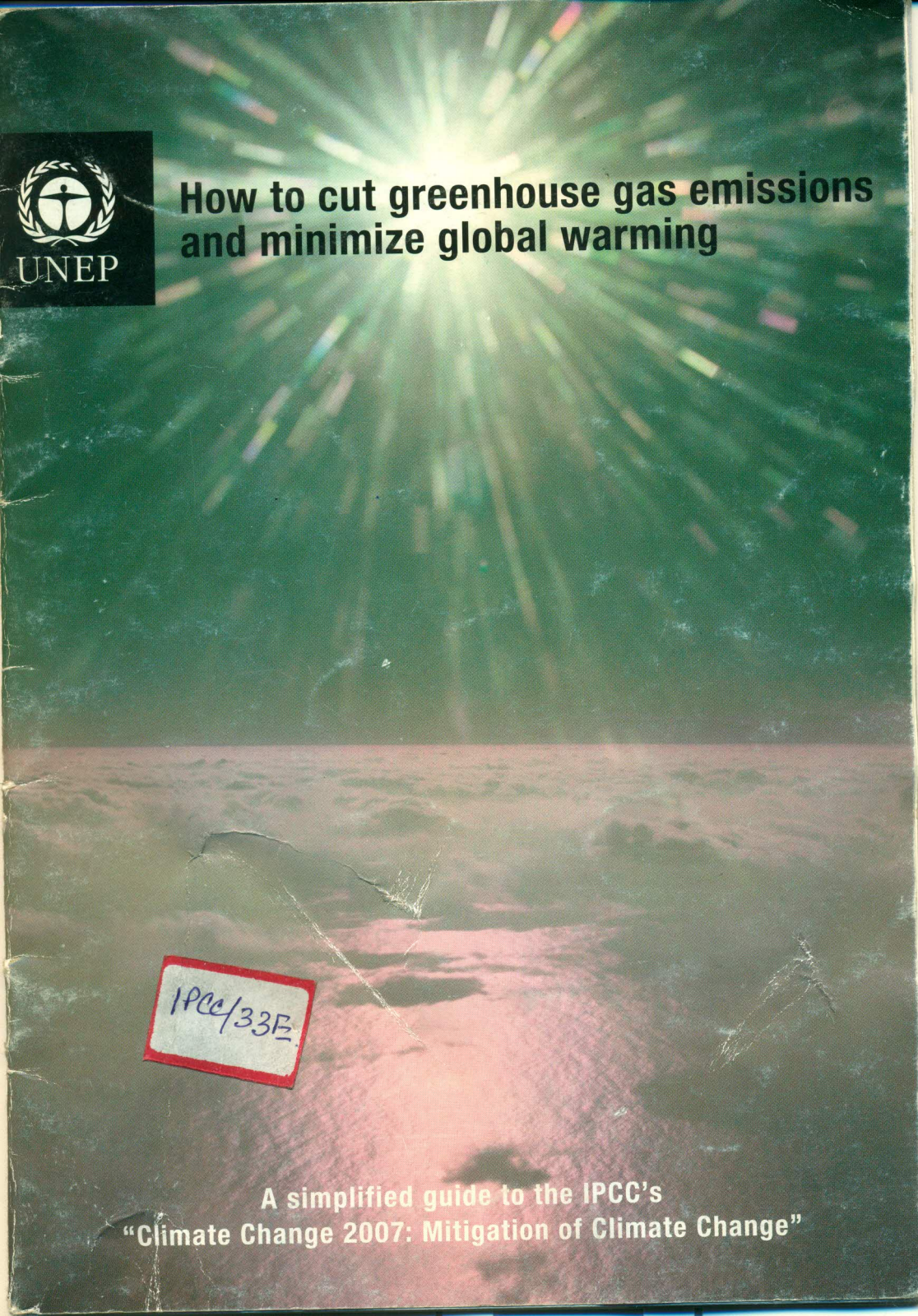
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How to cut greenhouse gas emissions and minimize global warming
IPCC/33E
A simplified guide to the IPCC's
"Climate Change 2007: Mitigation of Climate Change"

Published by the United Nations Environment Programme in November 2007. For additional copies, please contact UNEP, Information Unit for Conventions, International Environment House, 13 chemin des Anémones, CH-1219 Châtelaine (Geneva), Switzerland; iuc@unep.ch. To read the full IPCC report on mitigation, go to www.mnp.nl/ipcc/. See also www.ipcc.ch, www.unep.org and www.wmo.ch.

