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Synthesis of information relevant to the determination of the mitigation potential and to the identification of possible ranges of emission reduction objectives of Annex I Parties

Technical paper

Summary

This technical paper synthesizes submissions by Parties and other available information relevant to the determination of the mitigation potential and to the identification of possible ranges of emission reduction objectives of Annex I Parties. To arrive at an accurate estimate of the mitigation potential at the level of individual countries, much more information is needed than is currently available. This paper presents some options for further analyses and compiles some of the most important national and sectoral mitigation factors and indicators and provides data which can be used in the identification of possible ranges of emission reduction objectives of Annex I Parties.

CONTENTS

Annex

I. Introduction

A. Mandate

1. At its third session, the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol (AWG) requested the secretariat to prepare, under the guidance of the Chair of the AWG, a technical paper that synthesizes submissions referred to in paragraph 2 below and available information, inter alia, considering factors and criteria, relevant to the determination of the mitigation potential and to the identification of possible ranges of emission reduction objectives of Annex I Parties (FCCC/KP/AWG/2007/2, para. 23).

2. At the same session, the AWG invited Annex I Parties, in a position to do so, to submit to the secretariat information and data on the mitigation potential of policies, measures and technologies at their disposal, with a view to providing a basis for indicative ranges of emission reduction objectives by Annex I Parties (FCCC/KP/AWG/2007/2, para. 23). These submissions are contained in document FCCC/KP/AWG/2007/MISC.4.

B. Scope of the note

3. This document was prepared in response to the above mandate. Chapter II contains background information including definitions for mitigation potential and a summary of information on reductions required for different stabilization levels of greenhouse gas (GHG) concentrations in the atmosphere. This information was taken from the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC). Chapter III contains a synthesis of information provided by Parties in their submissions. Chapters IV and V compile information, including on factors and indicators[1], relevant to the determination of the mitigation potential and to the identification of possible ranges of emission reduction objectives of Annex I Parties, with an emphasis on domestic mitigation potential. Chapter IV provides data on the current status of these factors and indicators, reviewing national and sectoral aspects. Chapter V presents additional information on mitigation potential that may be useful in the identification of ranges of emission reduction objectives of Annex I Parties. Finally, chapter VI provides a summary of the information presented in this document and includes suggestions for possible further analyses.

4. References to Annex I Parties in the sources of information consulted, in particular the AR4, include those Annex I Parties that are not Parties to the Kyoto Protocol. Data for all these Parties have been compiled for the tables referred to in chapter IV; however, averages and maximum and minimum values within these tables are only for Annex I Parties that are Parties to the Kyoto Protocol.

5. Several experts were involved in developing this document, including experts from the IPCC, the International Energy Agency (IEA) and the Organisation for Economic Co-operation and Development (OECD). An expert meeting was held in Bonn, Germany, on 28 June 2007, to discuss the scope and contents of the document.

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[1] The mandate to the secretariat refers to factors and criteria. The secretariat recognizes that the term ‘criteria’ implies a value judgement which may carry political implications; for this reason, the secretariat has decided to compile indicators that are useful in the identification of possible ranges of emission reduction objectives of Annex I Parties.

C. Possible action by the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol

6. The AWG may wish to make use of the information contained in this document in its analysis of the mitigation potential of policies, measures and technologies at the disposal of Annex I Parties and to the identification of possible ranges of emission reductions by Annex I Parties and analysis of their contribution to the ultimate objective of the Convention and its Kyoto Protocol. Annex I Parties may wish to consider this information in the context of national activities relevant to the work of the AWG.

II. Background

A. Definitions for mitigation potential

7. The concept of mitigation potential is used in the AR4 to assess the scale of GHG reductions that could be made, relative to an emission baseline, for a given carbon price. It is expressed in cost per unit of GHG emissions avoided or reduced, and is further specified in terms of:

(a) **Market potential**, which is the mitigation potential based on private costs and private discount rates that might be expected to occur under forecast market conditions, including policies and measures currently in place, noting that barriers limit actual uptake; and

(b) **Economic potential**, which is the mitigation potential that takes into account social costs and benefits and social discount rates, assuming that market efficiency is improved by policies and measures and that barriers are removed.

8. The AR4 states that “studies of market potential can be used to inform policy makers about mitigation potential with existing policies and barriers, while studies of economic potentials show what might be achieved if appropriate new and additional policies were put into place to remove barriers and include social costs and benefits.”

B. Stabilization scenarios and the reduction of greenhouse gas emissions

9. The AR4 provides information on the emission reductions required to achieve different levels of stabilization of GHGs in the atmosphere. This information is summarized in table 1, which distinguishes between six categories of scenarios. For the lowest category analyzed (445–490 parts per million by volume (ppmv) of carbon dioxide equivalent (CO_2 eq)), global GHG emissions would need to be reduced to between 85 per cent and 50 per cent below 1990 levels in 2050.

10. Information on the global costs of such reductions is also contained in this table. In 2050, estimated global average macroeconomic costs to achieve the four lowest stabilization levels range between a 1 per cent gain and a 5.5 per cent decrease in global gross domestic product (GDP). It should be noted, however, that costs vary significantly across countries and sectors.

11. Information regarding the level of allowed GHG emissions for different groups of countries under different methods of allocating GHG emissions has also been assessed by the IPCC. The analysis covered a broad spectrum of national and regional parameters and assumptions, such as population, GDP, GDP growth and global emission pathways that lead to climate stabilization. A wide range of methods of allocating GHG emissions were also considered. Table 1 summarizes this analysis, which indicates that in order to achieve a stabilization level of 450 ppmv CO_2 eq, emissions from Annex I Parties would need to be between 25 per cent and 40 per cent below 1990 levels in 2020, and between 80 per cent to 95 per cent below 1990 levels in 2050. It should be noted that most methods of allocating GHG emissions

assume trading of emission allowances at the global level and, therefore, actual GHG emissions may be lower than the figures contained in columns 6 and 7 of table 1.

Table 1. Characteristics of greenhouse gas stabilization scenarios

Category	**CO_2 equivalent concentration (parts per million CO_2 equivalent)**	**Global mean temperature increase above pre-industrial at equilibrium using 'best estimate' climate sensitivity[a] (°C)**	**Change in global CO_2 emissions in 2050 (% of 2000 emissions)**	**Range of reduction in GDP in 2050 because of mitigation (%)**	**Allowed emissions by Annex I Parties in 2020 (% change from 1990 emissions)**	**Allowed emissions by Annex I Parties in 2050 (% change from 1990 emissions)**
I	445–490	2.0–2.4	-85 to -50	Decrease of up to 5.5	-25 to -40	-80 to -95
II	490–535	2.4–2.8	-60 to -30			
III	535–590	2.8–3.2	-30 to +5	Slight gain to decrease of 4	-10 to -30	-40 to -90
IV	590–710	3.2–4.0	+10 to +60	Gain of 1 to decrease of 2	0 to -25	-30 to -80
V	710–855	4.0–4.9	+25 to +85			
VI	855–1,130	4.9–6.1	+90 to +140			

Source: IPCC. Fourth Assessment Report (AR4), Contribution of Working Group III . Columns 1–4, table SPM.5; column 5, table SPM.6, columns 6 and 7, box 13.7.

[a] According to the AR4, the best estimate of climate sensitivity is 3 degrees Celsius.

III. Synthesis of submissions by Parties[2]

12. In their submissions, Parties referred to the conclusions agreed at the third session of the AWG to set the context for the analysis of mitigation potential and the identification of ranges of emission reduction objectives of Annex I Parties; in particular, they cited paragraphs 19 and 21 (a) of document FCCC/KP/AWG/2007/2.

13. A detailed sectoral analysis that takes into consideration broad national circumstances and specific sector efficiencies is necessary to better understand the mitigation potential of a country. One Party suggested that such an analysis could be pursued through two different approaches:

(a) **Efficiency analysis**: Mitigation potential is determined on the basis of the country's ability to increase efficiency in different sectors, considering indicators such as development and popularization of technology, technical and operational capacity and the cost of capital investment;

(b) **Analysis based on best available technology**: Mitigation potential is determined using the alternative policy, measure or technology that is most efficient in each sector, also considering the indicators in the efficiency analysis.

14. Several factors contributing to mitigation potential were referred to by Parties, including the carbon intensity (e.g. the amount of GHG emissions per output) of the electricity sector, the number and size of industries with high levels of energy intensity, and the ability to reduce emissions in sectors where

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[2] At the time of writing this document, submissions from the following Parties had been received by the secretariat: Germany on behalf of the European Community and its member States, Japan, New Zealand and Switzerland.

the adoption of policies and measures takes time, such as the buildings sector. Parties stated that such factors change with time and hence affect mitigation potential over the long term.

15. Some Parties presented in their submissions specific mitigation factors and indicators by type, namely: emissions per capita, per unit of GDP and per unit of product, and costs per unit of abatement classified under ‘emission related metric’; population growth, GDP per capita and average GDP growth classified under ‘economic metric’; the degree of sustainability of energy generation, available mitigation technologies, the distance from the world’s best practice and total cumulative emissions since 1750, 1850, 1950 and 1990, classified under ‘economic & social structure’; and others including exports as a percentage of GDP and the human development index (HDI).

16. Other Parties suggested indicators by sector, namely: CO_2 emissions per unit of output and thermal efficiency in power generation, for the energy industries sector; CO_2 emissions per energy use per unit of production, for the industry sector; CO_2 emissions per unit of floor area and per household, for the households and services sector; CO_2 emissions per unit of freight transported and per passenger, for the transport sector; and methane (CH_4) emissions per unit of waste buried and CO_2 emissions per unit of waste incinerated, for the waste sector.

17. Parties indicated that their mitigation potential is, to a large extent, determined by the costs of mitigation. Related indicators include the cost of abatement per tonne of CO_2 eq, the mitigation potential (e.g. amount of GHG emissions that can be reduced) at a given carbon price, for example, USD 50 and USD 100, the aggregate macroeconomic cost of measures, and sector- and economy-wide abatement costs. Parties also referred to information by the IPCC and stated that “macroeconomic costs of GHG stabilization at levels consistent with the 2°C limit are estimated to be equivalent to a reduction of the average annual GDP growth rates of less that 0.12%.” There are mitigation opportunities with net negative costs, which have the potential to reduce emissions by around 6 Gt CO_2 eq per year in 2030 (i.e. about 10 per cent of the projected global emissions by that time).

18. Parties also referred to other factors that can affect mitigation potential, such as the use of flexibility mechanisms, the treatment of land use, land-use change and forestry (LULUCF), and the issue of reducing emissions from deforestation in developing countries. It was suggested that the more Annex I Parties will be allowed to make use of international cooperation and flexibility mechanisms under the Kyoto Protocol in the period after 2012, the more ambitious national commitments will be. Factors and indicators suggested by Parties in their submissions have been taken into consideration and are discussed in more detail in chapter IV.

IV. Factors and indicators relevant to the determination of the mitigation potential and to the identification of ranges of emission reduction objectives of Annex I Parties[3]

19. The IPCC, in its special report on emission scenarios,[4] states that the major driving forces of past and future anthropogenic GHG emissions include demographics, economics, resources, technology and (non-climate) policies. Hence the extent to which these emissions can be reduced is largely determined by the social, political and economic structure of each country and how these are expected to develop in the future.

20. This chapter compiles some of the most important national and sectoral factors and indicators relevant to the determination of mitigation potential and to the identification of possible ranges of

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[3] Tables referred to in this chapter are found in the annex unless otherwise indicated.

[4] Nakicenovic N and Swart R (eds). 2000. *Emissions Scenarios: Special Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.

emission reduction objectives of Annex I Parties. It presents, first, broad socio-economic factors, such as total emissions, GDP, population and total primary energy supply; second, indicators underlying such socio-economic factors (generally referring to intensities, percentages or efficiencies at the national or sectoral level) that indicate where improvements to reduce GHG emissions could be made; and, third, cross-cutting factors including technology, policies and measures, and costs of mitigation.

