The Kyoto Protocol & Clean Development Mechanism

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Dr. Alwin Keil

The Kyoto Protocol and Clean Development Mechanism

Structure of the lecture

- The Greenhouse Effect
- Trends in Greenhouse Gas Emissions and Global Temperatures
- Impacts of Climate Change
- The Kyoto Protocol
- 'Flexibility Mechanisms'
- Beyond the Kyoto Protocol: Projections and Policy Implications of the Stern Review and the IPCC Fourth Assessment Report

The Greenhouse Effect

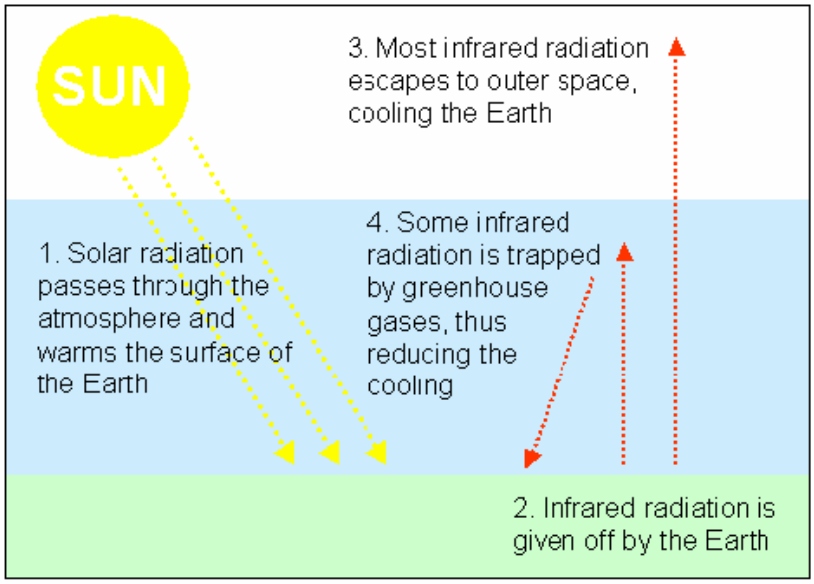


Figure 1. Illustration of the Greenhouse Effect

DEFRA (2005): 'Climate change and the greenhouse effect: a briefing from the Hadley Centre', available from http://www.metoffice.com/research/hadleycentre/pubs/brochures/2005/climate_greenhouse.pdf

Trends in Greenhouse Gas Emissions (1)

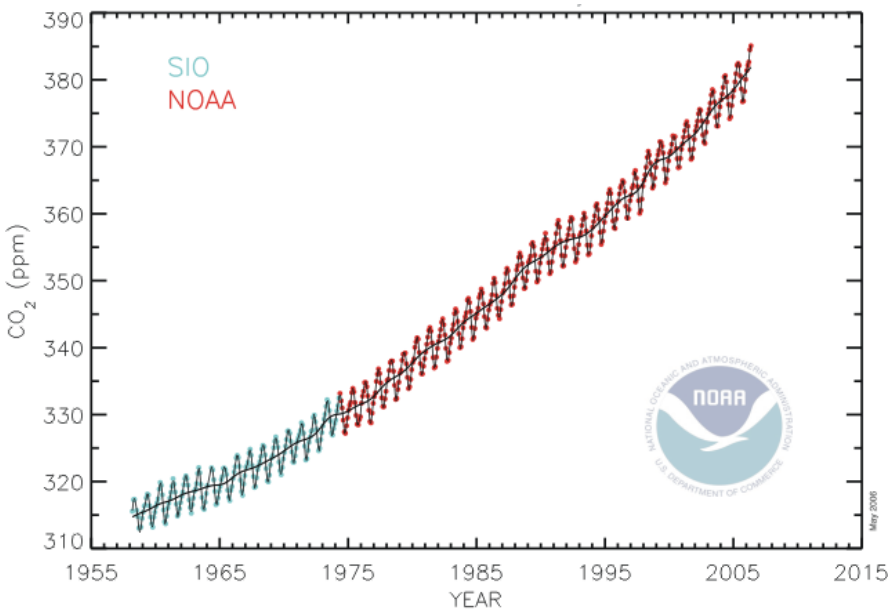
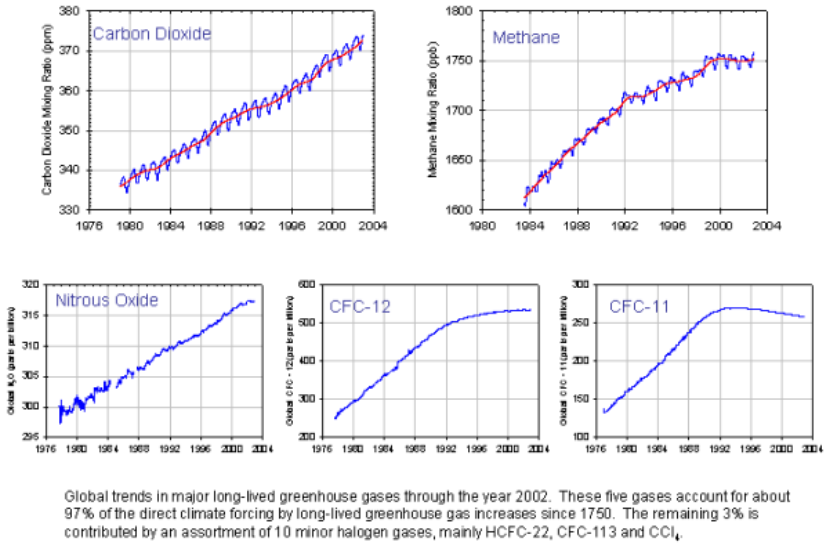


Figure 2. Monthly mean carbon dioxide concentrations measured on Mount Mauna Loa (Hawaii).

Source: National Oceanic and Atmospheric Administration (NOAA), 2006

Trends in Greenhouse Gas Emissions (2)



Global trends in major long-lived greenhouse gases through the year 2002. These five gases account for about 97% of the direct climate forcing by long-lived greenhouse gas increases since 1750. The remaining 3% is contributed by an assortment of 10 minor halogen gases, mainly HCFC-22, CFC-113 and CCl_4.

Figure 3. Gobal trends in major Greenhouse Gas concentrations to January 2003.