The IPCC is a 2007 Nobel Peace Prize laureate

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Foreword

When the WMO/UNEP Intergovernmental Panel on Climate Change (IPCC) released its landmark assessment report "Climate Change 2007", people stood up and took notice. Many understood for the first time that the Earth's climate has already started to warm, that the Arctic is melting, drought and flood patterns are shifting, and that these changes are set to accelerate over the coming decades.

Fortunately, after painting this bleak picture the IPCC also assessed possible solutions for minimizing climate change. By combining smart policies with green technologies, we – Governments, companies, organizations and individuals – can significantly reduce greenhouse gases. But there is no time for delay; we must act now if we are to avoid the worst consequences of climate change.

The role of national policymakers in this shared effort is to craft fiscal and policy frameworks that reward emissions cuts through price signals, energy-efficiency standards and other measures. Because the behavioral changes needed for reducing emissions go well beyond what voluntary actions and personal or corporate virtue can achieve, people and businesses need and want regulatory systems that make climate-friendly decisions simple and practical and that spread the responsibility fairly.

Local and regional policymakers can best contribute by reducing emissions from the buildings, energy utilities, public transport systems and other infrastructure and activities that they oversee. By recognizing that the future belongs to companies that can design and market low-emission products and services, business leaders can innovate in ways that are both profitable and climate-friendly.

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Civil society, including schools, community groups, the media, non-governmental organizations (NGOs) and consumers, can also make a real difference. Their tools include persuasion and lobbying, education, changed habits and thoughtful purchases and investments. Everyone emits greenhouse gases as they go about their daily business, and the cumulative effect of the small changes made by individuals can be enormous.

Will reducing global emissions over the next few decades be difficult and expensive? There will be costs, but there will also be savings. Indeed, it will cost the global economy and its people far more the longer we delay. Modern economies have also faced such challenges before, from financial turmoil and the globalization of markets to revolutions in technology and even the aftermath of total war; each time they have adapted and prospered. There is no reason today why our innovative and dynamic societies cannot successfully tackle the challenge of climate change as well.

Achim Steiner
UN Under-Secretary General and Executive Director,
United Nations Environment Programme

Introduction:

Our changing climate

The earth's average temperature has fluctuated widely over the eons, from a steamy 22°C when the dinosaurs roamed the planet to a chilly 10°C during the more recent ice ages. During the past 10,000 years the global temperature seems to have been remarkably stable, varying by less than 1°C, allowing human civilization to thrive at what is today a comfortable 15°C.

But the very success of this civilization is starting to disrupt the climate that has served us so well until now. The Intergovernmental Panel on Climate Change (IPCC) has concluded that, unless we make significant changes in our economy, the coming decades will experience rapid global warming accompanied by greater heat waves, new wind and storm patterns, worsening drought in some regions, increased flooding in others, melting glaciers and ice caps and rising sea levels. Looking ahead 100 years and more, the planet that future generations will inherit could be unrecognizable to those of us living on it today.

Fortunately, the human race has the knowledge and technology necessary for reducing global emissions of greenhouse gases (GHGs) over the next several decades despite growing incomes and populations. In addition, decision makers are increasingly aware of the links between climate change policies and sustainable development practices, and they are reflecting this understanding in their policies and actions. This promising conclusion is supported by the answers that the IPCC's most recent assessment provides to the key questions that decision makers are posing about the climate change challenge.

Question 1

How much higher will greenhouse gas emissions rise if we don't act?

Human activities release billions of tonnes of greenhouse gases into the atmosphere every year. Carbon dioxide is produced when fossil fuels are used to generate energy and when forests are cut down and burned. Methane and nitrous oxide are emitted from agriculture and other sources. Artificial chemicals such as PFCs and HFCs and other long-lived gases such as sulphur hexafluoride (SF_6) are released by industry.

The level of future emissions will depend in large part on the growth of populations and economies and on advances in technology. If Governments take a "business-as-usual" approach by adopting no further measures to limit emissions, then energy-related carbon dioxide (CO_2) emissions – the largest single component of global emissions – are projected to rise by 40–110% from the year 2000 to the year 2030. Looking at all sources of emissions, the six greenhouse gases cited in the paragraph above are projected to rise by 25 – 90% by 2030 compared to 2000. Although they contain only 20% of the world's population developed countries account for about half of current emissions.