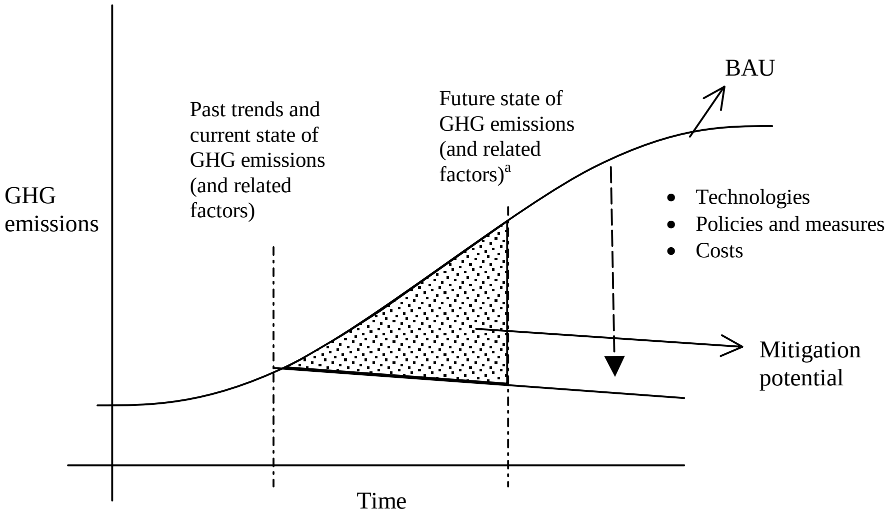
21. National GHG emissions are the sum of emissions from different sectors; therefore, mitigation potential is realized at the sectoral level. The contribution of each sector to total emissions and the trend of sectoral emissions provide information on the magnitude of emission reductions that would be possible, but only indirectly provide information on the mitigation potential itself. Instead, mitigation potential is determined by the ability to improve sectoral activities, processes and/or technologies that either increase energy efficiency or reduce carbon intensity.

22. For most countries, energy use is the largest single source of GHG emissions. GHG emissions from this source are determined by the amount of energy that is used and by the efficiency and carbon intensity of energy generation. Increasing the contribution of lower or zero GHG emitting sources of energy, such as wind or thermal sources, as well as increasing the efficiency of electricity and heat generation, provides opportunities to reduce GHG emissions. At the sectoral level, increasing efficiency in the use of energy results in a reduction in total energy used and hence in GHG emissions.

23. Another way to reduce emissions at the sectoral level is to reduce the carbon intensity of production processes; for example, by using fewer fertilizers in agricultural production. The LULUCF sector presents a particular case as it results in both GHG emissions and removals. Therefore this sector provides mitigation potential through reducing emissions by sources and enhancing removals by sinks. Aggregated figures referred to in this document make a distinction between the LULUCF sector and other sectors in order to separately refer to the mitigation potential of sources and of sinks.

24. As national circumstances change over time, the mitigation potential for a specific period of time should be assessed. Such an assessment should take into consideration past trends and the current and future status of those factors and indicators that determine the mitigation potential of a country. Figure 1 illustrates a simple approach to this end.

Figure 1. Mitigation potential for a specific period of time



Abbreviations: BAU = business as usual, GHG = greenhouse gas.
Note: Intensity is total emissions converted into relative parameters.
[a] Intensity and percentage factors may observe a decreasing trend from BAU improvements that are not necessarily linked to climate change interests.

25. In order to provide information to the AWG, this document provides data on the current status of most of the factors and indicators referred to in this chapter (see tables 1–12).[5] It should be noted that such data provide only a snapshot of the national and sectoral circumstances that determine the mitigation potential of Annex I Parties. These data were collected from a variety of sources. The first choice was data submitted by Parties to the secretariat; if such data were not available, other sources were used, using the following hierarchy:

(a) Submissions to the secretariat from Parties, including sources referred therein, the 2006 GHG inventory submissions and the latest national communications;

(b) IPCC Fourth Assessment Report;

(c) Other international sources such as data from the IEA, the World Bank, the Food and Agriculture Organization of the United Nations, OECD and Eurostat;

(d) Widely used data sources from non-governmental organizations such as Enerdata and World Resources Institute.

A. Nationwide factors and indicators

26. **Total GHG emissions and emission trends:**[6] These indicators provide information relevant to the possible magnitude of the mitigation potential. However, in isolation they do not directly indicate by how much emissions can be reduced. The amount of emissions varies by several orders of magnitude between Parties (table 1, column 1). Some countries experienced a substantial decline in emissions since 1990 (mainly the economies in transition), while others increased their emissions substantially (usually countries with high economic growth) (table 1, column 2). As the absolute amount of emissions alone provides only very limited information, total emissions are often converted into relative parameters, some of which are described in paragraphs 31 and 32 below.

27. **GDP and GDP growth:** These indicators provide information on the size and strength of the economy (table 1, column 5). Although they are not in themselves indicators of mitigation potential, the coupling of economic activity with energy use could provide an indication of mitigation potential, particularly for countries where fossil fuels contribute substantially to total primary energy supply (TPES).

28. **Population and population growth:** The size and trends of population can affect national GHG emissions, as a larger population generally implies higher demand and hence higher economic activity. Again, population in isolation is not an indicator of mitigation potential. Some countries' populations are expected to grow substantially from now until 2020 (e.g. Australia, Ireland and Turkey), whereas others are expected to be stable (e.g. European Union countries) or to decline (mainly economies in transition) (table 1, columns 3 and 4).

29. **TPES:** For most Annex I Parties, the production and/or use of energy is one of the main sources of GHG emissions. TPES accounts for all the energy that is supplied to the economy. It includes energy

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[5] Additional information on national and sectoral GHG emission trends is available for all Annex I Parties within the GHG emissions profiles, available at <http://unfccc.int/ghg_emissions_data/items/3954.php>.

[6] National estimates of historical emissions are not readily available. The scientific community has been addressing this issue in order to support consideration of the scientific and methodological aspects of the proposal by Brazil under the Subsidiary Body for Scientific and Technological Advice (SBSTA). The SBSTA, at its twenty-fourth session (May 2006), noted that it expects this work to be completed by the third quarter of 2007. It requested the secretariat to organize an in-session special side event at the twenty-seventh session of the SBSTA (December 2007) at which all Parties, research institutions and scientists engaged in this work could present their results (FCCC/SBSTA/2006/5, paras. 82 and 83). A report should be available by 13 October 2007.

generated in the country and that which is imported but excludes exported energy and international marine bunkers; TPES is also adjusted for stock changes (table 1, column 6). If the energy is used for electricity generation, the values also include the waste heat that is produced during the process. TPES in itself is not a direct indication of mitigation potential as this potential is further determined by the fuel mix and by the efficiency of energy use. Although increases in energy use can lead to higher GHG emissions, the increase in emission levels also depends on the carbon intensity of power and heat generation, including the fuel mix, and the efficiency of the process.

30. **Fuel mix, including renewables:** Countries differ in their mix of energy sources (table 3, columns 1–9). The mix defines, to some degree, the carbon intensity of TPES. A low contribution of renewable, nuclear or less carbon-intensive sources of energy to TPES could indicate high mitigation potential. It should be noted that the use of these sources is constrained by climatic factors and by the availability of natural resources, which therefore limits the mitigation potential.

31. **Emissions per GDP:** This is an indicator of the carbon intensity of the economy, which relates national emissions to economic activity (table 2, column 1). A country can have a high value if its emissions are relatively high and/or the GDP is relatively low. This is often the case for economies in transition. The value can be low for countries with low emissions and/or high GDP, such as highly developed economies with large renewable energy sources.

32. **Emissions per capita:** This indicator relates national emissions to the size of the population (table 2, column 2). A high value can but need not mean high national mitigation potential; this would be largely determined by the mitigation potential at the sectoral level.

33. **Energy supply per capita:** Energy supply per capita relates total energy supply to the size of the population (table 2, column 3). Depending on the fuel mix, a high value can mean high mitigation potential. Iceland, for example, has a relatively high value of energy supply per capita but lower mitigation potential owing to relatively large industrial activity compared with population size, and to the fact that most energy is produced from renewable sources.

34. **Share of exports in GDP:** A significant share of a country’s emissions can be attributed to production of goods for export. National GHG inventories do not split the reporting of emissions of goods for export, but a proxy indicator could be the share of exports in GDP (table 2, column 7). This indicator is limited, as it does not only include goods associated with high emission levels (e.g. cement, iron, steel, aluminum, chemical products and fossil fuels).

35. **HDI:** The state of a country’s development can be expressed in terms of life expectancy, education and GDP. In principle, high values of this index could mean that the country in question has the technical, financial and institutional resources to implement mitigation actions. Annex I Parties are usually at the top end of the scale and some economies in transition appear with slightly lower values (table 2, column 8).

36. **Final energy consumed per end-use sector:** The final energy consumption indicator includes only final energy use, so the waste heat that is lost during the transformation process (e.g. electricity production) is not accounted for. In all countries, the industry, transport and households and services sectors use a significant share of final energy. For some countries the agriculture sector, which also includes fisheries, is also relevant (table 3, columns 10–14). As stated in paragraph 21 above, increases in sectoral energy efficiency (e.g. using less energy per unit of product) provide important opportunities for mitigation as they decrease TPES.

B. Factors and indicators by sector

37. The share of national emissions among sectors, presented in table 4, is determined by several factors, which include the contribution of each sector to GDP, the efficiency of the use of energy for production and the carbon intensity of the production processes.

38. The split of sectors for the purposes of this document is presented in table 2 in the text. It is based on the source categories of the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*.

Table 2. Split of sectors used in this document

Sector used in this document	IPCC source category		Remark
Energy industries and fugitive emissions	1A1 1B	Energy industries Fugitive emissions from fuels	Includes emissions from electricity produced for the public market, refineries and other fuel production
Industry	1A2 2 3	Manufacturing industries and construction Industrial processes Solvents	Includes emissions from electricity produced by the industry for own use, but not from electricity purchased on the public market
Transport	1A3	Transport	Does not include emissions from the production of electricity that is used in this sector
Households and services	1A4 1A5	Other sectors Other	Does not include emissions from the production of electricity that is used in this sector
Agriculture	4	Agriculture	Only includes non-CO_2 and non-energy emissions. Energy related emissions are included under 'households and services'
Land use, land-use change and forestry	5	Land use, land-use change and forestry	Includes non-CO_2 emissions or removals from agricultural soils
Waste	6	Waste	
International transport	1A3a,i 1A3d,i	Transport civil aviation international Transport navigation international	These emissions are not included in the sector 'transport'

39. Emissions relating to electricity produced for the electricity grid are covered under 'energy industries', regardless of where is this used. The figures shown here therefore have to be viewed with caution, as 'industry' and 'households and services' do not include the emissions from all electricity used in these sectors. The reporting of GHG inventories under the UNFCCC does not provide for the allocation of emissions from electricity to the end-use sectors.

1. Energy industries and fugitive emissions

40. **Share of emissions from energy industries:** This category includes emissions from electricity and heat produced for the electricity grid, including electricity used in the industry and transport sectors. Emissions from imported electricity are accounted for in the country of origin. It also includes emissions from refineries and other fossil fuel production. For almost all Annex I Parties energy industries contribute significantly to emissions. Only a few countries that use renewable sources of energy (e.g. Switzerland and Iceland) or nuclear energy (e.g. France) extensively or import most of their electricity (e.g. Liechtenstein) have a relatively low share (table 5, column 1).

41. **Share of fugitive emissions:** Fugitive emissions include mainly CH_4 emissions that leak from gas fields and pipelines as well as from coal mines. Countries producing natural gas or coal have a high share in this sector (e.g. the Russian Federation, Canada, Norway and Australia) (table 5, column 2).

42. **CO_2 emissions per kWh in electricity production (carbon intensity of electricity generation):** The carbon intensity of electricity generation is calculated by dividing CO_2 emissions from electricity production by the amount of electricity generated. As it is difficult to separate heat from electricity generation in plants that provide both, this indicator in some cases has been calculated with the energy output including both electricity *and* heat. A high value indicates that the electricity generated is carbon intensive, which is usually the case with electricity generated from coal and oil. A low value indicates the use of renewable or nuclear energy or a high share of combined heat and power (CHP) generation (table 5, column 3). Alternative ways to calculate the carbon intensity may exclude the heat produced from electricity production or adjust values for desulphurization. These data are not as consistent as those provided by the IEA and hence are not included here.

43. **Share of renewable and nuclear energy and CHP production in electricity production:** High values in renewable sources of energy are usually due to the extensive use of hydropower (e.g. Austria, Norway and Switzerland) or geothermal energy (e.g. Iceland). Some countries generate a large proportion of their electricity from nuclear sources (e.g. France, Belgium and Slovakia). The share of CHP production is to be viewed with caution because for statistical reasons countries do not always report under ‘CHP plants’ those plants that are capable of producing electricity and heat at the same time. Some countries may report a 100 per cent share here, although they do not produce CHP 100 per cent of the time (table 5, columns 4–6).

