web site www.planetark.com/dailynewsstory.cfm?newsid=19675&newsdate=03-Feb-2003. **Australia:** Attorney General's Department, Office of Legislative Drafting, "Fuel Standards Quality Act of 2000: Fuel Standards (Diesel and Petrol)" (October 8, 2001).

[33]Because some power companies accumulated (banked) emissions allowances during Phase I of the program (1995 to 1999), the Phase II cap of 8.95 million tons per year will not be reached until the banked allowances have been exhausted.

Controlling Emissions of Mercury from Energy Use

In response to scientific research indicating potential adverse ecological and human health impacts caused by exposure to mercury, many nations are considering regulation and control of mercury emissions—including those attributed to energy use.

Recent estimates of global mercury emissions indicate that Europe and North America contribute less than 25 percent of global anthropogenic emissions (see table below). The majority of emissions originate from combustion of fossil fuels, particularly in Asian countries that rely heavily on coal for electricity generation, including China, India, and South and North Korea.[a] Other sources of mercury include processing of mineral resources at high temperatures, such as roasting and smelting of ores, kiln operations in the cement industry, incineration of waste materials, and production of certain chemicals.

Traditionally, regulation of energy-related mercury emissions has focused on municipal solid waste combustion.[b] Mercury is found in relatively higher concentrations in waste incineration exhaust gases than in the gases released from coal combustion and is thus simpler and less expensive to remove. As a result, most industrialized and many developing countries already have standards in place to control mercury levels in the exhaust gases from waste incineration facilities and in wastewater from the cleaning of their exhaust gases (see table on continuation page).[c]

A number of countries, including Canada, the United States, and the European Union, are now considering standards to control mercury emissions from coal-fired electricity generators:[d]

- Under the umbrella of the Canadian Council of Ministers of the Environment, federal, provincial, and territorial governments in Canada are working on developing a nationwide emission standard for the coal-fired electricity generation sector by the end of 2005.
- The United States is debating various multi-pollutant legislative initiatives, with mercury as one of the targeted pollutants. On December 14, 2000, the U.S. Environmental Protection Agency announced the decision that it is appropriate and necessary to regulate hazardous air pollutants (including mercury) from electric utility power plants.[e] A regulation is currently scheduled for proposal by December 15, 2003, and promulgation by December 15, 2004.
- The European Union is in the process of developing emissions monitoring procedures and control strategies based on Best Available Technology (BAT) as part of a daughter directive under the 1996 Air Quality Framework Directive (96/62/EC).

(continued on page 170)

Emissions of Mercury from Anthropogenic Sources by World Region, 1995
(Metric Tons per Year)

Region	Source of Emissions					Total
	Stationary Combustion of Fossil Fuels	Nonferrous Metal Production	Pig Iron and Steel Production	Cement Production	Waste Disposal	
Asia	860	87	12	82	33	**1,074**
Europe	186	15	10	26	12	**248**
North America	105	25	5	13	66	**214**
Africa	197	8	1	5	—	**211**
Australia and Oceania	100	4	0	1	0	**106**
South America	27	25	1	6	—	**59**
Total	**1,475**	**166**	**29**	**132**	**111**	**1,913**

Source: See note a below.

[a]European Commission, *Ambient Air Pollution by Mercury (Hg): Position Paper* (Luxembourg: Office for Official Publications of the European Communities, 2001), web site http://europa.eu.int/comm/environment/air/background.htm.

[b]Municipal solid waste combustion is considered an energy source, because many incinerators produce steam for heating.

[c]United Nations Environment Programme, *Global Mercury Assessment. Appendix: Overview of Existing and Future National Actions, Including Legislation, Relevant to Mercury as of November 1, 2002* (Geneva, Switzerland, December 2002), web site www.chem.unep.ch/mercury/Report/Finalreport/final-appendix-1Nov02.pdf; and "Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the Incineration of Waste," *Official Journal of the European Communities*, L332/91 (December 28, 2000), web site http://europa.eu.int/comm/environment/wasteinc/newdir/2000-76_en.pdf.

[d]United Nations Environment Programme, *Global Mercury Assessment. Appendix: Overview of Existing and Future National Actions, Including Legislation, Relevant to Mercury as of November 1, 2002* (Geneva, Switzerland, December 2002), web site www.chem.unep.ch/mercury/Report/Finalreport/final-appendix-1Nov02.pdf.

[e]U.S. Environmental Protection Agency, "Fact Sheet: EPA To Regulate Mercury and Other Air Toxics Emissions From Coal- and Oil-Fired Power Plants" (December 14, 2000), web site www.epa.gov/ttn/oarpg/t3/fact_sheets/fs_util.pdf.

and banking. This "cap and trade" approach, which allows emitters to choose the most cost-effective means for limiting sulfur dioxide emissions, has led to a 24-percent decrease in sulfur dioxide emissions between 1992 and 2001 [*19*].

Specifications for reducing nitrogen oxide emissions under the Acid Rain Program are also scheduled according to two phases. As with the sulfur dioxide rules, the Phase II nitrogen oxide limits, targeting certain coal-fired utility boilers, became effective in January 2000; however, the nitrogen oxide program neither sets an emissions cap nor incorporates emissions allowance trading as a compliance option. The program requires utility boilers to meet a specified nitrogen oxide emissions rate, depending on boiler capacity, providing flexibility for utilities by focusing on the emission rate to be achieved.

The U.S. Environmental Protection Agency (EPA) has also taken two actions to address the effects of interstate transport of nitrogen oxide emissions on downwind ozone nonattainment areas. In 1998, the EPA finalized the "nitrogen oxides SIP call" rules, which now require 19 States and the District of Columbia to revise their State Implementation Plans (SIPs) to control summertime nitrogen oxide emissions. In a separate action, aimed at the same interstate nitrogen oxides transport problem, the EPA in December 1999 found that emissions from large electric generating units and large industrial boilers and turbines in 12 States and the District of Columbia are significantly contributing to downwind States' ozone nonattainment problems. The rule requires the sources to control summertime nitrogen oxide emissions under the Federal Nitrogen Oxides Budget Trading Program, beginning May 1, 2003[34] [*20*].