Source: National Oceanic and Atmospheric Administration (NOAA), 2006

Trends in Greenhouse Gas Emissions (3)

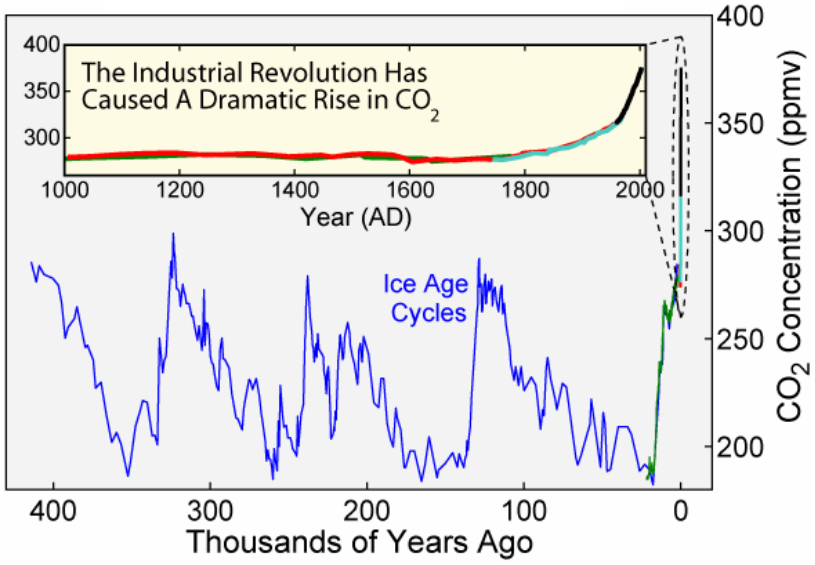


Figure 4. Long-term temporal variation of carbon dioxide concentrations.

Source: Global Warming Art, 2006, http://www.globalwarmingart.com

Trends in Greenhouse Gas Emissions (4)

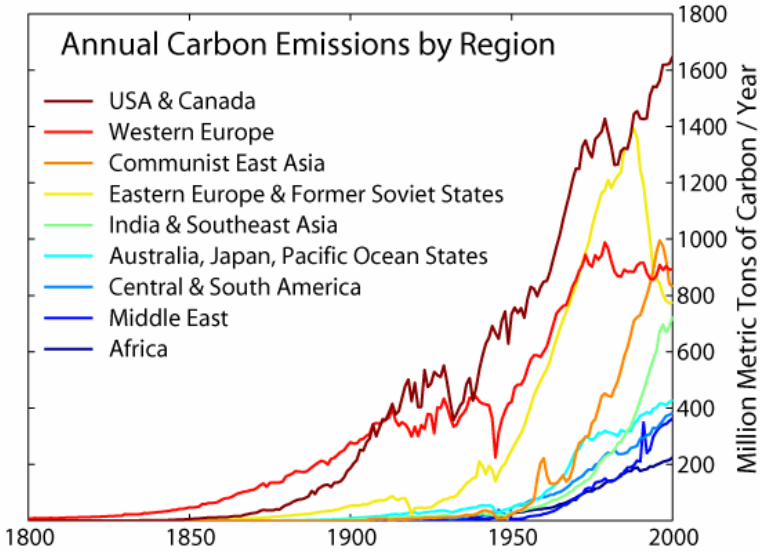


Figure 5. Annual carbon emissions by region.

Source: Global Warming Art, 2006, http://www.globalwarmingart.com

Trends in Greenhouse Gas Emissions (5)

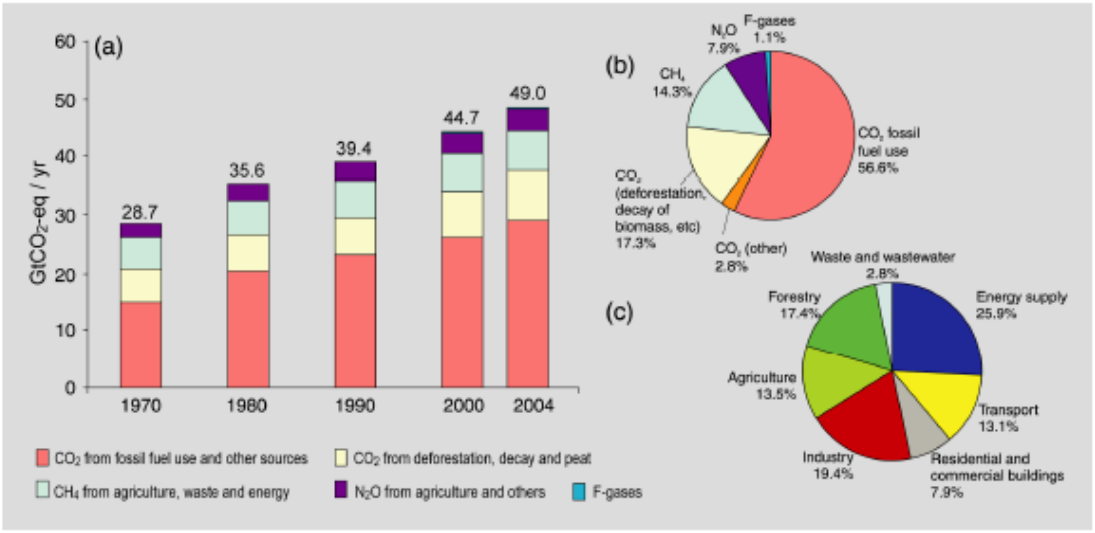


Figure SPM.3. (a) Global annual emissions of anthropogenic GHGs from 1970 to 2004.[5] (b) Share of different anthropogenic GHGs in total emissions in 2004 in terms of CO_2-eq. (c) Share of different sectors in total anthropogenic GHG emissions in 2004 in terms of CO_2-eq. (Forestry includes deforestation). {Figure 2.1}

Figure 6. Global anthropogenic Greenhouse Gas emissions.