44. **Efficiency of fossil fuel power plants:** The efficiency of fossil fuel power plants varies substantially. Usually energy input as fuel is compared with the energy output as electricity and sometimes heat. Efficiencies can, for example, exclude heat production from electricity production or correct for desulphurization (table 5, column 7).

2. Industry

45. **Share of emissions from industry:** Industry produces a significant share of emissions in all Annex I Parties. These emissions do not include those associated with electricity produced for the electricity grid and consumed by the industry. They include those from electricity produced by industry for its own use (table 6, column 1).

46. **Emission intensity per tonne of product:** The carbon intensity of production is calculated by dividing total emissions from production by the output. These values are not available in a consistent format and, for this reason, when the carbon intensity of industrial processes is being calculated, careful attention has to be paid to the boundaries of the production process, the products considered, the allocation of emissions from electricity production and other factors. Data reported under the UNFCCC are not detailed enough to allow a thorough calculation of the carbon intensity of industry. Some indicative values have been compiled for chemical and petrochemical production, as well as for cement production, in table 6, columns 2 and 3.

47. **Share of by-product emissions:** Several industrial processes result in GHGs as a by-product, for example, nitrous oxide (N_2O) and hydrofluorocarbon (HFC) from the chemical industry and CO_2 from cement production (table 6, column 4). Some of these emissions can be avoided at very low cost per tonne of CO_2 eq; they account for up to 8 per cent of total GHG emissions from individual Annex I Parties.

3. Transport

48. **Share of emissions from transport:** Transport contributes significantly to GHG emissions in all Annex I Parties (table 7, column 1).

49. **Emissions from transport per capita:** Total emissions can be related to the country's population size by dividing their total by total population. Carbon intensity of vehicles, travel volume, fuel efficiency and, in some cases, imports and exports of fuel (e.g. Luxembourg) influence this indicator (table 7, column 2).

50. **Fuel efficiency of passenger cars:** Passenger cars vary in the amount of fuel consumed per distance travelled, because of differences in car size, engine efficiency, driving practices and other factors (table 7, column 3).

51. **Passenger transport activity per capita:** Travel volume varies significantly among Annex I Parties. The total volume is measured in person kilometres and can be related to the country's population size by dividing it by total population. This indicator is influenced by factors such as consumer preferences, infrastructure and transport systems (table 7, column 4).

52. **Freight transport activity per capita:** Total freight volume also varies significantly among Annex I Parties. The total volume is measured in tonne kilometres and can be related to the country's population size by dividing it by total population. This value is influenced by the industrial activity of a country (table 7, column 5).

53. **Modal split of transport:** Passenger and freight transport activity can be split between road, rail, air transport and water, expressed as percentages. This split depends on consumer preferences, historical and current development of transport infrastructure, and prices of the modes of transport (table 7, columns 6 and 7).

54. **Population density:** Some countries are less populated per area than others and therefore may have more transport activity. Average population density is relatively low in countries such as Australia, Canada, Iceland and the Russian Federation, but it should be noted that in these countries population is usually concentrated in certain areas and large parts of the country are very scarcely populated. Japan, Netherlands and Belgium are examples of countries with a high population density (table 7, column 8).

4. Households and services

55. **Share of emissions from households and services:** Emissions from this sector originate directly from fuel used for space heating and indirectly from the use of electricity and heat. The reporting of GHG emissions under the UNFCCC does not split emissions from electricity and heat generation by sector, including household and services. Table 8, column 1, therefore includes only an incomplete picture of the direct emissions. It should also be noted that a greater degree of electrification reduces the contribution of direct emissions from this sector, and vice versa.

56. **Emissions from households and services per capita:** Emissions from this sector can be related to the country's population size by dividing their total by total population. Table 8, column 2, includes only an incomplete picture of the direct emissions for the same reasons stated in paragraph 55 above.

57. **Electricity use in households and services per capita:** Total electricity use in households and services can be related to the country's population size by dividing it by total population. The value is influenced by the number and efficiency of electrical appliances used and the amount of electricity that is used for heating and/or cooling. The values vary by a factor of 10 between Annex I countries (table 8, column 3).

58. **Heading and cooling degree days:**

58. **Heating and cooling degree days:** Varying climatic conditions throughout the year determine the amount of energy needed for cooling and heating. The sum of the number of days with an average temperature below 15°C (heating degree days) and of the number of days above 25°C (cooling degree days) is usually used as a measure of heating and cooling needs, respectively (table 8, columns 4 and 5).

59. Additional factors could include the average size of households and the number or people per household.

5. Agriculture (non-carbon dioxide)

60. **Share of emissions from agriculture:** CH_4 and N_2O emissions from this sector originate mainly from raising animals and using fertilizers. The share can be substantial for countries with extensive agricultural activity, such as Ireland and New Zealand (table 9, column 1).

61. **Emissions from agriculture per capita:** GHG emissions from agriculture can be related to the country's population size by dividing their total by total population. Countries with high agricultural output will have a high value (table 9, column 2), but this does not necessarily indicate high mitigation potential.

62. **Emissions per GDP from agriculture:** The carbon intensity of agricultural production can be calculated by dividing total non-CO_2 emissions from agriculture by total agricultural output. Because of the wide variety of agricultural products, the contribution of agriculture to national GDP could be used as a common metric for agricultural output (table 9, column 3). It should be noted that not all agricultural activities cause GHG emissions.

63. Additional efficiency-related indicators could include GHG emissions from meat and dairy production per calorie of animal products and N_2O emissions from use of nitrogen fertilizers per calorie of plant products.

6. Waste

64. **Share of emissions from waste:** Emission sources in this sector include solid waste disposal (landfills), wastewater treatment and incineration of waste not used for energy generation. Of these sources, decaying waste from landfills is usually the largest. Waste contributes less than 10 per cent of GHG emissions for all Annex I Parties (table 10, column 1).

65. **Emissions from waste per capita:** Waste emissions can be related to the country's population size by dividing their total by total population (table 10, column 2). Waste management practices, as well as the amount and biodegradability of industrial waste, can influence this indicator significantly.

66. **Percentage of CH_4 recovered:** CH_4 emissions from landfills can be captured and burned or used for electricity and heat generation at low cost. Annex I Parties report how much of the CH_4 generated in landfills is recovered. The value ranges between 72 per cent (United Kingdom of Great Britain and Northern Ireland) and zero (table 10, column 3).

67. **Municipal waste per capita:** The amount of municipal solid waste produced per capita varies by a factor of three between Annex I Parties (table 10, column 4). Only the organic fraction of the waste that is landfilled without gas recovery causes GHG emissions. Therefore a high value can but need not mean high emissions and therefore high reduction potential.

68. **Percentage of waste incinerated:** If waste is incinerated, most CH_4 emissions are avoided. Some countries have a clear strategy to incinerate waste, such as Japan (table 10, column 5).

69. **Percentage of waste landfilled:** CH_4 emissions can occur if waste is landfilled. In this case, the mitigation potential would be determined by the ability to recover CH_4 from landfills as discussed in paragraph 66 above (table 10, column 6).

7. Land use, land-use change and forestry

70. The LULUCF sector contributes to mitigation by removing CO_2 from the atmosphere, for example through reforestation, as well as by reducing emissions, for example through reduced forest degradation. The following factors and indicators are suggested:[7]

71. **Share of net emissions/removals from LULUCF:** LULUCF mitigation potential is determined by the potential to implement activities that reduce emissions and those that enhance sinks. It should be noted, however, that values for net emissions or removals can fluctuate substantially between years depending on market conditions, climate, fire, pest outbreaks and others. Table 11, column 1, provides only a snapshot of net emissions or removals from this sector and does not illustrate the longer term mitigation potential, which would take into account such fluctuations.

72. **Net emissions/removals from LULUCF per capita:** Net LULUCF emissions or removals can be related to the country's population size by dividing their total by total population (table 11, column 2). However, population is not the major driver of these emissions.

73. **Total forest area:** The total forested area of a country is a determinant of net emissions or removals in this sector. It should be noted that not all removals from forests are necessarily the result of direct human action. The largest areas are in Canada and the Russian Federation (table 11, column 3).

74. **Forest area as percentage of land area:** To show the importance of forests to a country, it is possible to express them as a percentage of total land area. Finland is the Annex I Party with the highest percentage of forest land area (table 11, column 4).

75. **Net emissions/removals per forest area:** Net LULUCF emissions or removals from forests can be related to the country's forested area by dividing their total by total forested area. New Zealand reports the highest values for this indicator (table 11, column 5).

76. **Net emissions/removals from soils per agricultural area**: Important mitigation potential is also found in soil management. Net emissions or removals from soils can be related to the country's agricultural area by dividing their total by total agricultural area (table 11, column 6).

8. International transport

77. **Emissions from international transport compared with national totals:** Emissions from international transport are usually excluded from national total GHG emissions. They can be substantial for countries with large international airports (e.g. Switzerland) and/or harbours (e.g. Netherlands) (table 12, columns 1 and 2).

78. **Emissions from international transport per capita:** International transport emissions can be related to the country's population size by dividing their total by total population (table 12, column 3). However, population is not the major driver of these emissions.

79. **Share of emissions from international aviation and shipping compared with total emissions from aviation and shipping:** Most countries report emissions associated with domestic aviation and

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[7] Additional factors and indicators for the LULUCF sector could relate to the use and treatment of harvested wood products. This is a matter currently being discussed by the Subsidiary Body for Scientific and Technological Advice and therefore has not been considered in developing this document.

shipping as part of total national GHG emissions, but exclude those associated with international aviation and shipping (table 12, columns 4 and 5).

C. Cross-cutting factors

80. **Technology and other options to reduce emissions:** An important factor contributing to mitigation potential is the availability of technological options to reduce emissions or enhance sinks in the various sectors. The AR4 provides a wealth of information on this subject. Table 13 provides a summary of options available today and options projected to be commercialized before 2030. Currently available technologies could reduce emissions substantially in almost all sectors.

81. **Policies and measures:** Another factor is the availability, suitability and degree of implementation of government policies and measures used to support the implementation of technological and other options. In its AR4, the IPCC notes that “a wide variety of national policies and instruments are available to governments to create the incentives for mitigation action. Their applicability depends on national circumstances and an understanding of their interactions, but experience from implementation in various countries and sectors shows there are advantages and disadvantages for any given instrument.” Table 14 provides a summary of relevant sectoral policies, measures and instruments. It should be noted that the synthesis of reports demonstrating progress in accordance with Article 3, paragraph 2, of the Kyoto Protocol refers to “more significant policy infrastructure and policy-making capacity to deal with climate change in many countries compared with earlier years” and, within this policy infrastructure, to “an apparent strengthening of integrated policy approaches, which aim to address climate change principally through sector policies” (FCCC/SBI/2006/INF.2, paras. 9 and 10).

82. **Costs of implementation:** A final cross-cutting factor contributing to mitigation potential is the cost of mitigation itself. Costs of mitigation are determined by, inter alia, the amount of GHG emissions to be reduced, the availability and costs of individual mitigation options, the choice of policy instruments (e.g. market-based mechanisms) and co-benefits of mitigation.

83. Studies on the costs of mitigation generally use model based calculations that assume a reference and a mitigation scenario to assess the additional costs of meeting ‘business as usual’ levels of service while emitting fewer GHGs. Such studies can provide useful insights but, in most cases, calculations include only the direct costs of implementing a particular emission reduction option, such as implementing a particular policy or switching from a particular technology or fuel to another. In addition, they usually ignore non-economic barriers or the co-benefits of reducing emissions, and rarely consider national institutional capacity and governance structure to implement and enforce certain policies.

84. The secretariat is currently developing an analysis of investment and finance needs to address climate change, in response to requests by the dialogue on long-term cooperative action to address climate change by enhancing implementation of the Convention (the Dialogue) and by the Conference of the Parties. This analysis will consider regional information on mitigation opportunities and costs in the agriculture, forestry, industry, buildings, transportation and waste sectors. The final report of this analysis should be available at the beginning of August and will be presented at the fourth workshop under the Dialogue, to be held in Vienna, Austria, in conjunction with the fourth session of the AWG.

V. Other information on mitigation potential

A. Projections of Annex I Parties

85. The UNFCCC reporting guidelines on national communications (FCCC/CP/1999/7) require Annex I Parties to provide information on projections including a ‘with measures’ projection that encompasses currently implemented and adopted policies and measures. Annex I Parties can also provide a ‘with additional measures’ projection which encompasses planned policies and measures. The difference between the ‘with measures’ and ‘with additional measures’ projections could provide some information on how governments expect planned and additional policies to contribute to reducing GHG emissions. It should be noted that Parties are not requested to provide information on costs associated with the planned reductions, nor do the guidelines provide a harmonized methodology to report these projections.