At these rates, our rising emissions may cause atmospheric concentrations of greenhouse gases to double some time during the second half of this century compared to pre-industrial levels (around

Figure 1. Global greenhouse gas emissions, 2004

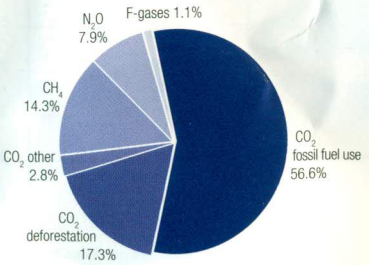
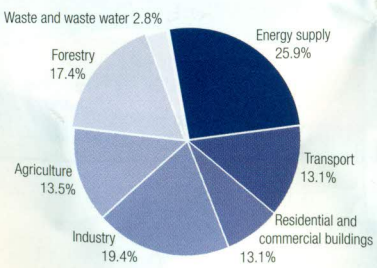


Figure 2. Greenhouse gas emissions by sectors, 2004



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the year 1750). The climate responds to emissions with some delay but this doubling would eventually cause it to warm by 2 – 4.5°C (3.6 – 8.1°F), with a best estimate of 3°C (5.4°F). This would have serious consequences for both the natural environment and for human well-being.

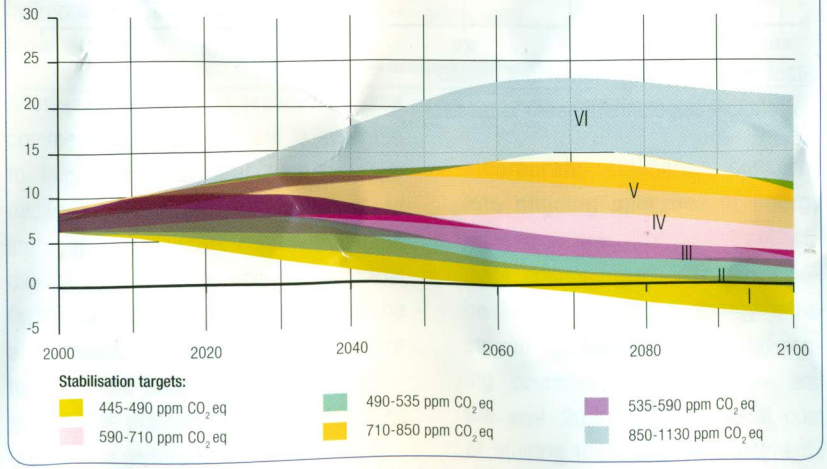
Question 2

How fast do we need to cut our emissions if we want to avoid the worst impacts of climate change?

Rather than ignoring the problem and following a business-as-usual approach, the international community could decide to make a concerted effort to lower its greenhouse gas emissions. While the inertia of the climate system now makes some warming inevitable, we can limit future climate change by stabilizing and then reducing emissions. For example:

- Limiting global mean temperature increases to 2 – 2.4°C above pre-industrial levels, thus greatly reducing the risk that the Greenland ice sheet will melt and that 20 – 50% or more of species will become extinct, would require global emissions to peak within 15 years and then fall to about 50 to 85% of current levels by 2050.
- Limiting the temperature increase to 2.8 – 3.2°C would require global emissions to peak within 25 years and then return to 2000 levels by around 2040. This could avoid the widespread disruption of ecosystems and ecosystem services and lower the risk that global food production will decline.

Figure 3. World Carbon dioxide Emissions, Gigatonnes

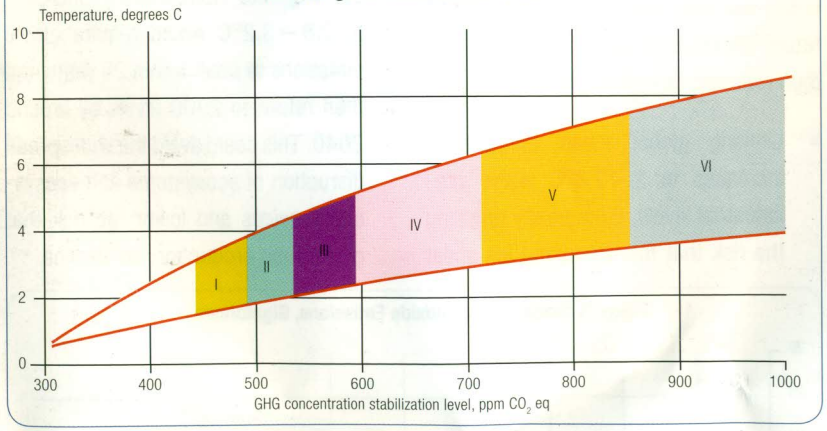


Note: Roman I to VI are the stabilization categories from the IPCC Fourth Assesment Report.