Source: IPCC 2007b

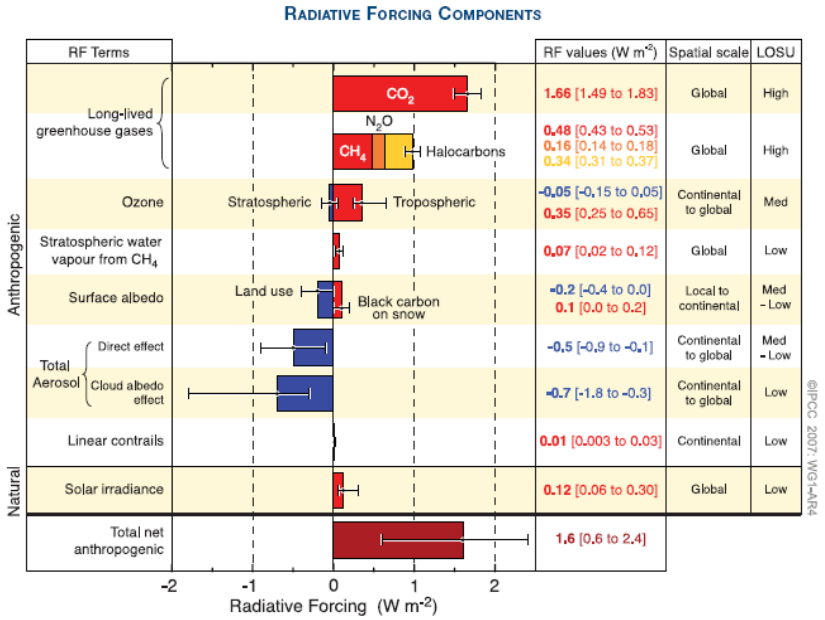


Figure SPM.2. *Global average radiative forcing (RF) estimates and ranges in 2005 for anthropogenic carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and other important agents and mechanisms, together with the typical geographical extent (spatial scale) of the forcing and the assessed level of scientific understanding (LOSU). The net anthropogenic radiative forcing and its range are also shown. These require summing asymmetric uncertainty estimates from the component terms, and cannot be obtained by simple addition. Additional forcing factors not included here are considered to have a very low LOSU. Volcanic aerosols contribute an additional natural forcing but are not included in this figure due to their episodic nature. The range for linear contrails does not include other possible effects of aviation on cloudiness. {2.9, Figure 2.20}*

Figure 7. Radiative forcing (RF) of factors relevant to climate change

Note: RF values are for 2005 relative to pre-industrial conditions defined at 1750.
Source: IPCC 2007a

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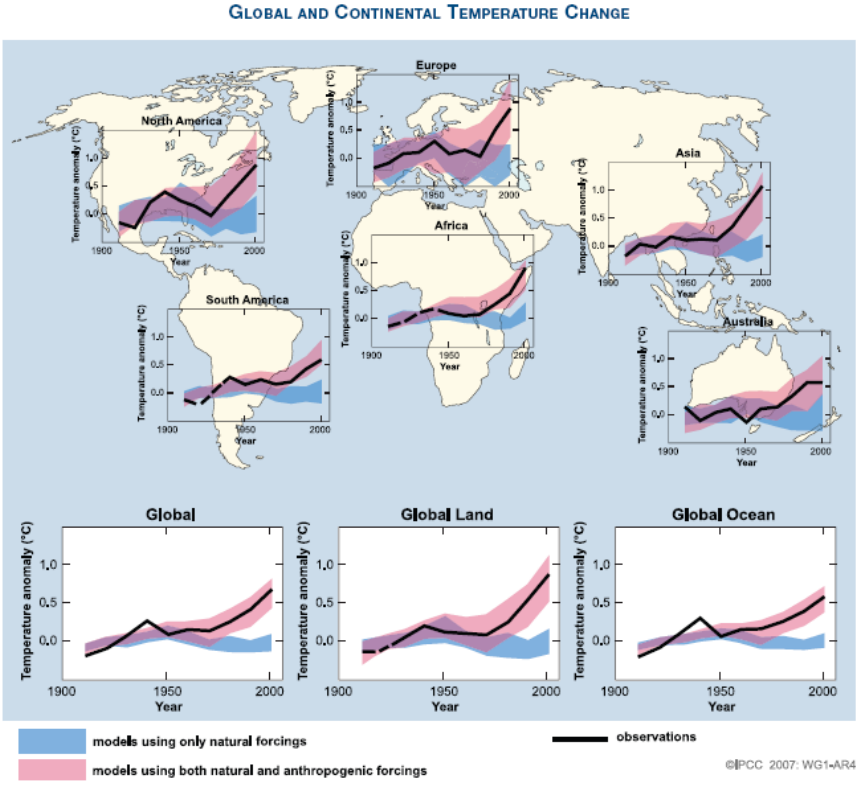

Figure 8. Global and continental temperature change from 1906 to 2005

Source: IPCC 2007a

Global Temperature Projections (1)

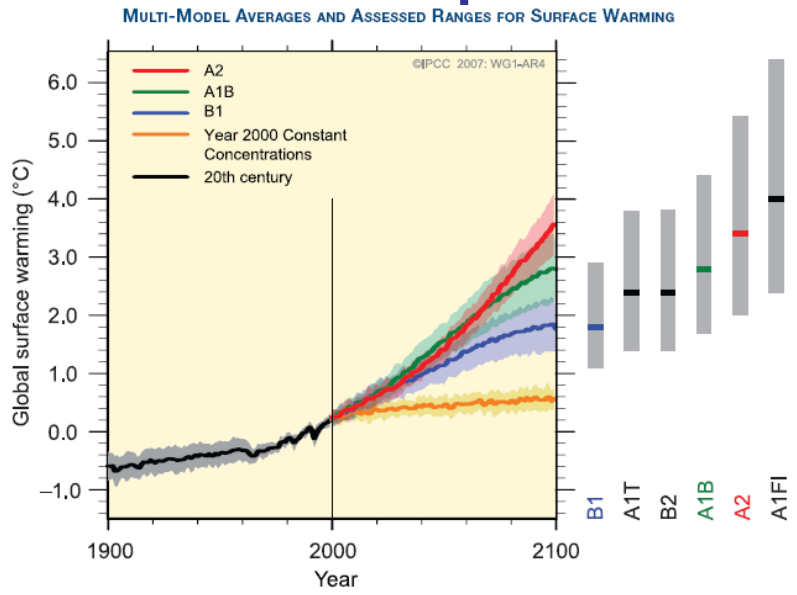

Figure SPM.5. *Solid lines are multi-model global averages of surface warming (relative to 1980–1999) for the scenarios A2, A1B and B1, shown as continuations of the 20th century simulations. Shading denotes the ±1 standard deviation range of individual model annual averages. The orange line is for the experiment where concentrations were held constant at year 2000 values. The grey bars at right indicate the best estimate (solid line within each bar) and the* ***likely*** *range assessed for the six SRES marker scenarios. The assessment of the best estimate and* ***likely*** *ranges in the grey bars includes the AOGCMs in the left part of the figure, as well as results from a hierarchy of independent models and observational constraints. {Figures 10.4 and 10.29}*

Underlying scenarios:

A1: Rapid economic growth, global population peaks by 2050, rapid introduction of new technologies, convergence among regions.