86. Table 3 summarizes data on projections submitted by Annex I Parties contained in their latest national communications. Column 1 contains GHG emissions in 1990 as reported in the chapter on projections within national communications; these may be slightly different from the information contained within national GHG inventories because they may have been prepared at a different date or they may have used different base year data. Most Parties provide a ‘with measures’ projection until 2010 and until 2020 (columns 2–4). The ‘with additional measures’ projection is provided by some Parties for 2010 and only by a few for 2020 (columns 5 and 6).

87. The information contained in table 3 indicates that some governments expect additional measures to result in emissions in 2010 between 43 per cent above and 56 per cent below 1990 levels (table 3, column 5), and in 2020 between 57 per cent above and 45 per cent below 1990 levels (table 3, column 6). The effect of additional measures, relative to the ‘with measures’ scenario, ranges between 1 per cent and 22 per cent in 2020 (table 3, column 8).

Table 3. Projections reported by Annex I Parties in their national communications

Party	National total GHG emissions in Convention base year (Mt CO_2 eq)[a]	Percentage change 'with measures' (%)			Percentage change 'with additional measures' (%)		Effect of additional measures (% of 1990)	
		1990–2005	1990–2010[b]	1990–2020	1990–2010[c]	1990–2020	2010[d]	2020[e]
Australia	417	28	35	54				
Austria	79		17		-1		18	
Belarus	105	-34	-25	-16				
Belgium	146	3	2	6	0		2	
Bulgaria	138	-51	-35	-24	-40	-33	6	8
Canada	599	24	38	50				
Croatia	34	-12	0	15	-12	-7	12	22
Czech Republic	192	-23	-24	-37	-27	-38	2	1
Denmark	69	1	5	-2				
Estonia	38		-56		-56		0	
Finland	71	11	10	15	-2	-3	12	18
France	567		6	12	0	-2	6	14
Germany	1,275		-21	-21	-29	-41	8	20
Greece	109	31	37	52	28		10	
Hungary	122	-28	-28	-20	-29	-23	0	3
Iceland	3		0	38				
Ireland	56	28	30	39				
Italy	521	5	11	27	4		8	
Japan	1,188		10		4		7	
Latvia	25	-51	-46	-35	-49	-45	3	10
Liechtenstein	0		4					
Lithuania	41	-57	-40	-34				
Luxembourg								
Monaco								
Netherlands	212	2	2	5	-1	2	3	3
New Zealand	62	24	34	48				
Norway	50		23	37				
Poland	569		-26	-16				
Portugal	60		47	60	43	57	4	3
Romania	262	-39	-27	-11	-31	-15	4	4
Russian Federation	2,961		-21	-4				
Slovakia	72	-32	-22	-3	-25	-8	2	4
Slovenia	20	4	5	1	-1	-6	6	7
Spain	286	47	52	85				
Sweden	72	-2	-1	6				
Switzerland	52	-2	-3	-6	-6		2	
Turkey	132	86	158	308				
Ukraine	925	-53	-48	-38				
United Kingdom	763		-18	-19	-24		6	
United States								
High		86	158	308	43	57	18	22
Low		-57	-56	-38	-56	-45	0	1

Abbreviations: GHG = greenhouse gas, Mt CO_2 eq = million tonnes of CO_2 equivalent.

Note: Data has been extracted from the latest national communication (NC). Exceptions: Belarus (second NC), Finland (report on demonstrable progress), Italy (third NC), Turkey (First NC) and Ukraine (second NC).

[a] Excluding land use, land-use change and forestry and excluding international transport, base year is 1990 except for Bulgaria (1988), Hungary (average of the years 1985 to 1987), Poland (1988), Romania (1989) and Slovenia (1986).

[b] The Russian Federation provided two equivalent scenarios. 'Scenario II' is included here, which is the only one that included non-CO_2 gases.

[c] United Kingdom provided several scenarios. Here the 'with additional measures - high ETS' scenario is shown.

[d] Calculated as the difference between the percentage change 'with measures' for the period 1990–2010 and the percentage change 'with additional measures' for the same period.

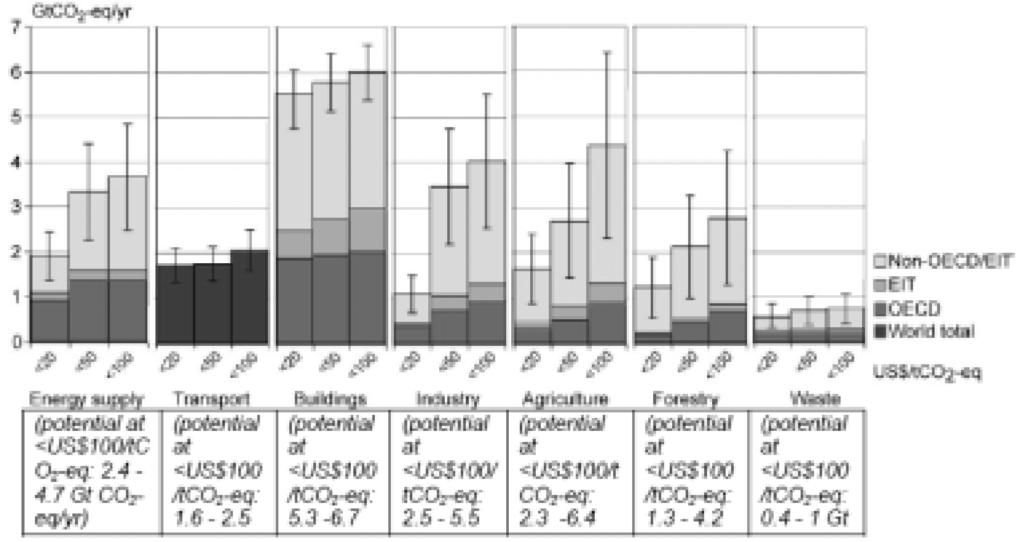
[e] Calculated as the difference between the percentage change 'with measures' for the period 1990–2020 and the percentage change 'with additional measures' for the same period.

B. Fourth Assessment Report of the Intergovernmental Panel on Climate Change

88. An economic analysis that considers all factors described in chapter IV for all individual Annex I Parties and sectors in a consistent manner does not exist. The IPCC, in its AR4, has assessed available literature on the economic potential to reduce GHG emissions by 2030 assuming that policies will be successful in removing barriers for implementation. It evaluated results from sectoral bottom-up studies[8] for three geographical regions (OECD, economies in transition and other) and from sectoral top-down studies[9] without geographical split. The IPCC found that results from both types of study are similar and states that “there is substantial economic potential for the mitigation of global GHG emissions over the coming decades, that could offset the projected growth of global emissions or reduce emissions below current levels”.

89. Figure 2 shows the results of the assessment of bottom-up studies by sector. It indicates that significant economic potential to reduce GHG emissions exists in all sectors and that mitigation potential increases as the price for carbon increases. It should be noted that values in this figure should be considered conservative because changes in lifestyle or behavioural aspects have not been considered, few studies have been undertaken for high carbon prices and some mitigation options were not analyzed.[10] The latter has led to an underestimation of the total economic potential of between 10 per cent and 15 per cent.

Figure 2. Estimated sectoral economic potential for global mitigation for different regions



Source: IPCC. Fourth Assessment Report, Contribution of Working Group III. Figure SPM.6.
Abbreviations: EIT = economy in transition, OECD = Organisation for Economic Co-operation and Development, GHG = greenhouse gas.
Note: The sectoral split in this table is not consistent with that referred to in table 2 in this document.

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[8] According to the AR4, “bottom-up studies are based on assessment of mitigation options, emphasizing specific technologies and regulations. They are typically sectoral studies taking the macro-economy as unchanged.”

[9] According to the AR4, “top-down studies assess the economy-wide potential of mitigation options. They use globally consistent frameworks and aggregated information about mitigation options and capture macroeconomic and market feedbacks.”

[10] Mitigation options not considered include the reduction of non-CO_2 emissions in buildings and transport, heat production and cogeneration in energy supply, efficiency of heavy duty vehicles, improvements in shipping and high-occupancy passenger transport, wastewater treatment and emission reduction from coal mines and gas pipelines.

90. An analysis has been carried out with support from experts involved in producing the AR4 to provide a rough indication of the emission reductions that would be achievable for different carbon prices. If economic potential from the energy supply, transport, buildings, industry and waste sectors[11] estimated for a carbon price under USD 20 is added and compared to the reference scenarios A1B and B2, aggregate emissions from Annex I Parties from these sectors in 2030 would be about 19 per cent and 15 per cent (for scenario A1B and B2, respectively) below 1990 levels. For a carbon price of up to USD 50, these emissions would be about 27 per cent and 23 per cent below 1990 levels. Finally, for a carbon price of up to USD 100, emissions would be about between 22 per cent and 39 per cent, and between 18 per cent to 34 per cent below 1990 levels.[12]

VI. Summary

91. This document synthesizes information relevant to the determination of the mitigation potential and to the identification of possible ranges of emission reduction objectives of Annex I Parties. It compiles some factors and indicators split into nationwide, sectoral and cross-cutting groups, together with data on the current status of most of these factors and indicators.

92. Determining mitigation potential raises a broad range of issues and requires complex analysis. The information presented in this document is limited owing to time constraints and the availability of information and national and sectoral experts. Information relevant to mitigation potential of Annex I Parties at the level of individual countries is not available. To obtain such information, several options could be considered:

(a) A comprehensive study on the mitigation potential of Annex I Parties could be pursued through a model by an independent entity, using information on the current situation and future developments provided by Parties and with the involvement of national experts. Such a process would, however, be resource-intensive and could take several years;

(b) The material that served as an input to the AR4 could be used to further disaggregate the mitigation potential of Annex I Parties; for example, the authors of each chapter could be asked to provide analysis at a regional or country level. However, different studies have used different assumptions and methods and it is unlikely that a country specific disaggregation would be possible for all sectors;

(c) A thorough assessment of mitigation potential could be undertaken by national experts on the basis of available information from the IPCC and other sources, further refined and complemented with national data on GHGs, available policies, measures and technologies and related costs.

93. Table 4 provides a summary of available estimates of ranges of emission reductions by Annex I Parties. These estimates are from information by the IPCC or calculated using data contained within the latest national communication of Annex I Parties.

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[11] The LULUCF sector has been excluded from this analysis as a baseline scenario is not available. It should be noted that mitigation potential relating to carbon from agricultural soils was also excluded because related emissions or removals are accounted for in the LULUCF sector.

[12] These values have been calculated on the basis of information contained in the AR4. A baseline scenario was required to calculate these values; however, such scenarios are not available for each individual sector and for the same geographical split. Moreover, available scenarios are based on different assumptions. For this reason, baseline scenarios used in this exercise were taken from the *World Energy Outlook 2004* by the IEA (Paris: IEA). Reductions of emissions from the transport sector have been allocated on the basis of the share of global GHG emissions from this sector. If compared with the baselines used in individual sectors, resulting emissions in 2030 would be between 11 per cent and 31 per cent below 1990 levels for a carbon price of up to USD 100.

Table 4. Estimates of emission reductions by Annex I Parties using various methods

Source of estimate		**2020 (%)**	**2030 (%)**	**2050 (%)**
National communications by some Annex I Parties: estimated effect of 'additional measures' on GHG emissions		57 to -45		
IPCC: required reductions for Annex I Parties based on allocation rules (before trading)	450 ppmv CO_2 eq	-25 to -40		-80 to -95
	550 ppmv CO_2 eq	-10 to -30		-40 to -90
	650 ppmv CO_2 eq	0 to -25		-30 to -80
IPCC: indication[a] of possible reductions by Annex I Parties relative to scenarios A1B and B2, based on different levels for carbon price	USD 100		A1B: -22 to -39 B2: -18 to -34	
	USD 50		A1B: -27 B2: -23	
	USD 20		A1B: -19 B2: -15	

Abbreviations: GHG = greenhouse gas, IPCC = Intergovernmental Panel on Climate Change.

[a] These figures exclude the agriculture and land use, land-use change and forestry sectors.

94. Table 4 indicates the following: (1) governments from those Parties that have reported relevant data expect 'additional measures' to result in emissions in 2020 between 57 per cent above and 45 per cent below 1990 levels; (2) required reductions by Annex I Parties in 2020 for a stabilization scenario of 450 ppmv CO_2 eq have been estimated to be between 25 per cent and 40 per cent below 1990 levels, as already referred to by the AWG at its third session (FCCC/KP/AWG/2007/2, para. 21 (a)); (3) based on an indicative analysis, the amount of emission reductions in 2030 for carbon prices between USD 20 and USD 100 could roughly be between 15 per cent and 39 per cent below 1990 levels for scenario A1B.