- Limiting the temperature increase to 3.2 – 4°C would require emissions to peak within the next 55 years. This would avoid only the most severe impacts relating to floods, droughts, ecosystems, food production and melting permafrost. There would still be a high risk that the Greenland ice sheet would melt completely.

Clearly, global emissions will need to start declining remarkably soon if we are to limit global warming to "just" the 2°C rise that many observers are calling for. Because our socio-economic and decision-making systems are also prone to inertia, even a target of 3°C would require us to start taking serious action now. So delay is clearly no longer an option: the next two to three decades will be critical for avoiding the most serious consequences of global warming.

Figure 4. Global mean temperature increase above pre-industrial level for a range of stabilization levels



Question 3

How can the energy industry reduce emissions?

Energy use is the largest source of greenhouse gas emissions. Global primary energy use almost doubled from 1970 to 2004 and continues to grow dramatically. Fossil fuels still account for four fifths of our energy, and they will dominate our global energy supply for the next several decades unless we make deliberate changes.

Emissions could be reduced by exploiting more fully a number of technologies that are already available today. These technologies would allow us to improve the efficiency of supplying and distributing energy, to switch from coal to gas, and to adopt renewable energy sources such as hydropower, solar, wind, geothermal and bio-energy.

Another technology that already has some commercial applications and is expected to improve further over the next few decades is known as carbon capture and storage. CCS involves capturing carbon dioxide from a power plant or industrial facility before it can be emitted into the atmosphere, transporting it to a secure location, and isolating it from the atmosphere, for example by storing it underground in a geological formation.

Other technologies under development include advanced nuclear power and advanced renewable energy sources, including tidal and wave energy, concentrating solar power systems and solar photovoltaics.

The commercialization of new types of bio-energy (solid and liquid fuels derived from crops and other biomass) may also offer significant potential. For example, biofuels could provide 5–10% of the fuel used by the global transport sector by 2030. Concerns about the possible impact on foods prices and biodiversity of diverting land from food crops or forests to biofuel production, however, would need to be addressed.

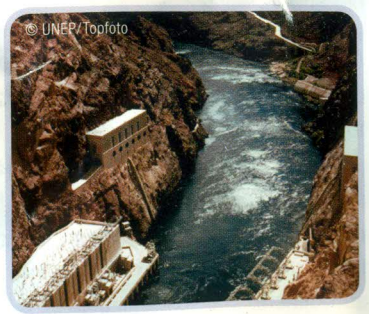
Policies that could encourage the faster take up of these technologies include:

- **Incorporate climate concerns into ongoing upgrades of energy infrastructure.** Irrespective of climate change, over $20 trillion will be invested in global energy infrastructure, especially in developing countries, between today and the year 2030. The additional cost of altering these energy investments

in ways that reduce greenhouse emissions would range from negligible to 5–10%. This does not reflect the many "co-benefits" of clean-energy investments, such as reduced air pollution and improved energy security.

- **Channel more sustained investment into research, development, demonstration and deployment**. Both the public and private sectors need to develop more cost-effective technologies with zero or very low greenhouse gas emissions and encourage their rapid deployment and diffusion.

- **Reward energy utilities and refiners who reduce emissions**. Reducing subsidies on fossil fuels, and introducing taxes or charges on carbon dioxide, would encourage suppliers to pursue low-emitting technologies. The early development of markets for clean technologies can also be encouraged through subsidies, feed-in tariffs (which encourage or require utilities to buy renewable electricity) and other incentives.



Question 4

How can transport emissions be reduced?

Transport is responsible for almost one quarter of the world's energy-related greenhouse emissions, with about three quarters of this coming from road vehicles. Over the past decade, these emissions have increased at a faster rate than in any other energy-using sector. Transport is expected to continue growing robustly over the next several decades so, unless there is a major shift away from current patterns, carbon dioxide emissions from this sector are projected to rise by 80% over current levels by 2030.