Additional requirements for electric power plant operators to reduce sulfur dioxide and nitrogen oxide emissions beyond the levels called for in current regulations are being considered at Federal levels (see box on page 171). It is envisioned that the new regulations will eliminate several of the individual programs that apply to the power generation sector and replace them with a less burdensome administrative system.

Controlling Emissions of Mercury from Energy Use (Continued)

To address transboundary issues related to the long-range transport of mercury emissions, countries are also working under the auspices of the United Nations Environment Programme (UNEP) to develop a global assessment of mercury and its compounds. The assessment, to include options for addressing any significant global adverse impacts of mercury, was presented to the UNEP Governing Council at its 22nd session in February 2003 for further action by the global community. A meeting of UNEP's Working Group on Mercury took place in Geneva, Switzerland in September 2002 to develop options for addressing global adverse impacts of mercury. Recommendations included the creation of an international legally binding treaty to reduce or eliminate mercury use and emissions.[f]

Sample Mercury Limits on Exhaust Gases from Municipal Waste Incineration

Country	Regulated Municipal Waste Process/Technology	Maximum Mercury Concentrations in Exhaust Gases	
		Current	New
Canada	Incineration at 11% oxygen (average)	0.02 mg/m3	
China	Incineration (average)	0.2 mg/m3	
Croatia	Incineration with gas flow of 10 g/h or more	1 mg/m3	
European Union	Incineration at 11% Oxygen (average over period of minimum 30 minutes and maximum 8 hours)	0.05 mg/m3	
Germany	Incineration at 11% Oxygen (daily maximum average)	0.03 mg/m3	
	Incineration at 11% Oxygen (half hour average)	0.05 mg/m3	
Norway	Incineration, facilities permitted after 1994 (average)	0.03 mg/m3	
South Korea	Incineration (average)	5 mg/m3	0.1 mg/m3 (January 1, 2005)
United States	Incineration at 7% oxygen (daily maximum)	0.08 mg/m3	

Source: United Nations Environment Programme, *Global Mercury Assessment. Appendix: Overview of Existing and Future National Actions, Including Legislation, Relevant to Mercury as of November 1, 2002* (Geneva, Switzerland, December 2002), web site www.chem.unep.ch/mercury/Report/Finalreport/final-appendix-1Nov02.pdf.

[f]United Nations Environment Programme, *Global Mercury Assessment* (Geneva, Switzerland, December 2002), web site www.chem.unep.ch/mercury/Report/Finalreport/final-assessment-report-25nov02.pdf.

[34]Under Section 126 of the Clean Air Act, States may petition the EPA to mitigate significant regional transport of nitrogen oxides. In May 1999, the EPA established the Federal Nitrogen Oxides Budget Trading Program as the general control remedy for reducing interstate ozone transport and required 392 facilities in the northeast to participate in the NO_X emissions cap-and-trade program.

Multipollutant Control Legislation in the United States

Electric power plant operators in the United States may face new requirements to reduce emissions of sulfur dioxide, nitrogen oxides, and mercury beyond the levels called for in current regulations. Some current Federal legislative initiatives also require mandatory reduction of carbon dioxide emissions. Whereas in the past each pollutant was addressed through a separate regulatory program, the new legislative initiatives focus on simultaneous reductions of multiple emissions in order to reduce the cost and administrative burden of compliance. The legislative initiatives now being considered would either override or streamline the 1990 Clean Air Act's New Source Review requirements for modernization at power plants built before the Clean Air Act and exempt from its regulations.

Three major legislative initiatives have been introduced in Congress during the 107th legislative session and have been referred to committee for further consideration. A fourth was announced early in the 108th Congress. Introduced first by Senators Jeffords and Lieberman in 2002 and later in 2003, the "Clean Power Act of 2003" is the most far-reaching of the multipollutant initiatives. As shown in the table below, it covers emissions of sulfur dioxide, nitrogen oxides, mercury, and carbon dioxide. The bill proposes a cap and trade scheme for meeting sulfur dioxide, nitrogen oxide, and carbon dioxide emission targets and a Maximum Achievable Control Technology (MACT) requirement to reduce mercury emissions. The current Clean Air Act requires the U.S. Environmental Protection Agency to adopt a performance standard based on MACT in the next few years, with compliance required by the end of 2007. In addition, the Clean Power Act of 2003 would require every power plant to be equipped with the most recent pollution controls required for new sources by the plant's 40th year of operation or by 2014, whichever is later.

The Clear Skies Initiative, announced by President Bush in February 2002 and introduced as House and Senate bills, proposes nationwide caps for sulfur dioxide and mercury and regional (East and West) caps for nitrogen oxides. The Clear Skies Initiative differs from the proposed Clean Power Act primarily in targeted emission reductions and proposed compliance dates. The final nitrogen oxides and sulfur dioxide targets are close to those proposed in the Clean Power Act of 2003, but mercury reductions are not as stringent, and the timetable for reaching the targets is delayed by 5 to 10 years, depending on the pollutant. The Clear Skies Initiative

(continued on page 172)

