Executive Summary

This report examines greenhouse gas (GHG) emissions at the global, national, sectoral, and fuel levels and identifies implications of the data for international cooperation on global climate change. Emissions are assessed within the broader socioeconomic context faced by countries, including factors such as economic output, population size, trade, investment, and sectoral structure.

Our hope is to make several contributions to the international dialogue on climate change policy. First, an exploration of the myriad sources of GHG emissions sheds significant light on the nature, challenges, and opportunities faced by governments, the private sector, and advocates in addressing the issue of climate change. Second, by giving policy-makers and other stakeholders sound, comprehensive information, we hope this report will contribute to better-informed debate and better decision-making, thereby advancing the prospects for compromise and cooperation. The key data and policy-related findings are summarized here.

- ***Global trends.*** Worldwide emissions of GHGs have increased steeply since 1945, with the largest absolute increases in carbon dioxide (CO_2) emissions occurring in 2004. This year also represented the largest percentage increase in emissions since 1976. Mid-range projections suggest that, in the absence of policy actions, GHG emissions will increase by another 50 percent by 2025 compared to present levels, with emissions in developing countries growing the fastest. Avoiding dangerous climate change will require slowing this global trend in the short term, and reversing it over the next one to two decades.
- ***Contributions of different GHGs.*** CO_2 comprises the majority of GHG emissions, at about 77 percent of the worldwide total (measured in global warming potentials). The remainder comes mostly from methane (CH_4) and nitrous oxide (N_2O), with small shares coming from fluorinated gases (SF_6, PFCs, and HFCs). The contributions of CH_4 and N_2O are significantly larger in developing countries, and in some cases are larger than energy-related CO_2 emissions. Emission estimates of CH_4 and N_2O, however, are subject to higher measurement uncertainties than energy-related CO_2 emissions.
- ***Contributions of different sectors.*** GHG emissions come from almost every human activity. The GHG Flow Diagram (Figure 1.3, p.4) illustrates the contributions that different sectors and activities make to the worldwide annual emissions of GHGs. Because of their large contributions, key policy targets are electricity and heat, transport, buildings, industry, land-use change and forestry, and agriculture. Future growth is likely to be especially high in the electricity and transport sectors, suggesting that these are particularly important sectors for promoting policy change, investment, and technology innovation.
- ***Current emissions by country.*** A relatively small number of countries produce a large majority of global GHG emissions. Most also rank among the most populous countries and have the largest economies. The major emitters include almost an equal number of developed and developing countries, as well as some transition economies of the former Soviet Union. An international climate change regime that does not establish adequate GHG mitigation incentives and/or obligations within these political entities—through domestic initiatives, international agreements, or both—will fail environmentally.
- ***Emission projections by country.*** Emission projections at the national level are highly uncertain. Uncertainties are especially acute in developing country economies, which tend to be more volatile and vulnerable to external shocks. Furthermore, past projections have a dubious record of accuracy. This presents serious difficulties for policy approaches that are based on such forecasting. For instance, fixed emission "caps" (such as Kyoto Protocol-style targets) are less likely to be viable in developing countries than in industrialized countries.

- ***Emissions intensity.*** Emissions intensity—the level of CO_2 emissions per unit of economic output—varies widely across countries, reflecting differences in economic structure, energy efficiency, and fuel mix. Over time, intensity levels decline in most countries because GDP usually increases at a faster rate than emissions. Declining carbon intensity in many developed and developing countries may suggest a preliminary or gradual "decoupling" of emissions and economic growth, although some of these trends are reversing. Intensity indicators present some advantages in establishing emission targets, but also some challenges, which in some cases could outweigh the benefits. The challenges include incorporation of non-CO_2 gases and complexity.
- ***Per capita emissions.*** Only a handful of the countries with the largest total emissions also rank among those with the highest per capita emissions. For some countries, per capita emissions vary significantly when CO_2 from land use and non-CO_2 gases are taken into account. Although per capita emissions are generally higher in wealthier countries, there are notable and diverse exceptions. Some middle-income developing countries, for instance, have per capita emission levels similar to those of richer industrialized economies. Accordingly, international agreements predicated on equal per capita emission entitlements will face difficulty garnering consensus because of the diverse national circumstances facing countries with similar per capita emissions profiles.
- ***Cumulative emissions.*** Most of the largest current emitters also rank among the largest historic emitters, with developed countries generally contributing a larger share, and developing countries a smaller share, of cumulative emissions (CO_2 emissions summed over time). A country's historic contribution may differ substantially depending on the time period assessed and whether or not CO_2 from land-use change is included in the calculation. Policy proposals that rely on historical emissions prior to 1990 face considerable barriers related to data quality and availability.
- ***Socioeconomic development.*** A striking aspect of the major GHG-emitting countries is their disparities in development levels, as measured by income per capita and other economic and human development indicators. Although in percentage terms, per capita income is growing faster in developing countries than in industrialized countries, in absolute terms, the income gap is actually widening. Successful international policy responses must account for differing national capacities, and support rather than threaten development prospects. In addition, further consideration of country classifications—in Annexes to the Climate Convention and Protocol—may be warranted in light of changes in development levels since the adoption of those agreements.
- ***Energy and fuels.*** Coal, the highest carbon fuel, plays a dominant role in global electric power generation, and its future growth is expected to be significant. Avoiding dangerous climate change will require reduced coal use or geologic sequestration of coal-related emissions. Similarly, major emitting countries will need to reduce their dependence on oil, particularly in the transport sector where it has near monopoly status. Natural gas, because of its lower carbon content and increasing cross-border trade, has the potential to offer climate benefits if it can offset coal and oil consumption in key sectors.
- ***Trade.*** Global trade—including energy fuels, raw materials, and manufactured goods—has increased remarkably over the past few decades. Traded products that are carbon-intensive include chemicals, motor vehicles, steel, and aluminum, among others. The significant quantities of energy and GHG emissions that are embodied in these products are, under prevailing GHG accounting systems, attributed to the country of production, not consumption. While an alternative accounting system is not warranted, sectors that are deeply integrated into the world economy may warrant attention under international agreements.
- ***Sectoral cooperation.*** Not all sectors or subsectors are conducive or appropriate as a basis for organizing international cooperation. A range of considerations, such as international competitiveness, uniformity of products/processes, and concentration of actors (such as domestic and multinational corporations) are likely to influence whether sectoral agreements or other initiatives are feasible or appropriate. Sectors such as motor vehicles, steel, and aluminum score well in regard to these characteristics. Overall, the findings suggest that a "sector-by-sector" approach to international cooperation is likely to be infeasible. Comprehensive agreements (covering most sectors and gases), with special provisions or supplementary agreements for specific sectors, offer greater promise. The sectoral analysis also helps illuminate both the perceived successful and unsuccessful aspects of the Kyoto Protocol. One of the characteristics of the Protocol that fostered consensus was that it did *not* establish sector-by-sector requirements. On the other hand, the Protocol includes sector-specific provisions, and some of the objections to Kyoto might be partially remedied by advancing cooperation in specific sectors.