The demand for vehicles and transport fuel responds only weakly to higher prices. Prospects for reducing emissions therefore depend very much on advances in transport technologies and regulations encouraging their adoption:

- Improving road vehicles will require continued technological progress together with strong policies to ensure that engineers focus on boosting fuel economy rather than on increasing horsepower and vehicle mass. New materials and advanced design could reduce the weight of light-duty vehicles by 20–30%. Directed-injection turbocharged diesels, improved batteries for electric and hybrid vehicles and biofuels could all contribute to reducing emissions.

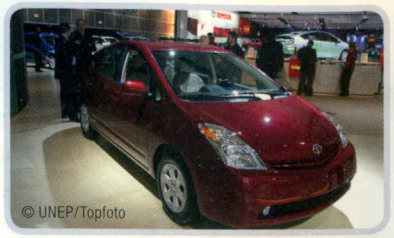
- Rail is one of the most energy-efficient modes of transport available today. Nevertheless, it could be made even cleaner through reduced aerodynamic drag, lower train weight, regenerative braking, better propulsion systems and a reliance on electricity from low-carbon sources.

- Shipping is also one of most energy-efficient forms of transport. Opportunities for cutting emissions even further include improving the hydrodynamics of hulls and propellers and using more energy-efficient machinery onboard.

- The fuel efficiency of passenger jet aircraft is likely to improve by 20% by 2015 compared to 1997, and a possible 40–50% improvement is anticipated by 2050. Without new policies, however, these projected annual improvements of 1–2% will be surpassed by a 5% annual growth in traffic, leading to an annual increase in carbon dioxide emissions of 3–4%.

Biofuels could substantially reduce these emissions but have not yet been commercialized for use by aircraft because of safety issues.

- Providing public transport systems and promoting walking and bicycling can further reduce emissions significantly. Making towns and cities more pedestrian friendly should be a top priority for urban planners. The associated health and other social benefits can also be significant.



Question 5

How can builders and residents lower emissions from buildings?

Approximately 30% of the emissions from residential and commercial buildings that would occur under the business-as-usual scenario could be reduced by 2030 with a net economic benefit due to energy savings. This remarkable potential is higher than for any other sector.

Emissions from buildings can be cut by reducing energy consumption, switching to low-carbon fuels and renewable energy sources, and controlling the emissions of non-CO_2 greenhouse gases such as the HFCs used in cooling and refrigeration units.

Many mature technologies that can reduce energy-related emissions are already on the market. They include passive solar design, energy-saving lamps and appliances, highly efficient ventilation and cooling systems, solar water heaters, insulation materials and techniques and multiple glazing.

The largest potential savings in energy use are in new buildings. The potential for energy savings of 75% or more, and even for houses that use net-zero energy, has already been demonstrated. These new buildings are designed and operated as complete systems that exploit opportunities for passively reducing energy demand. Realizing these savings will require greater cooperation amongst architects, engineers, contractors and residents.

The greatest challenge is developing effective strategies for retrofitting existing buildings. Encouraging people to make climate-friendly choices when selecting new appliances and heating or cooling systems and when adjusting their behavior will require programmes that give consumers easier access to information.

Effective government policies should include continuously updated standards for appliances and energy codes for buildings, financial incentives and demand-side management programmes through which utilities can reward customers for conserving energy.

Governments should also tackle the market barriers that have prevented many available technologies from being widely adopted. These barriers include the limited availability of reliable information on energy efficiency measures, a lack of proper incentives (such as the mismatch between the financial interests of

landlords who would invest in greater efficiency and the tenants who would benefit from lower energy bills), limited access to financing and the perverse effects of energy subsidies. A positive response to some of these challenges has been the emergence of Energy Service Companies, or ESCOs, which finance and implement energy-saving projects for buildings and are then paid a percentage of the resulting financial savings.

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Question 6

How can industry reduce emissions?

The greatest potential for reducing industrial emissions is located in the energy-intensive steel, cement, and pulp and paper industries. Significant opportunities also exist in the control of non-CO_2 gases. These gases include HFC-23 from the manufacture of HCFC-22 (a refrigerant used in air conditioners), PFCs from aluminium smelting and semiconductor production, sulphur hexafluoride from electrical switchgear and magnesium processing, and methane and nitrous oxide from the chemical and food industries.

While many technologies for cutting industrial emissions already exist, more low-cost options are urgently needed. The use of carbon capture and storage (CCS) technology could one day play an important role, albeit at higher cost.

