Greenhouse Gas Abatement and Climate Change

The World Bank Group supports a number of efforts to help its client countries reduce emissions of greenhouse gases through measures such as promoting energy efficiency and increasing the use of renewable energy.

In 1995, the Intergovernmental Panel on Climate Change (IPCC), a panel of experts assembled by the United Nations, concluded after detailed scientific reviews that "the balance of evidence suggests a discernible human influence on global climate." This human influence on climate comes from emissions of three greenhouse gases in particular—carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Such gases act like a blanket around the Earth, trapping heat emitted from the Earth's surface. Overall, about 80% of greenhouse gas (GHG) emissions from human activities are related to the production and use of energy—and particularly the burning of fossil fuels. The bulk of the remaining 20% is associated with agriculture and changes in land use, such as deforestation.

The objective of the UN Framework Convention on Climate Change (UNFCCC) is to achieve "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." The Convention is founded on the principle of "common but differentiated responsibilities." Commonality refers to the need of all nations to assume responsibility for the protection of the global atmosphere and the recognition that developing country GHG emissions will exceed those from the industrial nations within the coming generations. Differentiation is predicated on the scientific fact that the industrial countries are responsible for the bulk of the present atmospheric stock of GHGs, and the realization that developing countries are least able to bear the costs of GHG mitigation and are most vulnerable to climate change effects.

The Kyoto Protocol to the UNFCCC was adopted on December 11, 1997, and, if it enters into force, will result in binding emissions reduction limitations for 39 industrial countries and transition economies listed in Annex B to the Protocol. These parties agreed to ensure that their aggregate GHG emissions do not exceed their assigned amounts, "with a view to reducing their overall emissions by at least 5.2% below 1990 levels in the commitment period 2008 to 2012."

The Kyoto Protocol also contains provisions allowing various elements of flexibility for Annex B countries in meeting their obligations. These include the ability to trade carbon reductions among countries ("emissions trading") and to jointly implement projects that can lead to carbon reductions on a project basis by reducing emissions or improving sinks ("Joint Implementation"). Emissions trading can take place only among Annex B parties. Joint implementation involving non-Annex B (i.e., developing country) parties can take place under the Clean Development Mechanism (CDM), with crediting being allowed after 2000.

Commitments of Bank Borrower Countries

The World Bank's borrower countries that are parties to the Convention and may sign the Kyoto Protocol can be broadly classified in three categories: (a) transition economies in Eastern Europe and the former Soviet Union that are listed in Annex I of the UNFCCC and in Annex B of the Kyoto Protocol, (b) developing countries, and (c) least developed countries. A further dis-

tinction is made for those developing countries that are particularly vulnerable to the impacts of climate change. The operational implications of this categorization are highlighted in Table 1.

The Convention and the Protocol do not impose mandatory emissions restrictions on developing countries and least developed countries, whereas they call on industrial-country parties to limit their anthropogenic emissions of greenhouse gases. However, developing countries and least developed countries do have obligations to measure and monitor emissions within their countries.

Principles of World Bank Group Assistance

The World Bank's role is to help finance sustainable development. In fulfilling this role, the Bank has a substantial capacity to assist its client countries in implementing their commitments under international conventions. In the case of the UNFCCC and the Kyoto Protocol, the World Bank will ensure that its activities are consistent with these conventions and will actively support its member countries in building capacity and undertaking investments for their implementation. Global environmental externalities can be recognized at the project level and, increasingly, in economic and sector work and in national environmental action plans. Where appropriate, country assistance strategies also include global environmental issues.

Sustainable Development, Equity, and Consistency with the UNFCCC and the Kyoto Protocol

Defining which policies and investments are "consistent" with the Convention is difficult, especially regarding developing countries. It is universally recognized that the energy needs of developing countries are enormous, that increased energy consumption and economic growth will be essential if the living standards of the poor are to be raised, that without accelerated development in many countries domestic environmental degradation will worsen, and that the current threat from anthropogenic climate change is caused much more by affluent countries than by the poorer nations. For all these reasons, the Convention and the Protocol make it clear that continued growth of energy and use of fossil fuels in developing countries is consistent with the stipulations of the Convention and the Protocol. But guidance from the parties as to when and how such growth must be moderated in order to maintain this consistency will only evolve over time.