A1FI: A1 with intensive use of fossil fuels.

A1T: A1 with emphasis on renewable energy sources.

A1B: A1 with balance across all energy sources.

A2: Continuous population growth, slower and more fragmented economic growth and technological change.

B1: As A1, but development towards a service and information economy, emphasis on clean and resource efficient technologies, global solutions to economic, social, and environmental sustainability.

B2: Lower population growth than in A2, intermediate levels of economic growth, fragmented solutions to economic, social, and environmental sustainability.

Figure 9. Projected increase in global average surface air temperature until the year 2100, relative to 1980-1999.

Source: IPCC 2007a

Global Temperature Projections (2)

Best estimates by the ***Intergovernmental Panel on Climate Change*** (IPCC) of the rise in global mean temperatures by 2090-99 relative to 1980-99 vary between 1.8°C (B1 scenario) and 4.0°C (A1FI scenario).

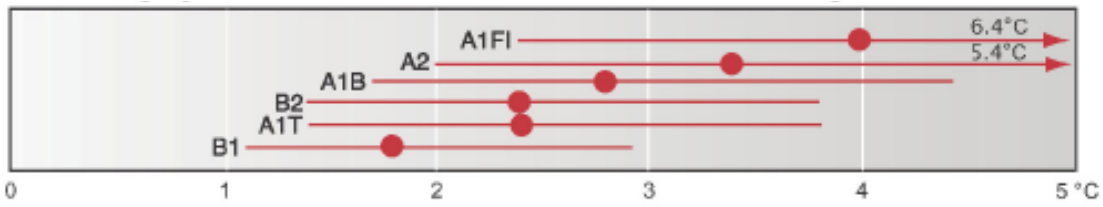

Figure 10. Global warming by 2090-99 relative to 1980-99 for non-mitigation scenarios.

Source: IPCC 2007b

The Impacts of Climate Change (1)

➔ The range of predicted temperature increases entails impact scenarios that vary widely in their level of severity.

- **But:** Even moderate increases in mean temperatures will have severe negative consequences especially for developing countries.
- At the same time, developing countries are most limited in their capacity to adapt to climate change.

➔ **The adverse impacts of climate change are expected to fall disproportionately on the poor** (Boko et al. 2007; Easterling et al. 2007; IPCC 2007b; Stern 2007).

The Impacts of Climate Change (2)

Adverse impacts

- General reduction in potential crop yields in most tropical and sub-tropical regions; in mid-latitude regions this applies for significant temperature increases only (approx. > 3°C).
- Decreased water availability in many water-scarce regions (large parts of Africa, sub-tropics).
- Increased frequency and/or severity of extreme climatic events (e.g., El Nino/La Nina, hurricanes).
- Increase in water-borne diseases (e.g., malaria, cholera), and heat-stress mortality.
- Increased risk of flooding for many human settlements both through extreme rainfall events and sea-level rise (e.g., Bangladesh, many island states).
- Severe damage of coral-reef ecosystems and fisheries.
- Negative effects on tourism (Tropical island states, winter sports…).
- Reduced potential for hydropower generation, increased energy demand for air-conditioning due to higher summer temperatures.

Sources: Zhao et al. 2005; IPCC 2007a; IPCC 2007b

The Impacts of Climate Change (3)

Beneficial impacts

- Increased potential crop yields in some mid- to higher-latitude regions for moderate temperature increases.
- Potential increase in global timber supply from appropriately managed forests (through carbon fertilization).
- Increased water availability in some water-scarce regions (parts of Southeast Asia).
- Reduced winter mortality in mid- and high-latitude regions.
- Reduced energy demand for heating due to higher winter temperatures.

Source: McCarthy et al. 2001

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The Impacts of Climate Change (4)

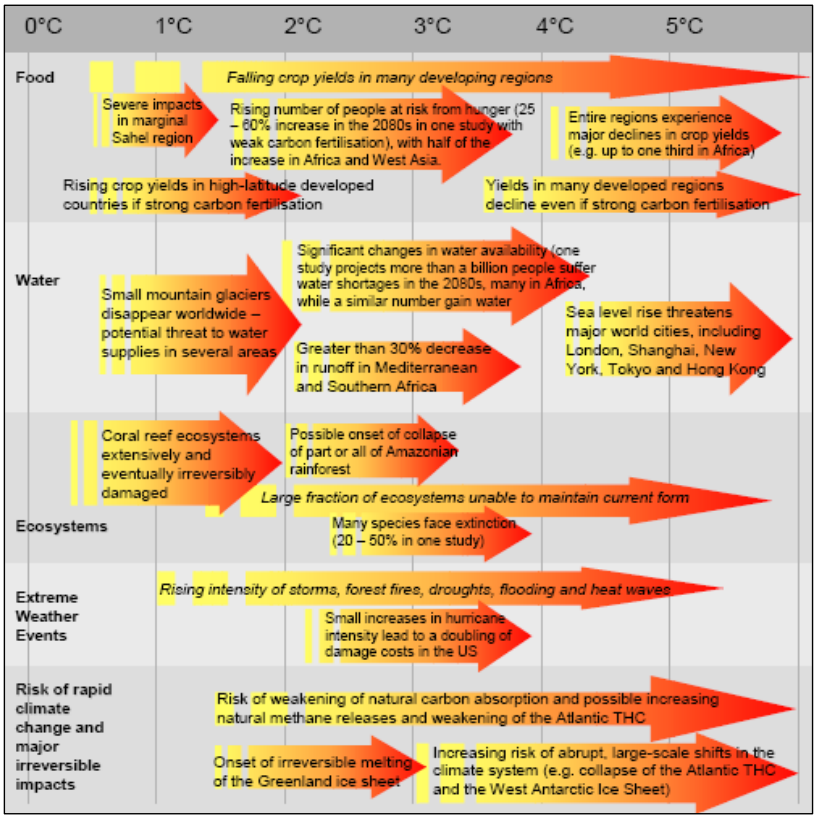

Figure 11. Impacts of climate change in dependence of global mean temperature increases. Source: Stern 2007

The Concept of Externality (1)

Greenhouse Gas (GHG) emissions, in an economic sense, are ***externalities***:

- An externality is any situation where ‚*an action of one economic agent affects the utility or production possibilities of another in a way that is not reflected in the marketplace*' (Just et al. 1982: 269).
- Divergence of private and social marginal costs.
- In the case of GHG emissions, the external effects are mainly negative, i.e., social costs are imposed on the global economy and future generations (Exception: ‚Carbon fertilization' as a positive external effect).
- Global institutions are needed to ***internalize the social costs*** of GHG emissions!