95. It should be noted that the results compiled in table 4 have been derived from analysis limited to domestic action and do not consider the use of flexibility mechanisms. As suggested by some Parties in their submissions, the use of market-based mechanisms, such as the clean development mechanism, joint implementation and emissions trading, and other flexibility measures increases achievable emission reductions considerably. The IPCC estimates that the potential outside the group of Annex I Parties is approximately the same as the potential within this group. This potential is also at the disposal of Annex I Parties.

Annex

Tables

A. Notes

Data are given for 2004 unless otherwise noted.
'KP Annex I Parties' refers to those Parties included in Annex I to the Convention that are also Party to the Kyoto Protocol.
European Community refers to the European Community and its member States.

B. Sources

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World Bank. World Development Indicators 2007 database <http://www.worldbank.org/data>
Word Resources Institute. Climate Analysis Indicators Tool (CAIT 3.0) database <http://cait.wri.org>

C. Abbreviations

CCS = carbon capture and storage
CHP = combined heat and power
g CO_2 = grams of CO_2
GDP = gross domestic product
GHG = greenhouse gas
IEA = International Energy Agency
IEA EB = Energy Balances database of the International Energy Agency
IPCC = Intergovernmental Panel on Climate Change
ktoe = thousand tonnes of oil equivalent
kWh = kilowatt per hour

LULUCF = land use, land-use change and forestry
Mt CO_2 eq = million tonnes of CO_2 equivalent
NO_x = Nitrous oxides
pkm = person kilometres
PPP = purchasing power parity
PV = photovoltaic
RD&D = research, design and development
t CO_2 eq = tonne of CO_2 equivalent
tkm = tonne kilometres
toe = tonne of oil equivalent
TPES = total primary energy supply

Table 1. Nationwide indicators of mitigation potential

Party	GHG emissions in 2004 (Mt CO_2 eq)[a]	Change in GHG emissions from base year to 2004 (%)[b]	Population in 2004 (million)	Projected population growth 2004–2020 (%)	GDP (PPP) in 2004 (USD billion (2000)/y)	TPES supply in 2003 (ktoe)
Australia	529	25	20	17	561	112,645
Austria	91	16	8	2	242	33,183
Belarus	74	-42	10	-9	63	25,797
Belgium	148	1	10	2	298	59,157
Bulgaria	68	-49	8	-12	58	19,510
Canada	758	27	32	14	919	260,641
Croatia	29	-5	5	-4	50	8,779
Czech Republic	147	-25	10	-3	182	44,117
Denmark	70	-1	5	4	159	20,755
Estonia	21	-51	1	-5	18	4,915
Finland	81	15	5	3	144	37,554
France	563	-1	60	4	1,626	271,287
Germany	1,015	-17	83	0	2,146	347,118
Greece	138	27	11	1	226	29,887
Hungary	84	-32	10	-5	156	26,341
Iceland	3	-5	0.3	13	9	3,386
Ireland	68	23	4	20	145	15,092
Italy	583	12	58	-2	1,491	181,026
Japan	1,355	7	128	-1	3,435	517,103
Latvia	11	-58	2	-8	25	4,375
Liechtenstein	0.27	18	0.03	13		
Lithuania	20	-60	3	-7	41	8,930
Luxembourg	13	0	0.5	20	29	4,262
Monaco	0.10	-3	0.03	20		
Netherlands	218	2	16	5	476	80,829
New Zealand	75	21	4	11	87	17,372
Norway	55	10	5	8	162	23,347
Poland	388	-31	39	-2	455	93,666
Portugal	85	41	10	4	189	25,778
Romania	155	-41	22	-6	169	39,009
Russian Federation	2,024	-32	144	-8	1,309	639,717
Slovakia	51	-30	5	-1	72	18,521
Slovenia	20	-1	2	-3	38	7,021
Spain	428	49	43	4	983	136,102
Sweden	70	-3	9	5	244	51,532
Switzerland	53	0	7	2	224	27,075
Turkey	294	73	72	20	511	78,954
Ukraine	413	-55	47	-16	279	132,555
United Kingdom	665	-14	59	5	1,696	231,954
United States	7,068	16	295	15	10,708	2,280,791
European Community	5,200	-10	487	1	11,309	1,791,921
Values for KP Annex I Parties:						
Average		37	940	1		
Sum	10,335				18,357	3,526,647
High	2,024	73	144	20	3,435	639,717
Low	0.10	-60	0.03	-16	9	3,386

[a] Excludes LULUCF and excludes international transport.

[b] Base year is 1990 except for Bulgaria (1988), Hungary (average of the years 1985 to 1987), Poland (1988), Romania (1989) and Slovenia (1986).

Table 2. Nationwide intensities

Party	GHG emissions/GDP PPP (t CO_2 eq/USD 1,000)	GHG emissions/capita (t CO_2 eq)	TPES/capita (toe)	GHG emissions/ TPES (t CO_2 eq./ toe)	TPES/GDP PPP (toe/USD 1,000)	GDP PPP/ capita (USD/capita)	Exports as proportion of GDP (%)	Human Development Index
Australia	0.94	26.5	5.6	4.70	0.20	28,112	18	0.96
Austria	0.38	11.2	4.1	2.75	0.14	29,672	51	0.94
Belarus	1.18	7.6	2.6	2.88	0.41	6,415	68	0.79
Belgium	0.50	14.2	5.7	2.50	0.20	28,638	84	0.95
Bulgaria	1.17	8.7	2.5	3.46	0.34	7,406	58	0.82
Canada	0.83	23.7	8.2	2.91	0.28	28,747	39	0.95
Croatia	0.59	6.5	1.9	3.35	0.18	10,964	47	0.85
Czech Republic	0.81	14.4	4.3	3.33	0.24	17,815	71	0.89
Denmark	0.44	12.9	3.8	3.35	0.13	29,278	45	0.94
Estonia	1.18	16.0	3.7	4.34	0.27	13,516	78	0.86
Finland	0.57	15.6	7.2	2.17	0.26	27,490	38	0.95
France	0.35	9.3	4.5	2.07	0.17	26,984	26	0.94
Germany	0.47	12.3	4.2	2.92	0.16	25,972	38	0.93
Greece	0.61	12.4	2.7	4.61	0.13	20,331	21	0.92
Hungary	0.54	8.3	2.6	3.19	0.17	15,427	64	0.87
Iceland	0.35	10.7	11.6	0.92	0.38	30,390	35	0.96
Ireland	0.47	16.8	3.7	4.54	0.10	35,585	83	0.96
Italy	0.39	10.0	3.1	3.22	0.12	25,694	25	0.94
Japan	0.39	10.6	4.0	2.62	0.15	26,850	13	0.95
Latvia	0.43	4.6	1.9	2.46	0.18	10,684	44	0.85
Liechtenstein		7.9						
Lithuania	0.49	5.9	2.6	2.26	0.22	12,019	52	0.86
Luxembourg	0.44	27.7	9.3	2.98	0.15	63,498	149	0.95
Monaco		3.0						
Netherlands	0.46	13.4	5.0	2.70	0.17	29,316	67	0.95
New Zealand	0.86	18.8	4.4	4.32	0.20	21,905	29	0.94
Norway	0.34	11.9	5.1	2.35	0.14	35,288	43	0.97
Poland	0.85	10.1	2.4	4.14	0.21	11,807	38	0.86
Portugal	0.45	8.1	2.5	3.28	0.14	18,145	29	0.90
Romania	0.91	7.1	1.8	3.96	0.23	7,756	36	0.81
Russian Federation	1.55	14.1	4.4	3.16	0.49	9,098	35	0.80
Slovakia	0.71	9.4	3.4	2.76	0.26	13,392	77	0.86
Slovenia	0.52	10.2	3.6	2.86	0.18	19,536	60	0.91
Spain	0.44	10.0	3.2	3.14	0.14	23,043	26	0.94
Sweden	0.29	7.8	5.7	1.36	0.21	27,102	46	0.95
Switzerland	0.24	7.3	3.7	1.96	0.12	30,994	46	0.95
Turkey	0.57	4.1	1.1	3.72	0.15	7,077	29	0.76
Ukraine	1.48	8.8	2.8	3.12	0.48	5,934	61	0.77
United Kingdom	0.39	11.2	3.9	2.87	0.14	28,511	25	0.94
United States	0.66	23.9	7.7	3.10	0.21	36,248	10	0.95
European Community	0.46	10.7	3.7	2.90	0.16	23,244		
Values for KP Annex I Parties								
Average	0.56	11.0	3.8	2.93	0.19	19,528		
High	1.55	27.7	11.6	4.61	0.49	63,498	149	0.97
Low	0.24	3.0	1.1	0.92	0.10	5,934	13	0.76

Table 3. Mix of energy sources per country

	Share in TPES in 2003 (%)									Share in final energy consumption in 2003 (%)				
Party	Coal	Oil	Gas	Nuclear	Hydropower	Geothermal	Solar/ wind/ other	Biomass/ waste	Electricity and heat[a]	Industry	Transport	Households and services[b]	Agriculture	Other[c]
Australia	42.6	31.9	19.7	0.0	1.2	0.0	0.1	4.4	0.0	32.4	40.4	21.2	2.8	3.3
Austria	12.0	42.9	22.8	0.0	9.4	0.1	0.3	11.0	1.5	28.3	27.7	36.7	2.5	4.9
Belarus	2.4	31.7	59.4	0.0	0.0	0.0	0.0	4.2	2.3	41.6	12.4	31.8	5.0	9.2
Belgium	10.0	41.8	24.3	20.9	0.0	0.0	0.0	2.0	0.9	36.3	24.3	32.9	2.0	4.5
Bulgaria	37.9	23.6	12.8	23.2	1.3	0.0	0.0	3.6	-2.4	42.1	23.7	29.7	2.8	1.7
Canada	11.5	35.2	30.4	7.5	11.1	0.0	0.0	4.5	-0.2	35.2	27.4	32.0	1.8	3.6
Croatia	7.4	52.8	26.8	0.0	4.8	0.0	0.0	4.3	3.8	28.1	26.9	37.2	3.9	3.9
Czech Republic	47.3	19.9	17.8	15.3	0.3	0.0	0.0	2.6	-3.2	35.8	22.5	35.5	1.1	5.1
Denmark	27.3	40.3	22.4	0.0	0.0	0.0	2.7	10.7	-3.5	18.9	32.8	40.5	6.1	1.8
Estonia	64.0	14.9	13.8	0.0	0.0	0.0	0.0	10.6	-3.3	24.7	24.1	46.5	2.5	2.2
Finland	21.9	28.6	10.9	15.8	2.2	0.0	0.0	19.5	1.1	45.7	18.1	26.4	3.0	6.7
France	5.3	33.6	14.5	42.4	1.9	0.0	0.0	4.4	-2.1	26.0	30.3	38.3	1.7	3.7
Germany	24.5	36.4	22.8	12.4	0.5	0.0	0.5	2.8	0.0	29.8	25.9	39.2	1.1	4.0
Greece	29.8	57.5	6.8	0.0	1.4	0.0	0.6	3.3	0.6	20.9	36.9	33.3	5.9	3.0
Hungary	14.2	23.9	45.1	11.0	0.1	0.3	0.0	3.1	2.3	23.8	20.1	50.2	3.3	2.6
Iceland	2.7	24.8	0.0	0.0	18.0	54.5	0.0	0.1	0.0	33.0	14.0	33.3	13.2	6.6
Ireland	17.2	56.3	24.2	0.0	0.3	0.0	0.3	1.1	0.7	18.3	38.8	38.4	2.3	2.2
Italy	8.2	48.3	35.0	0.0	1.6	2.7	0.1	1.7	2.4	31.9	31.7	30.8	2.6	3.1
Japan	20.8	49.7	13.7	12.1	1.6	0.6	0.1	1.3	0.0	38.7	26.4	29.2	1.9	3.9
Latvia	1.5	29.0	30.8	0.0	4.5	0.0	0.1	28.9	5.2	17.1	24.1	53.1	2.8	2.8
Liechtenstein														
Lithuania	2.1	24.5	26.7	45.8	0.3	0.0	0.3	7.6	-7.3	29.3	25.5	39.4	2.1	3.6
Luxembourg	1.8	64.3	25.0	0.0	0.2	0.0	0.0	1.2	7.5	22.1	59.2	18.0	0.3	0.4
Monaco														
Netherlands	10.8	39.0	44.5	1.3	0.0	0.0	0.2	2.4	1.8	34.1	24.2	30.3	6.1	5.3
New Zealand	10.4	39.1	22.2	0.0	11.7	11.4	0.4	4.8	0.0	35.3	41.6	18.4	2.8	1.9
Norway	3.4	20.9	27.3	0.0	38.9	0.0	0.1	6.5	2.9	41.1	22.8	29.0	3.9	3.2
Poland	61.5	21.6	12.0	0.0	0.2	0.0	0.0	5.6	-0.9	31.2	18.9	39.8	7.5	2.5
Portugal	12.7	59.3	10.2	0.0	5.2	0.3	0.2	11.0	0.9	35.9	34.8	23.9	2.2	3.2
Romania	22.5	26.5	37.7	3.3	2.9	0.0	0.0	7.5	-0.5	40.8	17.9	36.0	1.0	4.3
Russian Federation	16.8	20.6	53.5	6.2	2.1	0.0	0.0	1.0	-0.2	35.0	21.2	37.9	2.5	3.4
Slovakia	24.6	16.9	30.6	25.4	1.6	0.0	0.0	1.9	-1.0	41.7	19.7	34.1	2.2	2.4
Slovenia	21.6	35.5	12.9	19.3	3.9	0.0	0.0	6.7	0.2	33.0	27.1	33.7	1.7	4.5
Spain	14.8	50.7	15.7	11.8	2.6	0.0	0.8	3.5	0.1	33.4	37.5	21.5	2.6	5.0
Sweden	5.2	30.2	1.7	34.1	8.9	0.0	0.1	17.1	2.7	37.8	23.1	34.9	1.7	2.6
Switzerland	0.5	46.5	9.7	26.5	11.1	0.4	0.1	6.2	-1.0	19.4	32.5	44.3	0.7	3.2
Turkey	27.1	37.7	22.4	0.0	3.8	1.1	0.4	7.3	0.1	36.2	21.6	33.8	4.9	3.5
Ukraine	27.1	12.7	43.7	16.0	0.6	0.0	0.0	0.2	-0.3	41.6	10.0	41.0	4.0	3.3
United Kingdom	16.5	35.1	37.0	10.0	0.1	0.0	0.1	1.2	0.1	25.0	33.3	37.4	0.5	3.7
United States	23.3	40.4	22.8	9.0	1.1	0.4	0.1	3.0	0.0	24.9	40.4	29.5	0.9	4.4
European Community	18.5	37.1	23.7	14.5	1.5	0.3	0.3	4.2	0.0	30.3	28.6	34.9	2.3	3.8
Values for KP Annex I Parties														
Average	18.1	34.9	29.0	11.6	2.7	0.4	0.2	3.2	0.0	33.3	26.1	34.5	2.4	3.7
High	64.0	64.3	59.4	45.8	38.9	54.5	2.7	28.9	7.5	45.7	59.2	53.1	13.2	9.2
Low	0.5	12.7	0.0	0.0	0.0	0.0	0.0	0.1	-7.3	17.1	10.0	18.0	0.3	0.4