Key U.S. Legislative and Policy Initiatives for Multipollutant Control

Proposal Title	Sponsor	Annual Nitrogen Oxides (NO_x) (Million Tons)	Annual Sulfur Dioxide (SO_2) (Million Tons)	Annual Mercury (Hg) (Tons)	Annual Carbon Dioxide (CO_2) (Million Tons)
		Current Emission Levels from Fossil-Fueled Electricity Generation (2000)[a]			
		5.7	11.8	48	2,044 in 1990; 2,566 in 2000
		Proposed Reduction Goals and Time Table			
Clear Skies Initiative	Bush Administration	2.1 million tons in 2008; 1.7 million tons in 2018	4.5 million tons in 2010; 3.0 million tons in 2018	26 tons in 2010; 15 tons in 2018	Voluntary
Clean Power Act of 2003	James Jeffords (I-VT)	1.5 million tons by 2009	2.25 million tons by 2009	5 tons by 2008; 2.48 g/GWhr MACT in 2008	2,050 million metric tons by 2009
Clean Air Planning Act of 2003	Tom Carper (D-DE)	1.87 million tons by 2009; 1.70 million tons by 2013	4.50 million tons by 2009; 3.50 million tons in 2013; 2.25 million tons in 2016	24 tons by 2009; 10 tons by 2013	2006 level by 2009; 2001 level by 2013
Greenhouse Gas Cap-and-Trade	John McCain (R-AZ) and Joseph Lieberman (D-CT)	—	—	—	2000 level by 2010[b] 1990 level by 2016

[a]Sources: Electric Power Annual 2001. Energy Information Administration. U.S. Department of Energy. March 2003 for data on nitrogen oxides, sulfur dioxides and carbon dioxide. Data on mercury obtained from "Air Quality: Multi-Pollutant Legislation" Congressional Research Service. CRS Report Number RL31326. Updated October 22, 2002.

[b]Emissions of all six greenhouse gases would be covered (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride), and allowances would be traded in metric tons carbon dioxide equivalent. The bill would cover the transportation, industrial, and commercial sectors in addition to electricity generation.

Sources: U.S. Senator Tom Carper, "Carper-Chafee-Breaux-Baucus Offer '4 Pollutant Bill': Bipartisan Senators Introduce Clean Air Legislation," Press Release (Washington, DC, October 18, 2002), web site http://carper.senate.gov/press/02/10/101802.html; and L. Parker and J. Blodgett, *Air Quality: Multi-Pollutant Legislation* (Washington, DC: Congressional Research Service, Library of Congress, October 22, 2002), web site www.ncseonline.org/NLE/CRSreports/Nov02/RL31326.pdf.

In an effort to address the EPA requirement to promulgate mercury regulations by 2004, the proposed regulations will also for the first time target emissions of mercury from stationary combustion. The CAAA90 required the EPA to study and prepare a report to Congress on the hazards to human health that can reasonably be expected to occur as a result of emissions of hazardous air pollutants (HAPs) from fossil-fuel-fired electric power plants. In its December 2000 report to Congress, the EPA found that HAP control is appropriate for coal-fired and oil-fired utility boilers, with a particular focus on mercury emissions. A regulation is currently scheduled for proposal by December 15, 2003, and promulgation by December 15, 2004. In order to ensure that optimal alternatives will be available to reduce mercury emissions, an interagency effort is underway to develop "maximum achievable control technology" (MACT) options for inclusion in future regulation.

Because particulate matter consists of many different particles, and volatile organic compounds contribute to both particulate matter and ozone, the EPA sets general national ambient air quality standards for ozone and particulate matter that apply to metropolitan areas, rather than specifying emissions limits for individual polluters. It is then up to States and urban jurisdictions to regulate local emitters. In 1997 the EPA issued new ambient air quality standards for particulate matter and ozone. The ozone standard was tightened from 0.12 parts per million measured over 1 hour to 0.08 parts per million measured over 8 hours. In addition, the EPA added two new standards for particles with diameters of 2.5 micrometers or less, set at 15 micrograms per cubic meter and 65 micrograms per cubic meter, respectively, for the annual and 24-hour standards. These were added to the existing requirements for particles with diameters of 10 micrometers or less, which were set at 50 micrograms per cubic meter and 150 micrograms per cubic meter, respectively, for the annual and 24-hour standards.

Beginning in 2002, based on 3 years of monitored data, the EPA will designate areas as nonattainment that do not meet the new particulate matter standards. Moreover, based on new scientific evidence, the EPA has proposed revisions to both standards and is developing a two-phase, integrated implementation strategy for ozone, particulate matter, and regional haze programs. Currently, it is expected that nonattainment areas will be designated sometime between 2003 and 2005, and SIPs will have to be submitted to the EPA 2 to 3 years beyond that date. As a result, further emission reductions probably will not be required until sometime between 2007 and 2010.

CAAA90 also designates more stringent emissions standards for motor vehicles. The "Tier 1" standards cover emissions of several pollutants from light-duty vehicles, beginning with model year 1994. Tighter "Tier 2" standards, which are about 90 percent cleaner than Tier 1, will be phased in starting in 2004, marking the first time that cars and light-duty trucks will be subject to the same national pollution control system. The current emissions standards for heavy-duty vehicles, which have been in place since 1998, will be further tightened in two stages:

Multi-Pollutant Legislation in the United States (Continued)

provides for market-based cap and trade programs for nitrogen oxides and sulfur dioxide and also provides for mercury emissions trading. It includes carbon dioxide emission provisions that would be voluntary only.

The third bill, the Clean Air Planning Act of 2003, was introduced by Senator Tom Carper in October 2002 and later in April 2003. It has been promoted as a bipartisan bill that presents a compromise between the Clear Skies Initiative and the Clean Power Act. It would establish aggressive caps on emissions on sulfur dioxide, nitrogen oxides, and mercury, but they would be phased in over a longer period than proposed in the Clean Power Act. The bill would also introduce limited caps on carbon dioxide emissions. The bill proposes to reduce carbon dioxide emissions to 2005 levels by 2008 and to 2001 levels by 2012, whereas the Clean power Act would reduce carbon dioxide emissions to 1999 levels by 2008. The nitrogen oxide, sulfur dioxide, and mercury reduction targets and timelines included in the legislation are more aggressive than those outlined in the President's Clear Skies Initiative but less stringent than those proposed in the Clean Power Act.