There is significant potential in Bank client countries for efficiency gains, substitution of lower carbon fuels such as natural gas, and the application of renewable energy technologies. Emissions factors for various fuels are presented in Table 2.

There are also critical shortages of conventional energy supplies and, in many countries,

Table 1. Differentiated UNFCCC and Kyoto Protocol Commitments of World Bank Clients

World Bank client category	*Timetable for initial national communication*	*Description of mitigation policies and measures*	*Limitation of year 2000 emissions to 1990 levels*	*Financing for climate change mitigation*
Transition economies	Within 6 months of entry into force; flexibility granted	Detailed, with net GHG emissions projections	By 0-8%, but with flexibility and optional base year	GEF; bilaterals and multilaterals; Joint Implementation
Developing countries	Within 3 years of entry into force of the UNFCCC (by 1997)	General	No	GEF grant and concessional; bilaterals and multilaterals; CDM
Least developed countries	At country discretion	General	No	GEF grant and concessional; bilaterals and multilaterals; CDM

Note: GEF, Global Environment Facility; CDM, clean development mechanism.
Source: UNFCCC; Kyoto Protocol; GEF Legal Instrument; World Bank staff estimates.

Table 2. Emissions Factors for Utility and Industrial Combustion Systems
(*grams per gigajoule energy input*)

Source	Emissions factor				
	Carbon dioxide (CO_2)	*Carbon monoxide (CO)*	*Methane (CH_4)*	*Nitrogen dioxide (NO_2)*	*Nitrous oxide (N_2O)*
Utility application					
Natural gas boilers	56,100	19	0.1	267	—
Gas turbine, combined cycle	56,100	32	6.1	187	—
Gas turbine, simple cycle	56,100	32	5.9	188	—
Residual oil boilers	77,350	15	0.7	201	—
Distillate oil boilers	74,050	15	0.03	68	—
Municipal solid waste (mass feed)	—	98	—	140	—
Coal, spreader stoker	94,600	121	0.7	326	0.8
Coal, fluidized bed	94,600	—	0.6	255	—
Coal, pulverized	94,600	14	0.6	857	0.8
Coal, tangentially fired	94,600	14	0.6	330	0.8
Coal, pulverized, wall fired	94,600	14	0.6	461	0.8
Wood-fired boilers[a]	26,260	1,473	18	112	—
Industrial application					
Coal-fired boilers	94,600	93	2.4	329	—
Residual-fired boilers	77,350	15	2.9	161	—
Natural gas–fired boilers	56,100	17	1.4	67	—
Wood-fired boilers[a]	26,260	1,504	15	115	—
Bagasse/agricultural waste boilers	—	1,706	—	88	—
Municipal solid waste, mass burn	—	96	—	140	—
Municipal solid waste, small modular	—	19	—	139	—

— Not available.
Note: The table is based on fuel energy input rather than output; that is, it does not take account of combustion efficiency. Values are based on lower heating value, converted from original data in higher heating value using OECD/IEA assumptions (lower heating value is 10% below the higher heating value for natural gas; 5% for coal and oil); CO_2 values for coal represent an average value of subbituminous through anthracite.
a. Values for wood-fired boilers derived separately; not reported in IPCC.
Source: World Bank 1994a.

major shortcomings in energy policies. The World Bank's energy sector strategy encourages the adoption of appropriate energy pricing and institutional reform, which are prerequisites for improving both supply-side and demand-side efficiency and for more rapid adoption of no- and low-carbon-emitting energy sources. The strategy also recognizes the need to support commercial energy development as part of economic development and as a substitute for environmentally damaging dung and fuelwood consumption. The World Bank also considers within its investment operations cost-effective mitigative measures that would greatly reduce a country's vulnerability to climate change, particularly in the infrastructure and agricultural sectors.