[a] Can be negative due to imports and exports.

[b] IEA EB categories commercial and public services and residential.

[c] IEA EB categories non-specified other and non-energy use.

Table 4. National greenhouse gas emissions per sector

Party	Share of sector in total GHG emissions (without LULUCF and international transport) (%)						Compared with total GHG emissions (excluding LULUCF and international transport) (%)	
	Energy industries and fugitive emissions[a]	**Industry**[b]	**Transport**[c]	**Households and services**[d]	**Agriculture**[e]	**Waste**[f]	**LULUCF**[g]	**International transport**[h]
Australia	46.3	13.9	15.0	3.9	17.0	3.6	0.8	1.7
Austria	18.0	28.3	26.0	16.3	8.6	2.8	-18.2	1.7
Belarus	46.1	14.0	5.9	11.4	16.6	6.0	-16.0	0.4
Belgium	20.4	30.4	18.5	21.8	7.7	1.1	-0.8	18.8
Bulgaria	45.0	24.9	11.1	2.7	7.6	8.8	-32.7	1.1
Canada	36.3	16.2	25.5	11.0	7.2	3.8	10.7	1.5
Croatia	30.0	23.3	18.8	13.7	12.1	2.2	-55.5	0.5
Czech Republic	43.4	27.7	10.8	10.7	5.5	1.9	-3.3	0.6
Denmark	38.2	13.1	19.2	11.0	14.4	2.0	-3.3	7.3
Estonia	76.9	5.0	9.4	3.1	5.6	2.5	-37.6	2.6
Finland	40.9	21.7	17.3	10.0	6.9	3.2	-22.7	3.6
France	12.7	21.7	26.1	19.7	17.1	2.6	-9.2	4.6
Germany	37.7	20.6	17.0	16.9	6.3	1.4	-3.5	2.6
Greece	44.7	17.5	16.2	10.6	8.7	2.4	-3.9	9.8
Hungary	25.8	19.2	12.6	23.4	13.3	5.6	-6.6	0.8
Iceland	0.6	46.0	22.8	24.1	16.1	7.0	59.5	19.4
Ireland	23.2	11.9	18.4	16.1	27.7	2.7	-0.1	3.8
Italy	29.4	22.5	22.8	15.3	6.5	3.4	-18.0	2.5
Japan	28.3	33.2	19.1	13.9	2.0	3.5	-7.0	2.9
Latvia	20.8	13.1	27.0	14.5	17.3	7.3	-129.4	7.6
Liechtenstein	1.4	15.7	31.7	42.4	8.3	0.7	-13.4	
Lithuania	29.6	22.2	19.6	6.7	18.5	7.2	21.6	2.4
Luxembourg	3.5	26.2	57.1	10.4	3.0	0.6		10.1
Monaco	28.7	0.3	34.4	35.6		1.1	0.0	15.1
Netherlands	33.1	20.1	16.2	18.8	8.4	3.3	1.1	26.4
New Zealand	11.7	12.4	19.1	4.6	49.7	2.5	-32.6	4.4
Norway	29.0	26.4	26.2	7.5	7.8	2.9	-47.9	5.0
Poland	51.5	16.2	9.0	13.6	8.8	2.8	-6.7	0.4
Portugal	26.8	21.5	23.7	8.7	9.7	9.4	-3.2	5.0
Romania	38.5	28.2	11.0	7.8	9.0	5.5	-22.4	
Russian Federation	60.7	16.3	10.5	8.7	6.9	3.2	-9.8	
Slovakia	26.2	38.4	11.1	12.6	7.6	4.1	-8.3	0.3
Slovenia	33.4	17.6	21.2	14.1	9.8	3.2	-28.1	0.3
Spain	28.0	25.1	23.8	9.2	11.0	2.8	-7.1	7.7
Sweden	19.6	26.3	28.7	9.5	12.4	3.4	-23.6	12.0
Switzerland	6.9	17.2	29.4	35.2	9.9	1.4		6.5
Turkey	26.4	31.4	14.0	13.6	5.2	9.4		
Ukraine	37.0	33.6	9.1	10.8	7.4	2.1	-7.8	0.0
United Kingdom	33.9	17.7	20.2	18.0	6.8	3.4	-0.3	5.9
United States	35.6	16.9	26.5	12.1	6.2	2.7	-10.9	1.4
European Community	32.4	21.4	19.0	15.2	9.2	2.9	-7.8	5.2
Values for KP Annex I Parties								
Average	37.5	22.2	17.3	13.2	7.8	3.3	-7.1	3.2
High	76.9	46.0	57.1	42.4	49.7	9.4	59.5	26.4
Low	0.6	0.3	5.9	2.7	2.0	0.6	-129.4	0.0

[a] Sum of IPCC source categories 1A1 (energy industries) and 1B (fugitive emissions from fuels).

[b] Sum of IPCC source categories 1A2 9manufacturing industries and construction), 2 (industrial processes) and 3 (solvents).

[c] IPCC source category 1A3 (transport).

[d] Sum of IPCC source categories 1A4 (other sectors) and 1A5 (other). Indirect emissions from electricity use are only included under energy industries and fugitive emissions.

[e] IPCC source category 4 (agriculture).

[f] IPCC source category 6 (waste).

[g] IPCC source category 5 (land use, land-use change and forestry).

[h] Sum of IPCC source categories 1A3a,i (transport civil aviation, international) and 1A3d,i (transport navigation, international).

Table 5. Mitigation potential indicators for Energy industries and fugitive emissions

	Share of national GHG emissions (%)						
Party	**Energy industries**	**Fugitive emissions**	**CO_2 emissions / kWh (g CO_2/kWh)[a]**	**Share of renewable energy in electricity production (%)**	**Share of nuclear energy in electricity production (%)**	**Share of combined heat and power in electricity from fossil fuels (%)[b]**	**Efficiency of fossil fuel power plants (%)[c]**
Australia	40.6	5.7	841	8.3	0.0	5.7	32.7
Austria	17.1	0.9	221	70.5	0.0	34.2	
Belarus	43.9	2.2	302	0.1	0.0	54.7	
Belgium	20.0	0.4	281	2.6	59.0	19.9	
Bulgaria	42.3	2.7	471	4.0	44.9	26.3	
Canada	27.5	8.8	209	57.9	13.0	7.0	
Croatia	23.1	6.9	298	52.7	0.0	33.6	
Czech Republic	39.8	3.6	503	3.7	19.9	33.9	
Denmark	37.2	1.0	308	17.1	0.0	99.6	41.3
Estonia	73.4	3.5	701	0.2	0.0	10.4	
Finland	40.7	0.2	261	29.5	30.6	49.7	41.3
France	11.5	1.2	87	14.3	77.1	0.0	33.4
Germany	36.2	1.5	453	7.6	29.5	0.0	37.5
Greece	43.4	1.3	781	5.7	0.0	6.1	
Hungary	23.7	2.2	401	0.9	38.8	32.9	
Iceland	0.6		1	100.0	0.0	0.0	
Ireland	23.0	0.2	573	4.2	0.0	2.3	41.5
Italy	28.1	1.3	455	20.6	0.0	29.4	
Japan	28.3	0.0	424	9.7	31.0	0.0	42.1
Latvia	19.6	1.2	167	66.3	0.0	100.0	
Liechtenstein	1.0	0.3					
Lithuania	28.3	1.3	111	2.9	79.1	100.0	
Luxembourg	3.0	0.5	333	44.0	0.0	13.5	
Monaco	28.7						
Netherlands	32.5	0.6	440	4.9	4.2	100.0	
New Zealand	9.6	2.1	165	65.1	0.0	5.4	
Norway	22.8	6.2	7	85.2	0.0	8.0	41.3
Poland	47.6	3.9	665	2.2	0.0	100.0	
Portugal	25.3	1.5	452	34.6	0.0	13.5	
Romania	31.4	7.0	418	27.7	10.1	46.5	
Russian Federation	47.7	13.0	325	19.9	15.4	99.3	
Slovakia	24.0	2.2	247	16.1	53.7	90.4	
Slovenia	31.5	1.9	336	26.7	36.3	85.5	
Spain	27.1	1.0	383	21.9	27.1	22.1	
Sweden	18.3	1.3	51	51.4	44.6	87.5	41.3
Switzerland	6.4	0.5	24	60.7	38.0	100.0	
Turkey	26.0	0.4	462	19.8	0.0	19.2	
Ukraine	24.3	12.7	296	7.0	44.1	25.3	
United Kingdom	31.5	2.4	467	2.6	23.5	8.0	41.5
United States	32.6	3.0	576	7.6	20.9	11.0	35.1
European Community	30.5	1.8	370	14.9	31.8	29.3	
Values for KP Annex I Parties							
Average	32.8	4.7	423	21.3	26.1	32.9	0.0
High	73.4	13.0	781	100.0	79.1	100.0	42.1
Low	0.6	0.0	1	0.1	0.0	0.0	33.4

[a] CO_2 emissions from electricity and heat ('main producer' and 'Aatoproducer') divided by electricity and heat generated from these plants.

[b] Share of CHP in electricity from fossil fuels includes complete energy output of all plants that are CHP capable.

[c] Efficiency calculated as weighted average over all fossil fuel sources (coal, oil and gas) for 2003. Values are based on IEA statistics but are corrected for use of combined heat and power and for use of oxides of nitrogen and sulphur control. The United Kingdom and Ireland were analysed as one group, as were the Nordic countries of Denmark, Sweden, Norway and Finland.