In early January 2003, Senators McCain and Lieberman introduced legislation to reduce annual emissions of greenhouse gases by emitters in the electricity, transportation, industrial, and commercial sectors who produce 10,000 metric tons carbon equivalent or more per year.[a] The bill would create a system of tradable allowances allocated to emitters in each sector free of charge, with the goal of reducing greenhouse gas emissions to 2000 levels by 2010 and to 1990 levels by 2016. It does not address emissions of nitrogen oxides, sulfur dioxide, or mercury.

[a]U.S. Senator Joseph Lieberman, "Summary of Lieberman / McCain Draft Proposal on Climate Change," Press Release (Washington, DC, January 8, 2003), web site www.senate.gov / ~lieberman / press / 03 / 01 / 2003108655.html.

a new combined nitrogen oxide and hydrocarbon emission standard will take effect in 2004, and further emission reductions will be phased in starting in 2007 [***21***, ***22***]. Monetary penalties will be imposed on manufacturers of heavy-duty trucks and buses that are unable to meet the tighter emissions standards.

Concurrent with the introduction of Tier 2 emissions standards, the U.S. government is requiring a reduction in the sulfur content of gasoline and diesel used for transportation [***23***, ***24***]. The lower sulfur content will enable the effective use of modern pollution-control technology required for meeting the Tier 2 standards and will significantly reduce formation of smog and particulate matter. The new gasoline sulfur standard will be phased in between 2004 and 2007, in order to ease the transition for domestic refineries. According to the new standard, refiners and importers must produce a 97-percent reduction in the sulfur content of highway diesel by June 1, 2006, although the law incorporates a phase-in period and hardship provisions for small refiners through May 2010. In addition to these rules, the EPA also expects to tighten regulations for nonroad vehicles to reduce ozone and particulate matter emissions [***25***].

Canada

In Canada, emissions from stationary sources are regulated under the Thermal Power Generation Emissions National Guidelines for New Stationary Sources of the 1993 Canadian Environmental Protection Act (CEPA). In January 2003, the emission guidelines for new sources of electricity generation were updated, tightening emission limits for sulfur dioxide, nitrogen oxide, and particulate matter from new coal-, oil-, and gas-fired steam-electric power plants [***26***]. The new emission targets would lower sulfur dioxide emissions by 75 percent, to a rate of 4.24, 2.65, or 0.53 kilogram per megawatthour, depending on the energy content and sulfur concentration of the fuel used. Emissions of nitrogen oxide would be lowered by 60 percent, to a rate of 0.69 kilogram per megawatthour, and emissions of particulate matter would be lowered by 80 percent, to 0.095 kilogram per megawatthour. With these requirements, the long-term emission performance of all fossil-fired generation is targeted to approach that of natural gas.

Additional efforts to abate sulfur dioxide emissions have focused on the seven easternmost provinces, where smog levels are on the rise and acid rain is a concern.[35] The Eastern Canada Acid Rain Program placed a region-wide cap on sulfur dioxide emissions at 2.3 million metric tons per year for 1994, mostly restricting emissions from large industrial facilities. Recently, new measures at provincial levels were enacted to reduce nitrogen oxide emissions. Starting in 2007, fossil-fueled power plants in central and southern Ontario will face an annual cap of 39,000 tons, and emissions from plants in southern Quebec will be capped at 5,000 tons.

Addressing the problems of acid rain and ground-level ozone in Canada has required cooperation with the United States, given the transboundary flow of air pollutants between the two countries. Actions taken under the various sulfur dioxide and nitrogen oxide programs of the U.S. CAAA90 have supplemented Canada's domestic efforts. In addition, a December 2002 cross-border agreement between Canada and the United States set a target of cutting ozone in the U.S./Canada transboundary region by 43 percent by 2010 [***27***]. The agreement was seen as a major step toward harmonizing air quality standards for stationary and mobile sources, and negotiators have begun discussing its expansion to cover other pollutants.

Canadian regulation of mobile sources tends to mirror standards in the United States, in line with efforts to create an integrated vehicle manufacturing market in North America. Starting with the 1998 model year, regulations for light-duty vehicles were aligned with the Tier 1 standards of the United States. According to a regulation introduced in January 2003, model year 2004 and later vehicles will be required to meet the U.S. Tier 2 standards taking effect that same year [***28***]. In addition, the Canadian government has reached an agreement with vehicle manufacturers to equip new light-duty vehicles and trucks with the same emissions control and monitoring equipment needed to meet the U.S. Federal emissions standards for the 2001-2003 model years. In 1999, Canada approved a limit of 30 parts per million of sulfur content in gasoline, which would take effect by January 1, 2005. The average level of sulfur in Canadian gasoline is currently 350 parts per million, among the highest in the industrialized world. Canada will also require a diesel fuel sulfur cap of 15 parts per million by June 2006, mirroring the U.S. highway diesel regulation.

Mexico

Air pollution in the large cities of Mexico is a serious concern for the country. Mexico City, Guadalajara, and Ciudad Juarez are the most polluted, and Mexico City's air quality is among the worst in the world. Although industrial growth is causing increased environmental damage, transportation continues to be the largest source of emissions, contributing an estimated 70 percent of the local air pollution in Mexico City and the surrounding valley [***29***].

The Mexican government has presented several innovative proposals for fighting air pollution from transportation, including tax incentives for using cleaner fuels and

[35] The seven Canadian provinces covered under the Eastern Canada Acid Rain Program are Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Newfoundland, and Prince Edward Island.

smog control measures. In major urban centers, private car drivers are required to have catalytic converters or refrain from driving one day a week. In addition, dozens of manufacturers are taking advantage of government subsidies to outfit gasoline-powered delivery trucks with cleaner liquefied petroleum gas. The pollution control measures put in place in the mid-1990s have already improved visibility and air quality in Mexico City.