The Concept of Externality (2)

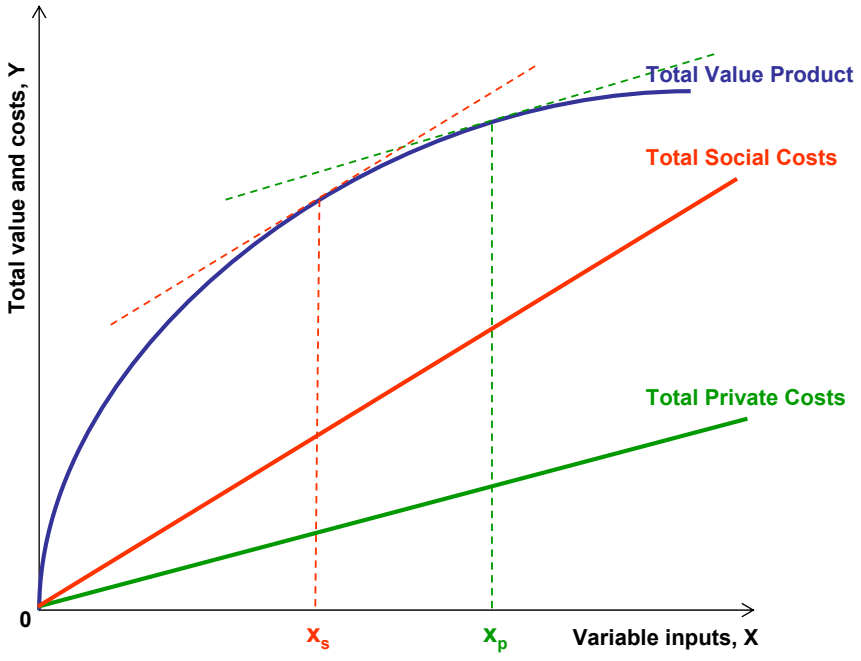

Figure 12. The concept of externality, differentiating between private and social costs. Source: Adapted from Ellis 1993: 256

Objective of the Kyoto Protocol

- The objective of the Kyoto Protocol is the ‚*Stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system*‘ (UNFCCC 1992)
- It is an agreement negotiated as an amendment to the **United Nations Framework Convention on Climate Change** (UNFCCC), which was adopted at the Earth Summit in Rio de Janeiro in 1992. The Convention has been ratified by 189 countries.
- All parties to the UNFCCC can sign or ratify the Kyoto Protocol, while non-parties to the UNFCCC cannot.
- The Kyoto Protocol was adopted at the third session of the Conference of Parties (COP-3) to the UNFCCC in 1997 in Kyoto, Japan.

Principles of the Kyoto Protocol (1)

The UNFCCC agreed to a set of ***‚common but differentiated responsibilities‘***, since…

- the largest share of historical and current global emissions of greenhouse gases has originated in developed countries;
- per capita emissions in developing countries are still relatively low;
- the share of global emissions originating in developing countries has to grow to meet their social and development needs.

Principles of the Kyoto Protocol (2)

➔ Countries are separated into two general categories with and without legally binding obligations to reduce GHG emissions:

1. **Industrialised countries**, referred to as Annex 1 countries (to the UNFCCC)

   ➔GHG emission reduction obligations

2. **Developing countries**, referred to as Non-Annex 1 countries

   ➔no GHG emission reduction obligations

The Protocol also reaffirms the principle that developed countries have to pay and supply technology to developing countries for climate-related studies and projects, as agreed in the UNFCCC.

Principles of the Kyoto Protocol (3)

- By ratifying the Protocol, a total of 39 Annex 1 countries commit themselves to reducing their collective GHG emissions by 5.2% during the period 2008-12, relative to the reference year 1990. Reduction targets expire in 2013.
- Compared to the emissions levels that would be expected by 2010 without the Protocol, this target represents a 29% cut!
- The goal is to lower overall emissions of six Greenhouse Gases - carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs, e.g., chlorofluorocarbons), and perfluorocarbons (PFCs) - calculated as an average over the five-year period of 2008-12.
- National targets range from 8% reductions for the European Union to 7% for the U.S.A., 6% for Japan, 0% for Russia, and permitted *increases* of 8% for Australia and 10% for Iceland.

Source: Aukland et al. 2002

Flexibility Mechanisms

In order to lower the overall costs of achieving the emission targets, the Kyoto Protocol includes three "***Flexibility Mechanisms***":

➔ In order to meet their GHG emission reduction targets, Annex 1 countries can access cost-effective opportunities to reduce emissions or remove carbon from the atmosphere in other countries.

➔ While the cost of limiting emissions varies considerably from region to region, the benefit for the atmosphere is the same, wherever the action is taken.

➔ The three Flexibility Mechanisms are:

- **Emissions Trading (ET, Article 17 of the Kyoto Protocol)**
- **Joint Implementation (JI, Article 6)**
- **Clean Development Mechanism (CDM, Article 12)**

Emissions Trading

Emissions Trading (ET) allows Annex B countries (Annex B to the Kyoto Protocol; almost identical with Annex 1 countries to the UNFCCC) to **transfer among themselves** portions of their assigned amounts of GHG emissions:

➔ Countries emitting less than they are allowed under the Kyoto Protocol can sell surplus allowances to those countries that have surpassed their emission limits.

➔ Such transfers do not have to be linked to emission reductions through specific projects.

➔ The Kyoto Protocol has a provision that these transfers be 'supplemental' to domestic actions to meet emission reduction commitments.

Joint Implementation (1)

Joint implementation (JI) allows Annex 1 countries to invest in emission reducing projects **in other Annex 1 countries** as an alternative to domestic emission reductions:

- ➔ Countries with relatively high costs for emission reductions (e.g., those that already use very energy-efficient technologies extensively) can reduce costs of complying with their Kyoto targets by using credits from JI projects, as costs of emission reductions are significantly lower in other countries.
- ➔ For example, a JI project might involve replacing a coal-fired power plant with a more efficient combined heat-and-power plant.

Joint Implementation (2)

- ➔ Most JI projects are expected to take place in the Annex 1 **transition economies** in Eastern Europe and the former Soviet Union, where the costs of reducing emissions are considered to be lower.
- ➔ Emission reductions achieved with JI projects are awarded credits called **Emission Reduction Units (ERUs)**, where one ERU signifies a reduction of one tonne of CO_2 equivalent.
- ➔ Unlike in the case of the Clean Development Mechanism, the JI has caused less concern of spurious emission reductions, as the JI, unlike the CDM, takes place in countries which have an emission reduction requirement.