Concerning climate change and the forestry sector, the scientific literature suggests that a significant fraction of total CO_2 releases from all sources is caused by tropical deforestation and burning. In addition, accelerated utilization of temperate and boreal forests contributes to rising global net emissions. The World Bank believes that measures for forest resource conservation, sustainable use, and enhancement could be an important part of many of its borrowers' climate change mitigation plans. These strategic directions provide potential synergies with the principles of the Convention on Biological Diversity. Carbon sink protection and enhancement actions are also in accord with the World Bank's support for the forest sector, as summarized in its 1991 forest policy paper (World Bank 1991). The policy

gives high priority to combating deforestation and maintaining areas of forest intact.

Strategic Elements

The strategic elements of the World Bank Group's assistance for mitigating climate change include:

- Promoting and capturing "win-win" policy and investment opportunities and, at the same time, identifying, analyzing, and clarifying tradeoffs between socioeconomic and global environmental objectives
- Supporting implementation of client countries' Convention and Protocol commitments as expressed in, inter alia, their national climate change plans and strategies
- Supporting clients who are parties to the agreements in integrating climate change considerations (including both GHG abatement and climate change adaptation) into development policy and planning
- Leveraging and maximizing the impact of resources available by virtue of the World Bank Group's role as implementing agency of the Global Environment Facility (GEF) and as a mobilizer of bilateral and private sector financing
- Integrating GEF financing with regular development finance and private sector resources for promoting transfer of no- and low-carbon energy, industry, and transport technologies
- Assisting in the development of a global market for carbon emissions offsets and credits that will help cut the costs of averting climate change.

World Bank Support for the Objectives of the Convention and the Protocol

The Convention and the Protocol recognize the complexity of the climate change problem by prescribing a broad range of policies and measures in the energy, transport, industry, agriculture, forestry, and waste management sectors. Especially relevant to the realization of the objectives of the Convention and the Protocol are three focal areas of World Bank assistance: energy efficiency, renewable energy, and mainstreaming of global environmental concerns.

Energy Efficiency

Macroeconomic and structural reforms are a centerpiece of World Bank advice to many of its client countries and will contribute a large fraction of future carbon and other GHG savings. A wide range of studies indicates that macroeconomic policies that effect structural change and promote efficient resource allocation are the single most important source of GHG emissions savings. The following examples help demonstrate this point.

First, energy subsidies add to the potential for climate change. Many countries, in both the industrial and the developing world, subsidize the use of fossil fuels. A World Bank study has shown that such subsidies are substantial for some countries and reach as much as 10% of gross domestic product (GDP). Worldwide fossil fuel subsidies are in excess of US$210 billion a year, or 20–25% of the value of global fossil fuel consumption at world prices. Phasing out subsidies would save scarce public resources and, at the same time, reduce GHG emissions. The study estimates that removal of fossil fuel subsidies would reduce global carbon emissions by almost 7%—in some countries, by more than 20%, assuming no change in world fuel prices.

Second, evidence is growing that changes in economic structure affect the future path of GHG emissions more than any other factor. A joint study by the China National Environmental Protection Agency, China's State Planning Commission, the UNDP, and the World Bank (UNDP 1994) emphasizes the importance of structural change for energy intensity, energy demand, and the associated GHG emissions reductions. The study isolates the factors that are responsible for reducing the energy intensity of the Chinese economy below the level that would be reached with static production technologies.

The study shows that only 21% of the total expected decline in energy intensity results from technical efficiency gains at the project level such as industrial modernization, improvement in industrial equipment, and energy conservation. The remaining 79% is the consequence of different types of structural change at the sectoral and subsectoral levels. The most important change is the shift in the product mix within subsectors, which contributes 37% of the total decline. This change represents movement up the product

quality ladder and a shift into higher value added products, mainly in the chemical, machinery, building materials, and light industry sectors. The findings indicate the enormous effects that structural changes have on energy intensity and, consequently, on energy consumption and associated CO_2 emissions. Macroeconomic and other policies can therefore have a larger impact on GHG emissions than any explicit mitigation option at the project level.