Mexican environmental initiatives also include developing clean taxis and small buses in order to reduce urban emissions. Mexico began producing cars with emissions controls in 1991. Since then, Pemex, the national oil company, has been reducing production of leaded gasoline. The company is in the process of desulfurizing crude oil at the Tula refinery and has replaced its high-sulfur diesel with a new “Pemex diesel” that contains only 0.05 percent sulfur.

Europe

In Europe, efforts to limit aggregate emissions of sulfur dioxide, nitrogen oxides, volatile organic compounds, and particulate matter were first coordinated under the 1979 United Nations/European Economic Commission’s Convention on Long-Range Transboundary Air Pollution (CLRTAP), which was drafted after scientists demonstrated the link between sulfur dioxide emissions in continental Europe and the acidification of Scandinavian lakes. Since its entry into force, the Convention has been extended by eight protocols that set emissions limits for a variety of pollutants. The 1999 Gothenburg Protocol calls for national emissions ceilings for sulfur dioxide, nitrogen oxides, volatile organic compounds, and ammonia. As with previous CLRTAP protocols, the Gothenburg Protocol specifies tight limit values for specific emissions sources based on the critical loads concept, and requires best available technologies to be used to achieve the emissions reductions. As of January 2003, only Denmark, Luxembourg, Norway, and Sweden had ratified the Gothenburg Protocol.

Parallel to CLRTAP developments, the EU agreed on the directive for National Emission Ceilings (NEC) for Certain Atmospheric Pollutants (Directive 2001/81/EC) to reduce overall sulfur dioxide emissions by 63 percent and cut emissions of nitrogen oxides, volatile organic compounds, and ammonia by 40 percent by 2010 [**30**]. The agreement, which was reached at the end of 2001, covers the same four pollutants as the Gothenburg Protocol; however, the national emission targets are stricter, particularly for sulfur dioxide (Table 34). The establishment of national emission ceilings is a regulatory innovation in EU air pollution control, in that the different emissions ceilings are tailored to meet country-specific circumstances and allow member countries flexibility in implementing control measures.

While the NEC directive addresses both stationary and mobile sources, another EU directive on the Limitation of Emissions of Certain Pollutants into the Air from Large Combustion Plants (Directive 2001/80/EC0) was passed in late 2001 targeting only stationary combustion. This directive amended the Large Combustion

Table 34. Emission Ceilings in the European Union National Emission Ceilings (NEC) Directive and the Convention on Long-Range Transboundary Air Pollution (CLRTAP) of the Gothenburg Protocol, 2010
(Thousand Metric Tons)

Country	Sulfur Dioxide		Nitrogen Oxides		Volatile Organic Compounds		Ammonia	
	NEC	CLRTAP	NEC	CLRTAP	NEC	CLRTAP	NEC	CLRTAP
Austria	39	39	103	107	159	159	66	66
Belgium	99	106	176	181	139	144	74	74
Denmark	55	55	127	127	85	85	69	69
Finland	110	116	170	170	130	130	31	31
France	375	400	810	860	1,050	1,100	780	780
Germany	520	550	1,051	1,081	995	995	550	550
Greece	523	546	344	344	261	261	73	73
Ireland	42	42	65	65	55	55	116	116
Italy	475	500	990	1,000	1,159	1,159	419	419
Luxembourg	4	4	11	11	9	9	7	7
Netherlands	50	50	260	266	185	191	128	128
Portugal	160	170	250	260	180	202	90	108
Spain	746	774	847	847	662	669	353	353
Sweden	67	67	148	148	241	241	57	57
United Kingdom	585	625	1,167	1,181	1,200	1,200	297	297
Total	**3,850**	**4,044**	**6,519**	**6,648**	**6,510**	**6,600**	**3,110**	**3,128**

Source: United Nations Economic Commission for Europe, Convention on Long-Range Transboundary Air Pollution, *Protocol To Abate Acidification, Eutrophication and Ground-Level Ozone, Annex II, Emission Ceilings* (Geneva, Switzerland: UNECE, 1999).

Plant Directive of 1988 (Directive 88/609/EEC), which imposed emissions limits for sulfur dioxide, nitrogen oxides, and dust on existing and new power plants with a rated thermal input capacity greater than 50 megawatts. For plants licensed before July 1, 1987, the 1988 directive placed a gradually declining ceiling (cap) on total annual emissions of each pollutant. The ceiling values differed by country. The directive did not stipulate how the emissions reductions were to be achieved, although the general approach used by several European countries has been to require the use of specific emissions control technologies and combustion fuels. All plants licensed after July 1, 1987, faced uniform emissions limit values, which were set according to plant capacity, size, and fuel type.

The new directive was seen as a package deal, along with the 2001 directive on NECs, toward the development of a comprehensive EU acidification strategy. The directive takes into account advances in combustion and abatement technologies and reduces the nitrogen oxides limit values for large solid fuel plants from 650 milligrams per cubic meter to 200 milligrams per cubic meter. This limit, which applies to both new and existing plants from 2016 onward, will be a crucial benchmark in the forthcoming negotiations with Eastern European candidate countries hoping to enter the EU. However, existing plants may be exempt from obligations concerning new emissions standards if they are operated for less than 20,000 hours between January 2008 and December 2015. The directive does provide member countries with some flexibility in terms of specifying control technologies but, unlike the U.S. regulatory scheme, does not include provisions for market-based emission reductions, such as allowance trading.