Clean Development Mechanism (1)

The ***Clean Development Mechanism (CDM)*** allows Annex 1 countries to invest in emission reducing projects **in Non-Annex 1 countries** as an alternative to domestic emission reductions:

➔ **Twofold purpose:** Apart from helping Annex 1 countries comply with their emission reduction commitments, CDM projects must assist developing countries in achieving sustainable development.

➔ To prevent Annex 1 countries from making unlimited use of CDM, the Kyoto Protocol has a provision that the use of CDM be 'supplemental' to domestic actions to reduce emissions (Article 6.1 d).

Clean Development Mechanism (2)

Procedure:

- An Annex 1 country wishing to get credits from a CDM project must obtain the **consent of the developing country** hosting the project that this will contribute to sustainable development.
- Using methodologies approved by the CDM Executive Board, the applicant (i.e., the Annex 1 country) must then make the case that the project would not have happened anyway, i.e., the prerequisite of **additionality** must be established.
- Moreover, it must establish a **baseline** estimating the future emissions in absence of the registered project.
- The case is then verified by a third party agency (the ‚Designated Operational Entity') to ensure the project results in real, measurable, and long-term emission reductions.

➔ Upon final approval by the CDM Executive Board, **Certified Emission Reductions (CERs)** are awarded to the applicant based on the difference between the baseline and the actual emissions.

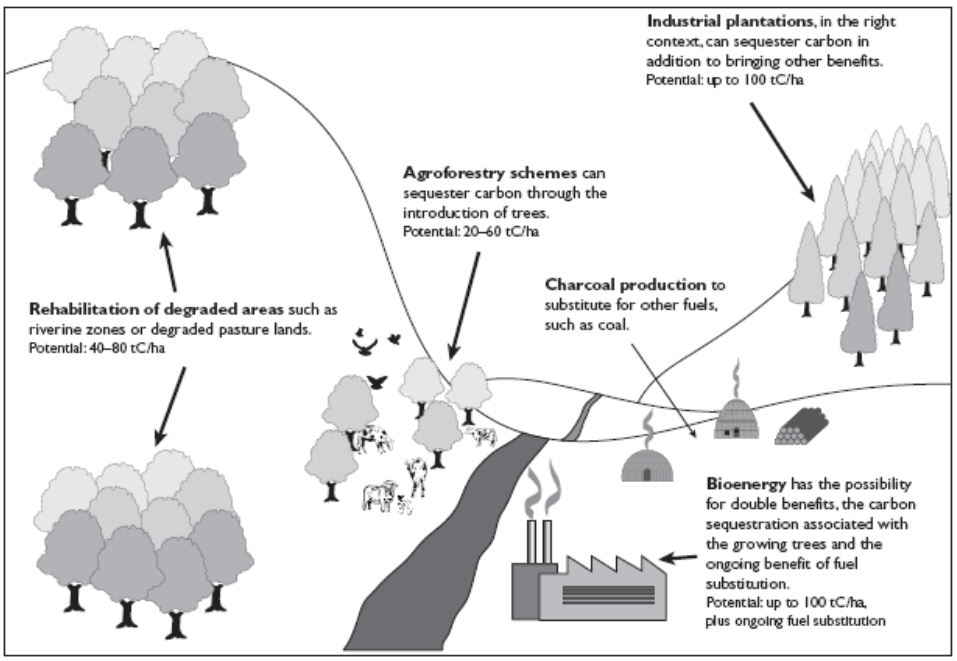

Figure 13. Eligible land use activities in the Clean Development Mechanism, indicating their potential for generating carbon offsets (in tonnes of carbon per ha per year).

Source: Aukland et al. 2002

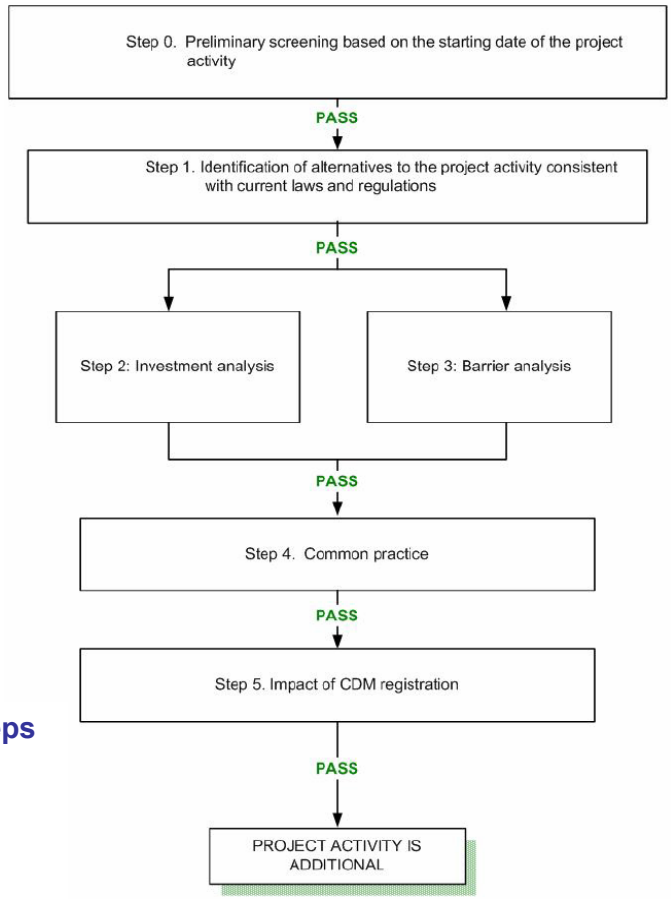

Figure 14. Schematic overview of steps involved in the assessment of ‚additionality' of projects under the Clean Development Mechanism

Source: UNFCCC 2005

Criticism of the Clean Development Mechanism (1)

The emission reduction accruing from a CDM project, obviously, depends on the emissions that would have occurred without the project. There are two sources of **risk of spurious carbon credits**:

- Since the CDM is an alternative to domestic emission reductions, the perfectly working CDM would produce the same amount of GHG emission reductions as a situation without the CDM. However, if **projects that would have happened anyway are registered as CDM projects**, the use of CDM will result in higher total emissions:

➔ The spurious credits will be used to allow higher domestic emissions while not delivering lower emissions in the developing country hosting the CDM project!