Some industrial facilities, particularly in developing countries, are newly built and feature the latest energy-efficient technologies. However, many older, inefficient facilities remain in operation in both industrialized and developing countries. In developing countries there continues to be a huge demand for technology transfer to upgrade industrial facilities, thus improving energy efficiency and reducing emissions.

Industrial investment decisions, many of which have long-term consequences, will continue to be driven by consumer preferences, costs, competitiveness and government regulation. Governments can influence these decisions with standards, tradable permit systems, and subsidies and tax credits.

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Question 7
How can farmers reduce emissions?

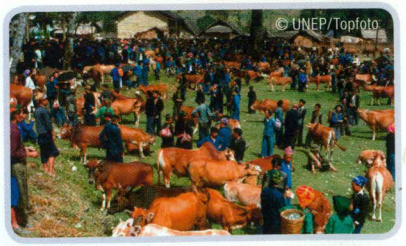
Many opportunities for lowering agricultural emissions involve current technologies and can be pursued immediately. Key options include upgrading the management of crop and grazing lands and revitalizing degraded lands. Improved water management in rice fields, set-asides that take farmland out of production, land-use change (such as converting cropland to grassland), agro-forestry and improved livestock and manure management can also contribute.

Sequestering carbon in the soil accounts for most – about 90% – of the potential emissions savings from agriculture. However, the risk that carbon stored in the soil could eventually be lost to the atmosphere due to changes in how the land is used or as a consequence of climate change itself needs to be carefully managed.

There is no universally applicable list of practices for reducing agricultural emissions: each one must be evaluated on a case by case basis according to the climate, social setting and historical patterns of land use and management in a particular setting.

Greater global demand for food – and thus for more livestock and nitrogen fertilizer – could boost future emissions of methane and nitrous oxide. Special efforts to reduce emissions from livestock and fertilizers will therefore be essential for preventing an increase in emissions from agriculture.

Farmers may also contribute to lowering emissions from the energy-supply and transport sectors through the successful commercialization of biofuels based on agricultural residues and dedicated energy crops. Limiting factors could include water supplies and concerns over environmental impacts and food security.



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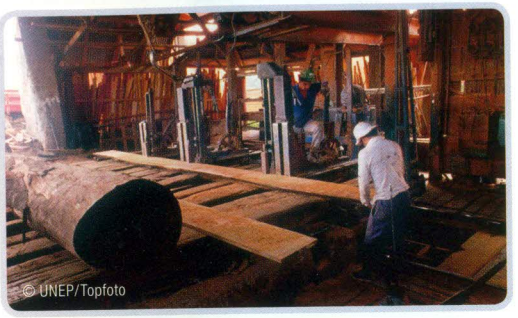
Question 8
How can forest managers reduce emissions?

Arresting today's high levels of deforestation and planting new trees could significantly reduce emissions from the world's forests or even transform them into a net "sink" that removes carbon dioxide from the atmosphere.

In the longer term, the best way to maintain or increase the ability of forests to store carbon is through sustainable forest management, defined as meeting the needs of a full range of users while maintaining the forest's ecological functions. The conservation and sustainable use of forests can ensure an annual sustained yield of timber, fibre or energy that is compatible with adapting to climate change, maintaining biodiversity and promoting sustainable development.

Other options include extending the ability of wood products to retain their carbon, substituting other materials for wood in certain products, and producing biomass for biofuels.



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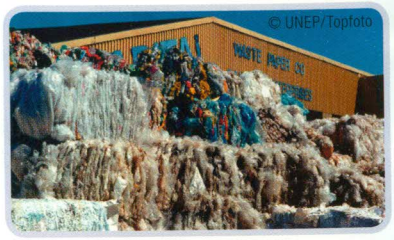
Question 9

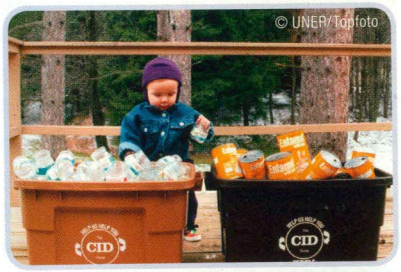
How can waste managers reduce emissions?

Waste management systems contribute less than 5% of global greenhouse emissions, although this percentage is expected to increase. The main source is methane from landfills followed by methane and nitrous oxide from wastewater. In addition, incinerating waste-containing substances such as plastics and synthetic textiles emits small amounts of methane.