Emissions from motor vehicles have been regulated in Europe since the 1970 Motor Vehicle Directive. The most stringent vehicle emission limits were passed in 1998 and 1999 by Directives 98/69/EC and 99/96/EC. As the law currently stands, all new vehicles must meet the "Euro 3" emissions standards for carbon monoxide, hydrocarbons, and nitrogen oxides by 2000 and 2001, depending on weight class. Between 2005 and 2008, the tighter Euro 4 and Euro 5 standards for new vehicles will take effect. Directive 98/70/EC designates current and future sulfur content limits for motor fuels. Germany, the Netherlands, Belgium, and the United Kingdom have encouraged the switch to low-sulfur gasoline and diesel by offering tax incentives. Sweden already requires "city diesel" to meet the same sulfur standard (50 parts per million) required by the EU in 2005. The EU recently finalized an amendment to Directive 98/70/EC that includes the mandatory introduction of sulfur-free gasoline and diesel fuels, with sulfur levels lower than 10 milligams per kilogram, by January 1, 2005, and a complete ban on all non-sulfur-free fuels by January 1, 2009 [***31***, ***32***]. The implementation of the measure would coincide with the introduction of Euro 4 vehicles in the European market.

Australia

In Australia, measures to reduce emissions of sulfur dioxide, nitrogen oxide, volatile organic compounds, and particulate matter from energy use have focused on the transportation sector. Australia relies heavily on domestic coal for electricity generation, with 60 percent of its generating capacity being coal-fired [***33***]; however, its domestic coal has lower sulfur content than the coal produced in most other countries, and sulfur dioxide emissions from power generation are relatively low. The ambient air concentrations of sulfur dioxide in most Australian towns and cities usually have remained well within a level that the government deems to be safe.

On the other hand, because of the health risks associated with high concentrations of nitrogen oxides, volatile organic compounds, and particulate matter, particularly in urban centers, the Australian government has begun to implement measures to reduce emissions of those pollutants. Approximately 80 percent of the nitrogen dioxide emissions in Australian cities come from motor vehicle exhaust [***34***].

Vehicle emissions in Australia are regulated under the Motor Vehicle Standards Act of 1989. The most stringent emissions standards for new vehicles were set in December 1999, based on the schedule of vehicle standards used in the EU. According to the new Australian Design Rule 79/00, Euro 2 standards for all new light-duty vehicles were phased in according to weight class and fuel type, starting in 2002. Rule 79/01 applies the Euro 3 standard for all new light-duty gasoline-powered vehicles starting in 2005 and the Euro 4 standard for all new light-duty diesel-powered vehicles starting in 2006. Rules 80/00 and 80/01 similarly phase in Euro 3 and Euro 4 emissions standards for new medium- and heavy-duty vehicles.

The high sulfur content of gasoline and diesel in Australia was identified as a particular problem for the effective operation of engine catalysts needed to meet tighter emission standards. In May 2001, the Australian government announced the first fuel quality standards to be adopted under the Fuel Quality Standards Act of 2000. Standards for gasoline and diesel began in 2002, in order to ensure compatibility between the fuels and vehicle emissions control technologies.

Japan

In Japan, the regulation of sulfur oxides and other particulate emissions from fuel combustion began after the passage of the Air Pollution Control Law of 1968. Emissions standards were established by order of the Prime Minister's Office and were last amended in 1998. Limit values for sulfur oxide emissions from stationary sources vary according to the geographic location of the facility and height of the exhaust stack, and nitrogen oxide emission limit values vary according to boiler or furnace type. Sulfur content limits for fuels were included under the Air Pollution Control Law by amendments in 1995 and have been in force since 1996. Vehicle emissions standards for nitrogen oxides, carbon monoxide, and hydrocarbons were also established by the Air Pollution Control Law and by the Automobile Nitrogen Oxide Law of 1992.

China

While emissions of sulfur dioxide, nitrogen oxides, and particulate matter have either declined or slowed in most industrialized countries, many developing countries are experiencing rapid growth in energy-related pollution. Issues of most pressing concern involve growing sulfur dioxide emissions and acid rain from coal-fired power plants and increasing levels of smog and particulate matter in urban areas caused by transportation and power generation. To address these environmental problems, many developing countries have introduced regulations targeting motor vehicle use and coal-fired power generation. However, compliance with emissions regulations is often low in developing countries, due to limited funding and inadequate means for measuring emissions levels and enforcing standards [***35***]. Thus, in the face of strong population growth and economic development, emissions of air pollutants in urban centers of the developing world have increased steadily.

According to a report by the World Bank, 16 of the world's 20 most polluted cities are in China [***36***]. Sulfur dioxide and soot caused by coal combustion are two major air pollutants, resulting in the formation of acid rain, which now falls on about 30 percent of China's total land area [***37***]. Ninety percent of the country's sulfur dioxide emissions are attributed to coal-fired boilers, and the government is focusing regulation on sulfur dioxide emissions from power generation and large industrial facilities [***38***].

In 1982 the Chinese government introduced a sulfur dioxide pollution levy, which became the cornerstone of national sulfur dioxide control. The levy system has proven to be only modestly successful at controlling emissions, because it is applied only to medium-sized and large sources, it appears to be set too low to encourage significant sulfur dioxide abatement, and the fee is rarely used for reinvestment in new abatement activities. To improve the system, the levy was changed in 2000 from a fee based on excess emissions to a charge on total emissions. Moreover, in 2002, China implemented a new coal policy, which is expected to reduce sulfur dioxide emissions nationwide by 10 percent from 2000 levels by 2005, and by 20 percent within "control zones" with high pollution, including Beijing, Shanghai, Tianjin, and 197 other cities [***39***]. The control zones account for 11.4 percent of China's land area but for 66 percent of the 20 million tons of sulfur dioxide emitted each year. The new policy increases the pollution levy to 5 yuan (60.4 cents) per ton and requires power companies and large industrial facilities to install desulfurization equipment [***40***]. Smaller facilities must use low-sulfur coal or cleaner fuel alternatives.