- The calculated emission reductions accruing from a CDM project are based on a hypothetical scenario, namely the baseline of the project. The baseline may be estimated through reference to emissions from similar activities and technologies in the same country or other countries, or to actual emissions prior to project implementation.

➔ **But:** The partners involved have a clear interest in establishing a **baseline with exaggerated emissions**!

➔ Risk of awarding spurious credits if a strict independent review is absent!

Criticism of the Clean Development Mechanism (2)

- The NGO ***CDM Watch*** argues that, thus far, the majority of the CDM projects would have happened anyway; among others, the NGO refers to project activities that were completed before their final approval as CDM projects, thus arguing that these would have been viable without the CDM financing, and are therefore **non-additional** (http://www.cdmwatch.org).
- NGOs have also criticized the inclusion of large hydropower projects as CDM projects, which they deem unsustainable. Other concerns are the lack of renewable energy CDM projects and the inclusion of carbon sinks as CDM projects (http://www.sinkswatch.org).
- In response to concerns about unsustainable projects or spurious carbon credits, the World Wide Fund for Nature (WWF) and other NGOs devised a ***'Gold Standard'*** methodology for certifying projects that uses much stricter criteria than required, such as allowing only renewable energy projects (http://www.cdmgoldstandard.org).

Economic Benefits from Flexibility Mechanisms

With costs of emission reduction typically much lower in developing countries than in industrialised countries, the latter can comply with their emission reduction targets at much lower cost through receiving credits for emission reductions in developing countries, as long as administrative costs are relatively low:

- The **Intergovernmental Panel on Climate Change (IPCC)** has compared projected GDP losses with full use of JI and CDM to a scenario where only domestic action is allowed: For example, for OECD Europe, projected losses lie between 0.13 and 0.81% of GDP with, as compared to 0.31 to 1.50% without the use of flexibility mechanisms.
- Current trading prices illustrate that it is cheaper to buy emission reduction from CDM projects than domestic emission reductions: whereas domestic emission reductions in Europe in 2005 typically cost around € 50 per tonne CO_2 equivalent, CER from the CDM could in the same year be purchased for as little as € 4 per tonne CO_2 equivalent!

Source: Watson 2001

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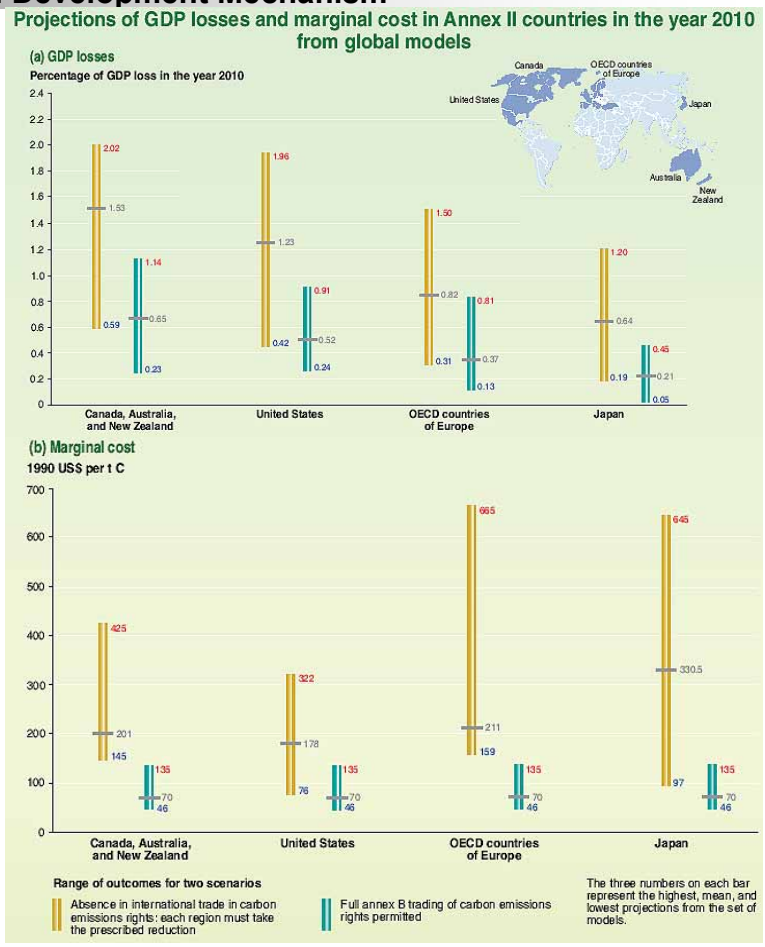

Figure 15. Projections of GDP losses and marginal costs in Annex 2 countries in the year 2010 from global models: (a) GDP losses and (b) marginal costs.

Source: Watson 2001

Note: Annex 2 countries are industrialised countríes with a special obligation to provide financial resources and facilitate technology transfer to developing countries. They include the 24 original OECD members plus the European Union.

Ratification status of the Kyoto Protocol

- The treaty was negotiated in Kyoto in December 1997.
- The agreement came into force in February 2005, following ratification by Russia.
- As of October 2007, a total of **176 countries** have ratified the agreement, representing **over 61.6% of emissions** from Annex 1 countries (UNFCCC, 2007).
- The most notable **exception are the U.S.A.** Other countries, like India and China, which have ratified the protocol, are Non-Annex 1 countries, i.e., they are not required to reduce carbon emissions despite their very large populations.

Effect of the Kyoto Protocol on Global Warming

- Modelling estimates indicate that, even if successfully and completely implemented, the Kyoto Protocol will reduce global warming by only somewhere between 0.11 and 0.21°C in a ‚constant compliance' scenario, i.e., if, after the Kyoto commitment period, Annex 1 nations do not reduce GHG emissions any further (Wigley 1998).
- In a scenario in which the Annex 1 countries continue to reduce their emissions after the Kyoto period by 1% per year, the warming reduction by 2100 would be some 14% (both scenarios assume continued growth of emissions in developing countries at a business-as-usual rate).

Beyond the Kyoto Protocol (1)

Stabilization of GHG concentrations is feasible and consistent with continued economic growth (Stern 2007).