Table 6. Mitigation potential indicators for the industry sector

Party	Share of sector in national GHG emissions 2004 (%)[a]	GHG emissions/output in chemical industry (CO_2 index)[b]	GHG emissions/tonne of cement (t CO_2/ t cement)[c]	Non-CO_2 process emissions as percentage of national total (%)[d]
Australia	13.9			1.1
Austria	28.3			2.0
Belarus	14.0			0.7
Belgium	30.4			3.5
Bulgaria	24.9			1.7
Canada	16.2		0.82	1.9
Croatia	23.3			3.4
Czech Republic	27.7			1.3
Denmark	13.1			1.9
Estonia	5.0			0.1
Finland	21.7			2.7
France	21.7	0.70		3.8
Germany	20.6	0.62	0.68	2.6
Greece	17.5			4.5
Hungary	19.2			3.2
Iceland	46.0			3.3
Ireland	11.9			1.0
Italy	22.5	0.55	0.68	2.6
Japan	33.2	0.73	0.75	1.5
Latvia	13.1			0.2
Liechtenstein	15.7			1.5
Lithuania	22.2			8.7
Luxembourg	26.2			0.4
Monaco	0.3			0.3
Netherlands	20.1	0.77		4.3
New Zealand	12.4			1.0
Norway	26.4			6.4
Poland	16.2			1.9
Portugal	21.5			1.2
Romania	28.2			2.4
Russian Federation	16.3			1.6
Slovakia	38.4			2.1
Slovenia	17.6			1.0
Spain	25.1		0.65	1.6
Sweden	26.3			2.3
Switzerland	17.2			2.0
Turkey	31.4			1.4
Ukraine	33.6			0.7
United Kingdom	17.7	0.71		2.2
United States	16.9	0.50	0.92	2.4
European Community	21.4			2.6
Values for KP Annex I Parties				
Average	22.2			2.1
High	46.0	0.77	0.82	8.7
Low	0.3	0.55	0.65	0.1

[a] Sum of IPCC source categories 1A2 Manufacturing industries and construction, 2 Industrial processes and 3 Solvents.

[b] The index is derived by dividing the lowest carbon intensity ('best practice') for the product mix of a country by the actual CO_2 emissions of the country. It excludes emissions from electricity use. An index of 1 would denote that the country is applying 100% best practice. A value of 0.8 denotes that only 80% of the emissions would occur, if best practice were applied. Results have to be viewed with caution as data quality and scope may vary between countries.

[c] Includes CO_2 emissions from fuel and electricity uses as well as process emissions for 2003. Results have to be viewed with caution as emissions also depend on product mix and product quality as well as the availability of alternative fuels.

[d] N_2O from adipic and nitric acid production and HFC-23 by-production.

Table 7. Mitigation potential indicators for the transport sector

Party	Share of sector in national GHG emissions 2004 (%)[a]	GHG emissions of sector/capita (t CO_2 eq)[b]	Fuel efficiency of passenger cars (litre/100km)	Personal transport activity (pkm/capita)	Freight transport activity (tkm/capita)[c]	Modal split of passenger transport (%)[d]			Modal split of freight transport (%)[e]			Population density (people/km^2)
						Road	Rail	Domestic air	Road	Rail	Water	
Australia	15.0	4.0										3
Austria	26.0	2.9	7.38	14,119	6,998	84.0	7.0	8.0	66.0	28.0	6.0	99
Belarus	6.0	0.4										47
Belgium	18.0	2.6			6,159				75.0	12.0	13.0	341
Bulgaria	11.0	1.0										70
Canada	25.5	6.1										3
Croatia	18.8	1.2										81
Czech Republic	10.8	1.6										129
Denmark	19.2	2.5										126
Estonia	9.4	1.5										30
Finland	17.3	2.7		13,980	7,875	93.7	4.6	1.8	68.5	24.5	7.0	16
France	26.1	2.4	7.17	14,405	4,495	90.0	8.6	1.5	80.7	16.7	2.7	111
Germany	17.0	2.1	8.11	12,609	6,419	92.1	7.0	0.9	71.7	16.3	12.0	232
Greece	16.2	2.0										84
Hungary	12.6	1.0										108
Iceland	22.8	2.4										3
Ireland	18.4	3.1	6.92		4,442				95.6	2.2	2.2	59
Italy	22.8	2.3		14,736	3,796	93.3	5.3	1.4	89.4	10.6	0.0	159
Japan	19.1	2.0										338
Latvia	27.0	1.2										36
Liechtenstein	31.7	2.5										216
Lithuania	19.6	1.2										52
Luxembourg	57.1	15.8										177
Monaco	34.4	1.0										21,812
Netherlands	16.2	2.2	8.04		8,119				26.1	39.7	34.2	393
New Zealand	19.1	3.6										15
Norway	26.2	3.1	7.46	13,926	7,190	88.9	4.8	6.3	45.3	6.1	48.6	12
Poland	9.0	0.9										118
Portugal	23.7	1.9			4,251				91.9	5.8	2.3	114
Romania	11.0	0.8										91
Russian Federation	10.5	1.5										8
Slovakia	11.1	1.1										110
Slovenia	21.2	2.2										99
Spain	23.8	2.4	7.59		9,054				86.5	3.1	10.4	86
Sweden	28.7	2.2										20
Switzerland	29.4	2.2										180
Turkey	14.0	0.6										93
Ukraine	9.1	0.8										78
United Kingdom	20.2	2.3	7.52	13,245	4,173	92.3	6.5	1.2	64.5	8.5	27.1	248
United States	26.5	6.3										31
European Community	19.0	2.0										
Values for KP Annex I Parties												
Average	17.3	1.9										
High	57.1	15.8										21,812
Low	5.9	0.4										3

[a] Refers to domestic transport only.

[b] Refers to domestic transport only.

[c] Value for Netherlands corrected (*0.01).

[d] Calculated based on passenger kilometres per transportation type.

[e] Calculation based on tonne kilometres per transportation type.

Table 8. Mitigation potential indicators for the households and services sector

Party	Share of sector in national GHG emissions 2004 (%)[a]	GHG emissions of sector/capita (t CO_2 eq)[b]	Electricity use/capita (kWh/capita)	Heating degree days[c]	Cooling degree days[d]
Australia	4	1.0	5,102	828	839
Austria	16	1.8	3,891	3,446	173
Belarus	11	0.9	901	4,299	88
Belgium	22	3.1	3,647	3,009	102
Bulgaria	3	0.2	1,958	2,624	430
Canada	11	2.6	8,835	4,493	171
Croatia	14	0.9	2,023	2,289	418
Czech Republic	11	1.5	2,650	3,569	108
Denmark	11	1.4	3,769	3,621	40
Estonia	3	0.5	2,421	4,605	38
Finland	10	1.5	6,699	5,212	48
France	20	1.8	4,203	2,478	241
Germany	17	2.1	3,067	3,252	122
Greece	11	1.3	2,831	1,269	923
Hungary	23	1.9	1,947	3,057	256
Iceland	24	2.6	4,779	5,031	40
Ireland	16	2.7	3,777	2,977	19
Italy	15	1.5	2,282	1,838	600
Japan	14	1.5	4,138	1,901	896
Latvia	15	0.7	1,414	4,237	58
Liechtenstein	42	3.4			
Lithuania	7	0.4	1,246	4,218	68
Luxembourg	10	2.9	4,053	3,467	99
Monaco	36	1.1			
Netherlands	19	2.5	3,342	3,035	68
New Zealand	5	0.9	4,748	1,609	165
Norway	8	0.9	11,021	4,535	43
Poland	14	1.4	1,283	3,719	100
Portugal	9	0.7	2,397	1,367	345
Romania	8	0.6	596	3,157	290
Russian Federation	9	1.2	1,448	5,235	197
Slovakia	13	1.2	1,845	3,498	158
Slovenia	14	1.4	2,370	3,290	189
Spain	9	0.9	2,614	1,431	702
Sweden	9	0.7	7,700	4,375	45
Switzerland	35	2.6	4,534	3,419	137
Turkey	14	0.6	724	2,048	641
Ukraine	11	0.9	851	3,752	224
United Kingdom	18	2.0	3,547	2,810	66
United States	12	2.9	8,119	2,159	882
European Community	15	1.6	2,947		
Values for KP Annex I Parties					
Average	13	1.4	2,838		
High	42	3.4	11,021	5,235	923
Low	3	0.2	596	1,269	19

[a] Sum of IPCC source categories 1A4 (other sectors) and 1A5 (other). Indirect emissions from electricity use or district heating are not included. Result therefore shows only an incomplete picture.

[b] As above excludes emissions from electricity use and district heating. Result therefore shows only an incomplete picture.

[c] Calculated for a period of 365 days for mean temperatures below 15°C.

[d] Calculated for a period of 365 for mean temperature above 25°C.

Table 9. Mitigation potential indicators for the Agriculture sector (non-carbon dioxide)

Party	**Share of sector in national GHG emissions 2004 (%)**	**GHG emissions of sector/capita (t CO_2 eq)**	**GHG emission of sector/GDP PPP of agricultural sector (tCO_2 eq/USD 1,000)**
Australia	17	4.5	4.8
Austria	9	1.0	1.7
Belarus	17	1.3	1.9
Belgium	8	1.1	3.8
Bulgaria	8	0.7	0.8
Canada	7	1.7	
Croatia	12	0.8	1.0
Czech Republic	5	0.8	1.3
Denmark	14	1.8	3.3
Estonia	6	0.9	1.5
Finland	7	1.1	1.2
France	17	1.6	2.4
Germany	6	0.8	2.7
Greece	9	1.1	0.9
Hungary	13	1.1	1.9
Iceland	16	1.7	0.8
Ireland	28	4.7	5.3
Italy	6	0.7	1.0
Japan	2	0.2	0.5
Latvia	17	0.8	1.7
Liechtenstein	8	0.7	
Lithuania	18	1.1	1.5
Luxembourg	3	0.8	2.4
Monaco			
Netherlands	8	1.1	1.8
New Zealand	50	9.4	
Norway	8	0.9	1.7
Poland	9	0.9	1.5
Portugal	10	0.8	1.3
Romania	9	0.6	0.6
Russian Federation	7	1.0	2.1
Slovakia	8	0.7	1.5
Slovenia	10	1.0	1.9
Spain	11	1.1	1.4
Sweden	12	1.0	2.0
Switzerland	10	0.7	
Turkey	5	0.2	0.2
Ukraine	7	0.6	0.9
United Kingdom	7	0.8	2.6
United States	6	1.5	3.1
European Community	9	1.0	
Values for KP Annex I Parties			
Average	8	0.9	
High	50	9.4	5.3
Low	2	0.2	0.2

Table 10. Mitigation potential indicators for the waste sector

Party	**Share of sector in national GHG emissions 2004 (%)**	**GHG emissions of sector/ capita (t CO_2 eq)**	**Percentage of methane recovered (%)**	**Municipal waste per capita (kg)[a]**	**Percentage of waste incinerated (%)**	**Percentage of waste landfilled (%)**
Australia	3.6	0.96	15.9	450		69.7
Austria	2.8	0.31	17.0	560	21.1	6.8
Belarus	6.0	0.45				
Belgium	1.1	0.16	47.0	460	34.3	11.6
Bulgaria	8.8	0.76				
Canada	3.8	0.90	19.0	420		
Croatia	2.2	0.14				
Czech Republic	1.9	0.28	16.0	290	14.0	79.8
Denmark	2.0	0.26	17.0	740	54.0	5.1
Estonia	2.5	0.41	7.0			
Finland	3.2	0.50	21.0	470	9.9	59.9
France	2.6	0.24	56.0	540	33.8	36.0
Germany	1.4	0.18	54.0	600	24.6	17.7
Greece	2.4	0.29	26.0	440		91.9
Hungary	5.6	0.46	2.0	460	5.6	90.4
Iceland	7.0	0.75	16.0	520	8.8	72.1
Ireland	2.7	0.45	34.0	740		66.1
Italy	3.4	0.35	34.0	540	12.1	54.4
Japan	3.5	0.37	0.2	400	74.0	3.4
Latvia	7.3	0.34	9.0			
Liechtenstein	0.7	0.05				
Lithuania	7.2	0.42				
Luxembourg	0.6	0.17	22.0	710	38.9	19.0
Monaco	1.1	0.03				
Netherlands	3.3	0.45	14.0	620	32.3	1.7
NewZealand	2.5	0.46	39.0	400		84.7
Norway	2.9	0.35	23.0	760	24.7	25.9
Poland	2.8	0.28		250	0.5	92.2
Portugal	9.4	0.76	19.0	470	21.1	64.1
Romania	5.5	0.39				
RussianFederation	3.2	0.45				
Slovakia	4.1	0.39		270	12.5	77.9
Slovenia	3.2	0.33	21.0			
Spain	2.8	0.28	16.0	650	6.7	51.7
Sweden	3.4	0.26	23.0	480	50.2	4.8
Switzerland	1.4	0.10	40.0	650	49.8	0.5
Turkey	9.4	0.38		440		97.8
Ukraine	2.1	0.19				
UnitedKingdom	3.4	0.38	72.0	580	8.4	64.3
UnitedStates	2.7	0.66	44.0	750	13.6	54.3
European Community	2.9	0.31				
Values for KP Annex I Parties						
Average	3.3	0.36				
High	9.4	0.90	72.0	760	74.0	97.8
Low	0.6	0.03	0.2	250	0.5	0.5

[a] Values for Australia, Canada and New Zealand cover household waste only.