A wide range of mature technologies are available for reducing these emissions. Many of them provide co-benefits involving public health, environmental protection and sustainable development.

Options include recovering gases emitted from landfills, improving landfill practices and wastewater management, controlling the composting of organic waste and using state-of-the-art incinerators that recuperate the energy used to run them. Waste emissions can also be indirectly reduced by measures for minimizing waste at source, recycling and re-using materials and wastes, conserving raw materials and improving energy and resource efficiency.





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Question 10

How can public policy motivate the private sector and consumers to reduce emissions?

Governments can play a major role in convincing industry and consumers to be climate-friendly by providing incentives that are clear, predictable, long term and robust.

It is important to ensure that policies are not counterproductive. Direct and indirect subsidies for fossil fuel use, for example, remain common practice, although those for coal have declined over the past decade in many countries.

Many public policies for promoting the development, deployment and diffusion of new technologies are applicable to a wide range of economic sectors. Examples of policies and measures already in use include:

- regulations and standards, such as fuel economy standards for automobiles or efficiency standards for appliances;
- taxes and charges for raising the costs of emissions;
- tradable emissions permits, which allow companies and utilities that reduce their emissions successfully to sell their remaining quotas to companies that find emission cuts to be more difficult or expensive;
- voluntary agreements through which an industry or an individual company pledges itself to improve its processes or to achieve a certain emissions target;
- subsidies or financial incentives that reward the buyers or sellers of low-emission technologies, thus enabling these technologies to gain a footing in the marketplace;
- research and development programmes, which can lower the costs of launching new technologies; and
- information programmes for helping consumers to understand and locate climate-friendly products and services.

Pricing carbon

Tradable permits and carbon taxes are often highlighted by economists as being particularly efficient policy measures because they can place a price on carbon.

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By reflecting the true cost of emissions, a carbon price can provide a signal to firms and households to cut emissions. It can also stimulate the research and development of low-carbon technologies.

Under a tradable permits (or cap-and-trade) system, the volume of allowed emissions – the "cap" – determines the carbon price and the environmental effectiveness of the system. Uncertainty about the actual price that the market will place on carbon, however, makes it difficult to estimate the total cost of meeting emission reduction targets in this manner. Researchers estimate that carbon prices in the range of $20 – 80 per tonne of CO_2 by 2030 would be consistent with limiting the increase in global mean temperature to about 3°C. Limiting the temperature increase to about 2°C would require carbon prices of around $100 per tonne of CO_2. By way of comparison, prices in the European Union's Emissions Trading Scheme in 2005 – 2006 varied between $6 and 40/t$CO_2$.

Adopting a carbon tax, on the other hand, would make it easier to estimate the costs of cutting emissions but more difficult to predict the amount of carbon dioxide that will actually be reduced. Carbon taxes are particularly attractive to many economists because of the efficient way in which they can influence decisions in the marketplace. Politicians, on the other hand, may find it challenging to implement the concept.

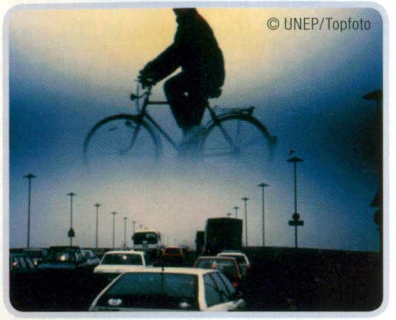
A diversified portfolio

Because no one sector or technology can address the entire climate change challenge, the best approach is to adopt a diversified portfolio of policies addressing all major sectors. Some of the cheapest options for reducing emissions involve electricity savings in buildings, fuel savings in vehicles and increased carbon content in agricultural soils. Because energy supply is the largest contributor to emissions, policies to promote a shift to less carbon-intensive energy sources are particularly effective. In any case, the most effective mix of climate change policies will vary from country to country.

To ensure that their policies are effective, Governments must pay special attention to identifying and removing barriers to innovation. These can include market prices that do not incorporate externalities such as pollution, misplaced incentives, vested interests that resist change, lack of effective regulatory agencies and imperfect information that fails to give the right signals.

In addition to policies set by national officials, regional, state, provincial and local governments also have a policy role to play. To date such governments have adopted renewable energy portfolio standards, energy efficiency programmes, public transport programmes, sustainable purchasing policies and much more. These climate change measures can influence national policies, address local concerns, create incentives for new industries and bring other environmental co-benefits.