This finding is consistent with recent research in OECD countries. An extensive ongoing study at the Lawrence Berkeley Laboratory analyzed the impacts of various factors on CO_2 emissions in manufacturing industries in major OECD economies. Structural change within the manufacturing sector since 1973 has reduced CO_2 emissions in that sector by about 20% in Germany, Japan, and the United States. What is more striking is that reductions in energy intensity cut emissions by 25–35% in these and most other OECD countries. Without this evolution of both structure and intensity, CO_2 emissions from manufacturing in the early 1990s would have been twice their actual level.

Renewable Energy

Renewable energy is a growing focus of World Bank/GEF projects. Studies by the World Bank point out the insufficiency of energy efficiency measures alone and the massive shift to renewable energy required if the IPCC-prescribed stabilization of atmospheric CO_2 concentrations is to be achieved.

A small number of renewable energy forms have emerged as the most promising in the immediate term. *Biomass-based applications,* such as direct combustion of wood residues in the forest product industries, industrial-scale methane generation from animal and distillery wastes, and so on, have long been used commercially in many countries. New techniques such as fluidized-bed combustion systems and modern gasification systems, especially when combined with high efficiency gas turbines, are likely to expand these applications considerably.

For large, grid-connected power applications, *windfarms* and *solar thermal conversion,* particularly with use of parabolic trough technology, have made important technical and economic progress in the last decade due, in large part, to valuable operational experience acquired in California. Depending on the available wind regime, some windfarm installations can already be competitive with fossil-fuel alternatives. Solar thermal schemes are still relatively more costly, but the cost differential can be reduced by properly configuring the solar field with a combined-cycle/gas-turbine set that obviates the need for energy storage. *Photovoltaic (PV) cell* costs have dropped from about US$50 per peak watt in the mid-1970s to less than US$5 per peak watt today, considerably expanding opportunities for practical use of PV power, particularly for rural applications such as lighting, water pumping, battery charging, and vaccine refrigeration. Further cost reductions can extend PV use in the future for peak-shaving purposes in urban areas.

Mainstreaming Global Environmental Concerns

The successful pursuit of environmentally sustainable development at the national level will ultimately depend on the protection of the global commons, including the atmosphere. The commons are being degraded because decisions taken at the country level on use of natural resources for national economic development do not adequately reflect the global impacts of the actions. Agricultural, industrial, energy, transport, and other national sector development strategies and programs generally fail to consider the impact of the emissions of greenhouse gases on climate change. Hence, local and global optima for resource utilization diverge.

The principal challenge for sustainable use of the global commons, therefore, is to bring about the internalization of global environmental externalities in national economic and sector development policies and programs, as well as in local management of natural resources. This challenge breaks down into two main elements:

- Countries should be informed about options and encouraged to pursue actions that are in their own best interest and will also help to capture global environmental benefits. Policies and measures for energy efficiency, for example, typically reduce fuel consumption, SO_2, NO_x, and particulate emissions, and carbon emissions. Thus, up to a point, global and domestic benefits are produced jointly.

- Reflecting global environmental externalities in national decisionmaking will frequently require going beyond "no regrets" actions of the type referred to above. In Convention and GEF terminology, this is the case when the additional domestic costs of addressing the global externality exceed the extra domestic benefits and the host country incurs "incremental costs." This would, for example, be the case when reduction of carbon emissions from burning fossil fuel requires going beyond the level dictated by national economic efficiency. The GEF has been established to help countries meet the incremental costs of capturing additional global environmental benefits, that is, in effect, to make available the "global premium" on national environmental management.

The World Bank has initiated support to bring the global environmental dimension into its regular economic and sector work program as it relates to sector development strategies, and in later stages, into strategic planning of environmental management (e.g., in national environmental action plans). Complementary efforts are under way to apply greenhouse gas accounting techniques at the individual investment level, where global externality impacts serve as an input to the environmental scoping process and affect project choice.

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