In a parallel effort to encourage a switch to cleaner burning fuels, the government has introduced a tax on high-sulfur coals. In Beijing, officials aiming to phase out coal from the city center have established 40 "coal-free zones" and have made plans to construct natural gas pipelines. Similar efforts are underway in other major Chinese cities. In addition, pilot sulfur dioxide emissions trading programs are underway in Benxi (Liaoning Province) and Nantong (Jiangsu Province), and in early 2002 the State Environmental Protection Administration (SEPA) announced that the provinces of Shandong, Shanxi, Henan, and Jiangsu, the special administrative regions of Macau and Hong Kong, and three cities (Shanghai, Tianjin, and Liuzhou) would pioneer China's first cross-provincial border trading scheme. Rules and a timetable for the pilot trading program have not yet been developed.

China is also moving toward adopting Euro 2 emissions standards for light-duty and heavy-duty vehicles. Beijing will be the first Chinese city to implement the new national standards, requiring that all new light-duty and heavy-duty vehicles sold in Beijing after January 1, 2003, comply with the Euro 2 standards. In an additional effort to reduce air pollution in the city, the municipal government is ordering city vehicles to convert to liquefied petroleum gas and natural gas.

India

Urban air quality in India ranks among the world's poorest [***41***]. Efforts to improve urban air quality have focused on vehicles, which account for the majority of the country's air pollution. Emissions limits for gasoline- and diesel-powered vehicles came into force in 1991 and 1992, respectively. Emissions standards for passenger cars and commercial vehicles were tightened in 2000 at levels equivalent to the Euro 1 standards. For the metro areas of Delhi, Mumbai, Chennai, and Kolkata, tighter Euro 2 standards have been required since 2001, and the sulfur content of motor fuels sold in the four metro areas has also been restricted to 500 parts per million since 2001, in order to be compatible with the tighter vehicle emissions standards. Since January 2000, motor fuel sulfur content in all other regions of the country has been limited to 2,500 parts per million.

The measures taken to reduce vehicle emissions in New Delhi have been more controversial. In 1998, India's

Supreme Court ordered all the city's buses to be run on compressed natural gas by March 31, 2001. Compliance was to be achieved either by converting existing diesel engines or by replacing the buses themselves. Only 200 compressed natural gas buses were available by the initial deadline, however (out of a total fleet of 12,000), and protests ensued as all other buses were banned from use [***42***]. To ease the transition for both bus owners and commuters, the Delhi government is now allowing a gradual phaseout of the existing diesel bus fleet [***43***].

Although India is a large coal consumer, its Central Pollution Control Board has not set any sulfur dioxide emissions limits for coal-fired power plants, because most of the coal mined in India is low in sulfur content. Coal-fired power plants do not face any nitrogen oxide emissions limits either, although thermal plants fueled by natural gas and naphtha face standards between 50 and 100 parts per million, depending on their capacity. Enforcement of the standards has been recognized as a major problem in India [***44***].

References

1. Intergovernmental Panel on Climate Change, *Climate Change 2001: The Scientific Basis* (Cambridge, UK: Cambridge University Press, 2001), p. 788.
2. Intergovernmental Panel on Climate Change, *Climate Change 2001: The Scientific Basis* (Cambridge, UK: Cambridge University Press, 2001).
3. United Nations, *United Nations Framework Convention on Climate Change* (1992), Article 2, "Objective," p. 9, web site http://unfccc.int/resource/docs/convkp/conveng.pdf.
4. United Nations Framework Convention on Climate Change, "Greenhouse Gas Inventory Database," web site http://ghg.unfccc.int.
5. S. Ruth and A. Retyum, "CERA Decision Brief: Russia: Holding the Kyoto Trump Card" (Cambridge, MA: Cambridge Energy Research Associates, September 2002).
6. Remarks by President Bush on Global Climate Change, Office of the Press Secretary, The White House (June 11, 2001).
7. "President Announces Clear Skies & Global Climate Change Initiatives," web site www.whitehouse.gov/news/releases/2002/02/20020214-5.html (February 14, 2002).
8. Letter to President Bush From Secretary of Energy Spencer Abraham and Secretary of Commerce Donald L. Evans, "Reporting on Progress with the Climate Change Science and Technology Program," web site www.climatescience.gov/Library/climateletter.htm (September 9, 2002).
9. R.G. Newell, J.N. Sanchirico, and S. Kerr, "Fishing Quota Markets," Resources for the Future Discussion Paper 02-20 (August 2002).
10. Commission of the European Communities, *Proposal for a Directive of the European Parliament and of the Council Establishing a Scheme for Greenhouse Gas Emission Allowance Trading Within the Community and Amending Council Directive 96/61/EC, COM (2001) 581* (Brussels, Belgium, October 23, 2001), web site www.europa.eu.int/comm/environment/climat/emission.htm.
11. Jorge Moreira Da Silva, *Report on the Proposal for a European Parliament and Council Directive Establishing a Scheme for Greenhouse Gas Emission Allowance Trading Within the Community and Amending Council Directive 96/61/EC*, A5-0303/2002 (Brussels, Belgium: European Parliament, September 13, 2002), EUROPARL web site, www.europarl.eu.int; and European Union, EurActiv.com, "Parliament Set for Fight Against Council Agreement on Emissions Trading" (December 13, 2002), web site www.euractiv.com/cgi-bin/cgint.exe/3004509-555?targ=1&204&OIDN=1504424&-home=search.
12. United Nations Environmental Programme, *An Emerging Market for the Environment: A Guide to Emissions Trading* (Denmark: UNEP Collaborating Centre on Energy and the Environment, UN Conference on Trade and Development, 2002).
13. Point Carbon, "The Carbon Market in 2002" (September 25, 2002), web site www.pointcarbon.com/article.php?articleID=1959.
14. A.C. Christiansen, "Overview of European Emissions Trading Programs," Point Carbon Presentation at EMA 6th Annual Fall Meeting and International Conference (Toronto, Canada, September 29-October 1, 2002).
15. J.D. Kilgroe, C.B. Sedman, R.K. Srivastava, J.V. Ryan, C.W. Lee, and S.A. Thorneloe, *Control of Mercury Emissions from Coal-Fired Electric Utility Boilers: Interim Report*, EPA-600/R-01-109 (Research Triangle Park, NC, December 2001), web site www.epa.gov/ordntrnt/ORD/NRMRL/Pubs/600R01109/600R01109.htm.
16. European Environment Agency, *Environmental Signals 2000: Environmental Assessment Report No. 6* (Copenhagen, Denmark, May 2000) web site http://reports.eea.eu.int/signals-2000/en.
17. U.S. Environmental Protection Agency, *Latest Findings on National Air Quality: 2001 Status and Trends*, EPA 454/K-02-001 (Research Triangle park, NC, September 2002), web site www.epa.gov/airprogm/oar/aqtrnd01/summary.pdf.