Table 11. Mitigation potential indicators for the land use, land-use change and forestry sector

Party	**Share of sector compared with national GHG emissions in 2004 (%)**	**Net GHG emissions or removals of sector/capita (t CO_2 eq)**	**Forest area (km^2)[a]**	**Forest area as percentage of land area (%)**	**Net CO_2 emissions or removals per forested area (t CO_2/km^2)[b]**	**Net CO_2 emissions/ removals from soils per agricultural area (t CO_2/km^2)[c]**
Australia	0.8	0.2	167,836	2.2	-314	321
Austria	-18.2	-2.0	33,764	41.0	-505	6
Belarus	-16.0	-1.2	79,667	38.4	-264	
Belgium	-0.8	-0.1	6,210	20.5	-467	126
Bulgaria	-32.7	-2.8	40,636	37.4	-196	-220
Canada	10.7	2.5	2,551,313	28.1	20	
Croatia	-55.5	-3.6	20,896	37.4	-781	
Czech Republic	-3.3	-0.5	25,911	33.5	-217	-1
Denmark	-3.3	-0.4	4,684	11.0	-736	45
Estonia	-37.6	-6.0	21,128	49.8	-378	
Finland	-22.7	-3.5	224,877	73.8	-116	264
France	-9.2	-0.9	156,846	28.5	-434	28
Germany	-3.5	-0.4	108,402	31.1	-724	221
Greece	-3.9	-0.5	65,561	50.9	-65	
Hungary	-6.6	-0.5	17,703	19.8	-277	
Iceland	59.5	6.3	524	0.5	-230	46
Ireland	-0.1	0.0	5,224	7.6	-128	14
Italy	-18.0	-1.8	127,680	43.4	-725	
Japan	-7.0	-0.7	249,507	68.5	-376	-26
Latvia	-129.4	-6.0	29,303	47.0	-464	-14
Liechtenstein	-13.4	-1.1	59	36.6	-323	98
Lithuania	21.6	1.3	19,877	31.7	-438	
Luxembourg						
Monaco	0.0	-0.001				
Netherlands	1.1	0.1	4,433	13.1	-552	180
New Zealand	-32.6	-6.1	18,772	7.0	-1359	1
Norway	-47.9	-5.7	94,985	31.2	-300	169
Poland	-6.7	-0.7	91,710	30.1	-397	124
Portugal	-3.2	-0.3	31,210	34.1	-128	1,229
Romania	-22.4	-1.6	67,573	29.4	-513	
Russian Federation	-9.8	-1.4	6,195,041	37.8	-85	
Slovakia	-8.3	-0.8	19,307	40.1	-207	-17
Slovenia	-28.1	-2.9	11,638	57.8	-485	
Spain	-7.1	-0.7	188,572	37.8	-162	
Sweden	-23.6	-1.8	274,285	66.8	-68	39
Switzerland			12,234	30.6	-187	51
Turkey						
Ukraine	-7.8	-0.7	99,740	17.2	-557	63
United Kingdom	-0.3	0.0	24,630	10.2	-662	48
United States	-10.9	-2.6				-12
European Community	-7.8	-0.8	1,601,163	38.3		
Values for KP Annex I Parties						
Average	-7.1	-0.8		33.8		
High	59.5	6.3	6,195,041	73.8	20	1,229
Low	-129.4	-6.1	59	0.5	-1359	-220

[a] Forest area data for Croatia corrected (*0.001).

[b] Net CO_2 emissions and removals from IPCC source category 5.A (forest land) divided by forest area.

[c] Net CO_2 emissions and removals from IPCC source categories 5.B (cropland) and 5.C (grassland) divided by cropland and grassland area.

Table 12. Mitigation potential indicators for international transport

Party	Share of international aviation in national GHG emissions (%)	Share of international navigation in national GHG emissions (%)	GHG emissions of sector/capita (t CO_2 eq)	Share of international aviation in total aviation (%)[a]	Share of international shipping in total shipping (%)[b]
Australia	1.1	0.5	0.4		
Austria	1.7		0.2	88.9	
Belarus	0.4		0.0	97.6	
Belgium	2.6	16.2	2.7	99.7	98.4
Bulgaria	0.6	0.5	0.1	79.6	100.0
Canada	1.3	0.3	0.4	55.2	23.9
Croatia	0.3	0.2	0.0	35.4	43.8
Czech Republic	0.6		0.1	90.7	
Denmark	3.6	3.7	0.9	95.0	83.6
Estonia	0.4	2.2	0.4	97.5	94.6
Finland	1.6	2.1	0.6	79.4	75.5
France	2.8	1.8	0.4	76.0	77.7
Germany	1.8	0.9	0.3	80.0	90.4
Greece	2.3	7.5	1.2	71.7	82.4
Hungary	0.8		0.1	100.0	
Iceland	12.0	7.4	2.1	93.8	92.4
Ireland	3.1	0.7	0.6	95.3	89.6
Italy	1.4	1.1	0.2	75.1	49.2
Japan	1.6	1.3	0.3	65.4	56.7
Latvia	1.4	6.3	0.4	98.4	93.4
Liechtenstein	0.1		0.0	85.0	
Lithuania	0.6	1.8	0.1	98.7	95.1
Luxembourg	10.1		2.8		
Monaco		15.1	0.5		90.9
Netherlands	4.8	21.5	3.5	99.6	98.2
New Zealand	3.4	1.0	0.8	68.2	69.0
Norway	1.6	3.4	0.6	47.2	43.3
Poland	0.2	0.2	0.0	97.5	80.5
Portugal	2.8	2.2	0.4	85.5	89.7
Romania					
Russian Federation				63.8	84.8
Slovakia	0.3		0.0	42.8	
Slovenia	0.3		0.0	97.0	
Spain	2.2	5.4	0.8	62.0	90.4
Sweden	2.6	9.5	0.9	72.6	91.8
Switzerland	6.5		0.5	96.0	
Turkey					
Ukraine		0.0	0.0		42.0
United Kingdom	5.0	0.9	0.7	93.5	61.1
United States	0.9	0.5	0.3	27.6	41.7
European Community	2.3	2.9	0.6		
Values for KP Annex I Parties					
Average	1.5	1.7	0.4		
High	12.0	21.5	3.5	100.0	100.0
Low	0.1	0.0	0.0	35.4	23.9

[a] Share reported by Parties in national GHG inventories.

[b] Share reported by Parties in national GHG inventories.

Table 13. Key mitigation technologies and practices by sector

Sector	**Key mitigation technologies and practices commercially available**	**Key mitigation technologies and practices projected to be commercialized before 2030**
Energy supply	Improved supply and distribution efficiency; fuel switching from coal to gas; nuclear power; renewable heat and power (hydropower, solar, wind, geothermal and bioenergy); combined heat and power; early applications of CCS (e.g. storage of removed CO_2 from natural gas)	CCS for gas, biomass and coal-fired electricity generating facilities; advanced nuclear power; advanced renewable energy, including tidal and wave power, concentrating solar and solar PV
Transport	More fuel efficient vehicles; hybrid vehicles; cleaner diesel vehicles; biofuels; modal shifts from road transport to rail and public transport systems; non-motorized transport (e.g. cycling and walking); land-use and transport planning	Second generation biofuels; more efficient aircraft; advanced electric and hybrid vehicles with more powerful and reliable batteries
Buildings	Efficient lighting and daylighting; more efficient electrical appliances and heating and cooling devices; more efficient cooking stoves, improved insulation; passive and active solar design for heating and cooling; alternative refrigeration fluids and recovery and recycle of fluorinated gases	Integrated design of commercial buildings including technologies such as intelligent meters that provide feedback and control; solar PV integrated in buildings
Industry	More efficient end-use electrical equipment; heat and power recovery; material recycling and substitution; control of non-CO_2 gas emissions; a wide array of process-specific technologies	Advanced energy efficiency; CCS for cement, ammonia and iron manufacture; inert electrodes for aluminium manufacture
Agriculture	Improved crop and grazing land management to increase soil carbon storage; restoration of cultivated peaty soils and degraded lands; improved rice cultivation techniques and livestock and manure management to reduce CH_4 emissions; improved nitrogen fertilizer application techniques to reduce N_2O emissions; dedicated energy crops to replace fossil fuel use; improved energy efficiency	Improvement in crop yields
Forestry/ forests	Afforestation; reforestation; forest management; reduced deforestation; harvested wood product management; use of forestry products for bioenergy to replace fossil fuel use	Tree species improvement to increase biomass productivity and carbon sequestration; improved remote sensing technologies for analysis of vegetation or soil carbon sequestration potential and for mapping land-use change
Waste	Landfill methane recovery; waste incineration with energy recovery; composting of organic waste; controlled waste water treatment; recycling and waste minimization	Biocovers and biofilters to optimize CH_4 oxidation

Source: IPCC. Fourth Assessment Report, Contribution of Working Group III. Table SPM.3.
Note: (1) sectors and technologies are listed in no particular order; (2) non-technological practices such as lifestyle changes that are cross-cutting are not included in this table.

Table 14. Selected sectoral policies, measures and instruments proven to be environmentally effective[a]

Sector	**Policies,**[b] **measures and instruments shown to be environmentally effective**	**Key constraints or opportunities**
Energy supply	Reduction of fossil fuel subsidies	Resistance by vested interests may make them difficult to implement
	Taxes or carbon charges on fossil fuels	
	Feed-in tariffs for renewable energy technologies	May be appropriate to create markets for low emission technologies
	Renewable energy obligations	
	Producer subsidies	
Transport	Mandatory fuel economy, biofuel blending and CO_2 standards for road transport	Partial coverage of vehicle fleet may limit effectiveness
	Taxes on vehicle purchase, registration and use, and on motor fuels; road and parking pricing	Effectiveness may drop with higher incomes
	Influence mobility needs through land-use regulations and infrastructure planning	Particularly appropriate for countries that are building up their transportation systems
	Investment in attractive public transport facilities and non-motorized forms of transport	
Buildings	Appliance standards and labelling	Periodic revision of standards needed
	Building codes and certification	Attractive for new buildings. Enforcement can be difficult
	Demand-side management programmes	Need for regulations so that utilities may profit
	Public sector leadership programmes, including procurement	Government purchasing can expand demand for energy-efficient products
	Incentives for energy service companies	Success factor: access to third party financing
Industry	Provision of benchmark information	May be appropriate to stimulate technology uptake. Stability of national policy important in view of international competitiveness
	Performance standards	
	Subsidies and tax credits	
	Tradable permits	Predictable allocation mechanisms and stable price signals important for investments
	Voluntary agreements	Success factors include: clear targets, a baseline scenario, third party involvement in design and review, formal provisions of monitoring and close cooperation between government and industry.
Agriculture	Financial incentives and regulations for improved land management, soil carbon content maintenance and efficient use of fertilizers and irrigation	May encourage synergy with sustainable development goals and with reducing vulnerability to climate change, thereby overcoming barriers to implementation
Forestry/ Forests	Financial incentives (national and international) to increase forest area, reduce deforestation, and maintain and manage forests	Constraints include lack of investment capital and land tenure issues. Can help poverty alleviation
	Land-use regulation and enforcement	
Waste management	Financial incentives for improved waste and wastewater management	May stimulate technology diffusion
	Renewable energy incentives or obligations	Local availability of low-cost fuel
	Waste management regulations	Most effectively applied at national level with enforcement strategies

Source: IPCC. Fourth Assessment Report, Contribution of Working Group III. Table SPM.7.

[a] Policies, measures and instruments have been shown to be environmentally effective in national tests or applications.

[b] Public RD&D investment in low emission technologies has proven to be effective in all sectors.

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