- ➔ **Prerequisite:** ‚Decarbonisation' of both developed and developing economies. In the long term, annual global emissions need to be reduced to below 5 Gt CO_2e (carbon-dioxide-equivalents), which is the level that can be absorbed without increasing GHG concentrations in the atmosphere.
- ➔ Stabilization of GHG emissions at 550 ppm CO_2e requires global emissions to peak in the next 10-20 years and then fall by at least 1-3% per year.
- ➔ By 2050, global emissions need to be approx. 25% below current levels.
- ➔ Since by 2050 the world economy is expected to be 3-4 times as large as today's, **emissions per unit of GDP need to be around 80% below the current level!**

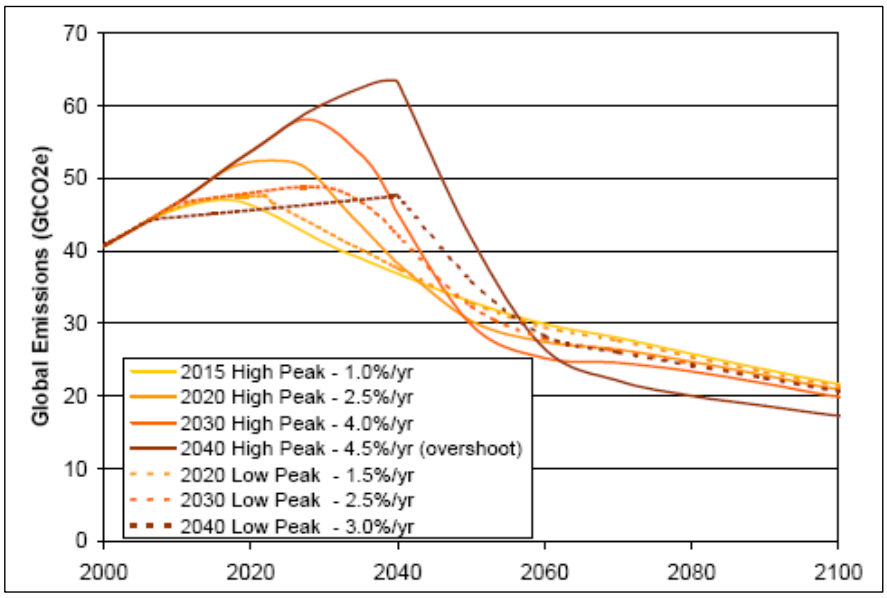

Figure 16. Illustrative emissions paths to stabilize Greenhouse Gas concentrations in the atmosphere at 550 ppm CO_2e.

Source: Stern 2007

Beyond the Kyoto Protocol (2)

Stabilization of GHG concentrations at 500 to 550 ppm CO_2e is estimated to cost around 1% of GDP by 2050 (Stern 2007).

GHG emissions can be cut through four basic methods:

- Reducing demand for emissions-intensive goods and services.
- Increased energy efficiency, saving both money and emissions.
- Action on non-energy emissions, e.g., avoiding deforestation.
- Switching to lower-carbon technologies for power, heating, and transport.

➔ The costs incurred will differ significantly depending on the mix of methods used (e.g., avoiding deforestation is viewed as a very cost-effective method!).

➔ The expansion of markets for low-carbon, high-efficiency goods and services will bring **new business opportunities**.

➔ **The Stern Review concludes that the benefits of strong, early action will considerably outweigh the costs.**

Beyond the Kyoto Protocol (3)

Policies to reduce GHG emissions should be based on three elements (Stern 2007):

1. Carbon pricing (as initiated by the Kyoto Protocol)

➔ GHG emissions are an externality; an appropriate price means that emitters are faced with the full social cost of their action.

➔ Simulations indicate that a carbon price of 20-80US$/t CO_2e would be consistent with a stabilization of GHG concentrations at 550 ppm CO_2e by the year 2100 (IPCC 2007b).

➔ Pricing can be done explicitly, through tax or trading, or implicitly, through regulation.

➔ Incentive to invest in alternative, low-carbon technologies.

➔ **Prerequisite:** There must be confidence that climate change policies will persist! If this is not achieved, over-investment in conventional, high-carbon infrastructure may take place, resulting in more expensive and difficult emission cuts later on.

➔ **But:** Establishing credibility takes time!

Beyond the Kyoto Protocol (4)

2. Support of the development of low-carbon and high-efficiency technologies

- The private sector plays the major role in research, development, and diffusion of low-carbon and high-efficiency technologies, but closer collaboration between governments and the industry could further stimulate the development of a broad portfolio of technologies and reduce costs incurred.
- Direct public-sector support of early-stage technologies may be necessary (e.g., subsidies for electricity from regenerative sources) in order to provide a strong incentive for the private sector to bring forward the technologies needed.

Beyond the Kyoto Protocol (5)

3. Removal of barriers to behavioral change

Even where measures to reduce emissions are cost-effective, there may be barriers preventing action:

➔ Lack of reliable information, high transaction costs, organisational and behavioral inertia.

➔ Policies can help remove these barriers through:

- Regulatory measures that provide clarity and certainty, e.g., minimum energy-efficiency standards for buildings and appliances.
- Information policies, e.g., energy-efficiency labelling of products, dissemination of ‚best practices'.
- Financing schemes to help consumers overcome the initial investment constraints to energy efficiency improvements.

➔ **A post-Kyoto international agreement on action against climate change is crucial for providing incentives for the development, deployment, and diffusion of appropriate technologies.**

Beyond the Kyoto Protocol (6)

Climate change has gained considerable political momentum in 2007 based on the scientific evidence presented in the Stern Review and the IPCC Fourth Assessment Report:

- **February: The EU unilaterally commit themselves to reduce GHG emissions by 20% by 2020 (30% relative to 1990 levels. This target is binding for all 27 member countries, but the distribution of emission reductions among them is still to be negotiated.**
- **June: G8 Summit in Heiligendamm leads to a joint statement of the G8 countries and major Non-Annex 1 countries (Brazil, China, India, Mexico, and South Africa) re-affirming their commitment to the UNFCCC according to the principle of common but differentiated responsibilities and respective capabilities.**
- **August: Vienna Climate Change Talks on further commitments for Annex 1 countries.**
- **September: High-level meeting at the UN-headquarters calls for international action against climate change.**
- **December: United Nations Climate Change Conference in Bali (COP-13).**

UN Climate Change Conference in Bali (COP-13)

- **The goal of COP-13 is to form a ‚roadmap' for a future international agreement on global action against climate change in the period after 2012 (i.e., the year the commitment period of the Kyoto Protocol expires).**
- **This goal comprises three elements:**
  - **To launch negotiations on a climate change agreement for the post-2012 period.**
  - **To set the agenda for these negotiations.**
  - **To reach agreement on when these negotiations will have to be concluded (preferably by 2009 to allow for sufficient time for ratification of the new agreement).**

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- Intergovernmental Panel on Climate Change (IPCC), http://www.ipcc.ch
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- Stern Review, http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_index.cfm
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