18. United Nations Environment Programme, *Report of the Global Mercury Assessment Working Group on the Work of Its First Meeting*, UNEP(DTIE)/MGA/WG.1/8 (Geneva, Switzerland, September 2002).

19. U.S. Environmental Protection Agency, *Latest Findings on National Air Quality: 2001 Status and Trends*, EPA 454/K-02-001 (Research Triangle park, NC, September 2002), web site www.epa.gov/airprogm/oar/aqtrnd01/summary.pdf.

20. U.S. Environmental Protection Agency, "Fact Sheet: The Federal NO_X Budget Trading Program," web site www.epa.gov/airmarkets/fednox/fnbtp-fact.pdf.

21. U.S. Environmental Protection Agency, *Final Emission Standards for 2004 and Later Model Year Highway Heavy Duty Vehicles and Engines*, EPA420-F-00-026 (Washington, DC, July 2000).

22. U.S. Environment Protection Agency, *Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements*, EPA420-f-00-057 (Washington, DC, December 2000).

23. U.S. Environmental Protection Agency, "Control of Air Pollution from New Motor Vehicles: Tier 2 Motor Vehicle Emission Standards and Gasoline Control Requirements," *Federal Register*, 40 CFR Parts 80, 85, and 86 (February 10, 2000).

24. U.S. Environmental Protection Agency, "Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements: Final Rule," *Federal Register*, 40 CFR Parts 69, 80, and 86 (January 18, 2001).

25. U.S. Environmental Protection Agency, *Latest Findings on National Air Quality: 2001 Status and Trends*, EPA 454/K-02-001 (Research Triangle park, NC, September 2002), web site www.epa.gov/airprogm/oar/aqtrnd01/summary.pdf.

26. Government of Canada, "News Release: Government of Canada Tightens Emission Guidelines for New Electricity Plants" (Ottawa, January 3, 2003).

27. Government of Canada, "News Release: Canada and the United States Embark on New Era of Cleaner Air," (Washington, DC, December 7, 2000), web site www.ec.gc.ca/press/001207_n_e.htm.

28. "On-Road Vehicle and Engine Emission Regulations (SOR/2003-2). Part II," *Canada Gazette*, Vol. 137, No. 1 (January 1, 2003).

29. "City Continues To Improve Environment," *The News* (October 29, 2001).

30. "Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on National Emission Ceilings for Certain Atmospheric Pollutants," *Official Journal of the European Communities*, L309/22 (November 27, 2001), web site http://europa.eu.int/eur-lex/pri/en/oj/dat/2001/l_309/l_30920011127en00220030.pdf.

31. Council of the European Union, "Agreement on Sulphur Content in Petrol and Diesel Fuels," 15476/02 (Presse 397) (December 10, 2002), web site http://ue.eu.int/pressData/en/misc/73606.pdf.

32. European Union, EurActiv.com, "Parliament and Council Reach Agreement on Sulphur-Free Fuels" (December 12, 2002), web site www.euractiv.com/cgi-bin/cgint.exe/3943338-467?targ=1&204&OIDN=1504413&-home=search.

33. DRI-WEFA, *World Energy Service: Asia/Pacific Outlook 2002* (Lexington, MA, 2002), p. 25.

34. Environment Australia, "Fact Sheet - Nitrogen Dioxide (NO_2)" (November 12, 2001), web site www.ea.gov.au/atmosphere/airquality/nitrogen dioxide.html.

35. M. Kojima and M. Lovei, *Urban Air Quality Management: Coordinating Transport, Environment, and Energy Policies in Developing Countries*, Technical Paper No. 508 (Washington, DC: World Bank, September 2001), p. 17.

36. World Bank Group, *World Development Indicators 2001* (Washington, DC, April 2001), web site www.worldbank.org/data/wdi2001/index.htm.

37. Stockholm Environment Institute and United Nations Development Programme, *China Human Development Report 2002: Making Green Development a Choice* (Hong Kong: Oxford University Press, 2002), web site www.unchina.org/undp/documents/chdr2002.pdf.

38. "China to Slash SO_2," *Environmental Health Perspectives*, Vol. 110, No. 9 (September 2002).

39. N.J. Smith, "China OKs Plan for Tackling Sulfur Dioxide with Added Emphasis on Emissions Trading," *BNA International Environment Reporter*, Vol. 25, No. 24 (November 20, 2002).

40. "China – Emissions Plan Set to Expand" *China Daily* (November 19, 2002).

41. "Smoking Cities," *BBC News Online* (January 25, 1999), web site news.bbc.co.uk.

42. "Capital Punishment," *The Economist*, Vol. 359, No. 8216 (April 7, 2001), p. 44.

43. C. Chauhan, "Private Operators Told To Pull Out 3,700 Buses," *The Hindustani Times* (November 29, 2001).

44. S. Sinha, "Environmental Guidelines for Power Plants in India and Other Nations," *Environmental Quality Management*, Vol. 11, No. 1 (Autumn 2001), pp. 57-69.