Corporations themselves also have incentives to support, influence or pre-empt Government action by independently pursuing technological innovation. Proactive efforts to innovate can also create financial value or differentiate a company and its products. But no matter how proactive an industry chooses to be, effective government policies will remain essential to spurring the technological innovation needed for reducing global emissions.



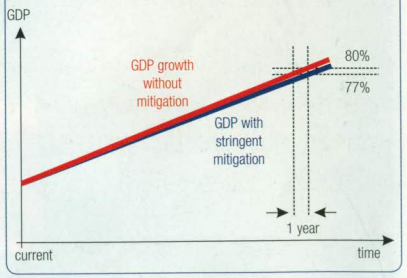
Question 11
Will reducing emissions cost a lot?

Reducing greenhouse gas emissions will cost money, but the amounts required are clearly affordable. For example, the kind of carbon prices cited above, in the range of $50 – 100 per tonne of CO_2, are equivalent to an increase of $25 – 50 per barrel of crude oil, or $0.12 – 0.24 per litre of gasoline. This is the same order of magnitude as the recent price hikes seen in the global oil market. Such price levels would translate into an overall expenditure for emission reduction of 1 – 2% of global GDP (Gross Domestic Product). This is comparable to all current expenditures being made for protecting the environment.

The impact of such expenditures on the economy as a whole are projected to be limited. For example, economists have explored the macro-economic costs of stabilizing greenhouse gases at levels both above and below a doubling of atmospheric concentrations. They conclude that the cost would range from less than 3% of GDP to a gain of +0.6% by the year 2030. A 3% reduction of GDP in 2030 is very small compared to the projected growth in the global economy over the next few decades; it would reduce the annual economic growth rate over that period by about 0.1 percentage points.

It is important to remember that climate policies can bring many win-win benefits that are not factored into such cost estimates. In addition to reduced damages from climate change, these benefits include technological innovation, increased employment, improved energy security, and health benefits from reduced pollution. As a result, climate policies offering significant co-benefits can offer a true no-regrets approach in which substantial advantages accrue even if the impact of human-induced climate change itself should turn out to be less than current projections suggest.

Figure 5. Illustration of cost numbers



Conclusion:
Building a sustainable future

Reducing greenhouse gas emissions will have to be one of the international community's top priorities over the coming decades. There will be many difficulties and detours along the road to building climate-friendly economies. Coordinating Government policies; ensuring that global action on climate change also promotes sustainable development; addressing concerns over the fairness of contributions from rich and poor countries; helping those industries that feel threatened by emissions reductions; assisting individuals to make the right choices about products, services, living arrangements and transport; and overcoming the general inertia of human affairs are just some of the challenges that will need to be addressed.

Many of the measures for minimizing climate change are consistent with what needs to be done anyway to promote sustainable development. Integrating climate change considerations into our long-term economic and development choices is vital. Climate policies can also support – and benefit from – efforts to protect and sustainably use biological diversity, improve public health, enhance energy security and boost the productivity of water and land and other limited natural resources.

An ambitious assault on greenhouse gas emissions is also well suited to the modern trend of adopting more inclusive forms of governance, where Governments, the private sector, non-governmental organizations and civil society collaborate on achieving common goals.

Working together, we have the know-how to reduce the human footprint on the Earth and build a more sustainable future. The IPCC's "Climate Change 2007" will remain a valuable resource and inspiration as we pursue this vision.

About the IPCC

Scientists, economists and other climate change researchers regularly publish their findings in peer-reviewed journals. To make these findings more accessible to policymakers, the World Meteorological Organization and the United Nations Environment Programme established the Intergovernmental Panel on Climate Change (IPCC) in 1988.

The IPCC's mandate is to make policy-relevant assessments of the existing worldwide literature on the scientific, technical and socio-economic aspects of climate change. Its multi-volume assessment reports of 1990, 1996, 2001 and 2007 played a major role in inspiring governments to adopt and implement the United Nations Framework Convention on Climate Change and the Kyoto Protocol.

Positioned at the intersection between science and policy, the IPCC engages hundreds of leading experts to write its reports and thousands of experts and government officials to review them. Its procedures emphasize rigour, transparency and inclusiveness. The IPCC is widely considered the most effective international mechanism of its kind and received the Nobel Peace Prize in 2007 for its efforts.

Notes

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