GREENHOUSE GAS–AIR POLLUTION INTERACTIONS AND SYNERGIES

GAINS

POTENTIALS AND COSTS FOR GREENHOUSE GAS MITIGATION IN ANNEX 1 COUNTRIES

INITIAL RESULTS

Markus Amann, Imrich Bertok, Jens Borken, Janusz Cofala, Chris Heyes, Lena Hoglund, Zbigniew Klimont, Pallav Purohit, Peter Rafaj, Wolfgang Schöpp, Geza Toth, Fabian Wagner, Wilfried Winiwarter

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INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS
A-2361 LAXENBURG, AUSTRIA http://gains.iiasa.ac.at

This report presents initial results of a comparison of mitigation efforts across Annex 1 Parties.

The following additional information sources are available at http://gains.iiasa.ac.at/Annex1.html:

- An interactive **GAINS GHG mitigation efforts calculator** that allows online-comparison of mitigation efforts across Annex 1 Parties. Free access is provided at http://gains.iiasa.ac.at/MEC.
- Access to all input data employed for the calculations for all countries via the on-line version of the GAINS model at http://gains.iiasa.ac.at/Annex1.html.

The following reports document specific methodology details:

- GHG mitigation potentials and costs from energy use and industrial sources in Annex 1 countries. J. Cofala, P. Purohit, P.Rafaj. Z. Klimont, 2008
- GHG mitigation potentials and costs in the transport sector of Annex 1 countries. J. Borken-Kleefeld *et al.,* 2008
- GHG mitigation potentials and costs from land-use, land-use changes and forestry (LULUCF) in Annex 1 countries. H. Böttcher *et al.*, 2008
- Potentials and costs for mitigation of non-CO_2 greenhouse gases in Annex 1 countries. L. Höglund-Isaksson et al., 2008

Further information:

Markus Amann
Atmospheric Pollution and Economic Development Programme
International Institute for
Applied Systems Analysis (IIASA)
Schlossplatz 1
A-2361 Laxenburg
Austria

Tel: +43 2236 807 432
Email: amann@iiasa.ac.at
Web: http://gains.iiasa.ac.at

Executive summary

Mitigation efforts and investments over the next two to three decades are critical for the further development of greenhouse gas emissions. Opportunities exist to achieve lower stabilisation levels of greenhouse gases. However, it will be a formidable challenge to negotiating Parties to arrive at a generally accepted scheme for sharing efforts among Annex 1 countries that achieves the necessary emission reductions.

This report presents first results of a comparison of greenhouse gas mitigation potentials and costs for Annex 1 countries.

In this report the International Institute for Applied Systems Analysis (IIASA) presents first results of a coherent international comparison of greenhouse gas mitigation efforts among Annex 1 Parties in 2020. In brief, the methodology (i) adopts exogenous projections of future economic activities as a starting point, (ii) develops a corresponding baseline projection of greenhouse gas emissions for 2020 with information derived from the national GHG inventories that have been reported by Parties to the UNFCCC for 2005, (iii) estimates, with a bottom-up approach, for each economic sector in each country the potential emission reductions that could be achieved through application of the available mitigation measures, and (iv) quantifies the associated costs required for these measures under the specific national conditions. The approach includes all six gases that are included in the Kyoto protocol (i.e., CO_2, CH_4, N_2O, HFCs, PFCs, SF_6) and covers all anthropogenic sources that are included in the emission reporting of Annex 1 countries to UNFCCC (i.e., Energy, Industrial Processes, Agriculture, Waste, and from LULUCF). In addition, the analysis quantifies the implications of GHG mitigation strategies on air pollution.

Under the adopted assumptions, a technical mitigation potential of approximately 24 percent (4.5 Gt CO_2) in relation to 1990 is estimated. The economic potential, e.g., for a carbon price of €100 /t CO_2eq (as calculated with a four percent interest rate) is estimated at an 18 percent GHG reduction compared to 1990 (Figure 4.2). The market potential for the same carbon price amounts at 13 percent reduction compared to 1990 (Figure 4.1). It is noteworthy that, because of measures with negative costs, total costs to the economy turn positive beyond a three percent GHG reduction compared to 1990 for the 20 percent interest rate, and a 15 percent reduction for the interest rate of four percent.

A GAINS GHG mitigation target calculator (http://gains.iiasa.ac.at/MEC) allows an interactive comparison of mitigation potentials and costs via the Internet.

About the authors

The work was carried out by IIASA scientists working at the Atmospheric Pollution and Economic Development programme (led by Markus Amann) and IIASA's Forestry programme (coordinated by Michael Obersteiner). Team members include Imrich Bertok, Jens Borken, Janusz Cofala, Chris Heyes, Lena Hoglund, Zbigniew Klimont, Pallav Purohit, Peter Rafaj, Wolfgang Schöpp, Geza Toth, Fabian Wagner and Wilfried Winiwarter, all working at IIASA's Atmospheric Pollution and Economic Development programme, and Hannes Boettcher, Florian Kraxner from IIASA's Forestry programme.

Acknowledgements

The authors want to express their gratitude to the International Institute for Applied Systems Analysis (IIASA) for providing financial resources that enabled development of the methodology and an initial implementation for 36 Annex 1 Parties.

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Furthermore, the authors acknowledge the constructive support received from the International Energy Agency through Fatih Birol by providing early access to the World Energy Outlook 2008.

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1 Introduction

Climate change impacts can be reduced, delayed or avoided by mitigation of greenhouse gases (GHGs). Mitigation efforts and investments over the next two to three decades will have a large impact on opportunities to achieve lower stabilisation levels. Delayed emission reductions significantly constrain the opportunities to achieve lower stabilisation levels and increase the risk of more severe climate change impacts (IPCC, 2007). While stabilization of GHG concentrations can only be achieved through the participation of developing countries in coordinated mitigation action in the medium to longer time frame, there is an immediate urgency to reduce emissions from industrialized countries. In particular, the Bali Action Plan refers to cuts in the emissions of Annex 1 Parties between 25 and 40 percent in 2020 compared to 1990 if greenhouse gas concentrations are to stabilize at 450 ppb (UNFCCC, 2007).

Given this overall target, it will be a formidable challenge to negotiating Parties to arrive at a generally accepted scheme for sharing efforts among Annex 1 Parties that achieves the indicated emission reductions within the coming decade. Not only must negotiators understand the numerous mitigation measures, their costs, and their impacts on GHG emissions; but the negotiators must forge a politically acceptable agreement to each of the 40 Annex 1 countries.

Building on IIASA's expertise in helping negotiators agree on international environmental treaties, IIASA has developed a scientific tool to support the current negotiations. Known as GAINS (Greenhouse gas – Air pollution Interactions and Synergies), the tool not only helps negotiators identify the most cost effective way to reduce GHG emissions, but also allows negotiators to compare mitigation efforts among Parties. This is crucial for demonstrating the perceived fairness of a negotiated agreement and therefore its political acceptability.

In developing such a tool, IIASA's researchers have had to meet a range of challenges including:

- the large number of available mitigation measures for multiple gases, in different economic sectors and many countries and their numerous interactions that requires an integrated systems perspective,
- the fact that the assessment needs to be carried out for a future target year (e.g., 2020), and that the baseline transition from today's situation until then will involve numerous dynamic changes that are influenced by a wide range of exogenous factors,
- the limited practical experience in the technical, institutional and economic performances of many mitigation measures, and
- the fact that many mitigation measures involve significant changes in the current infrastructures of energy systems, industry and the housing sector, as well as changes in the personal behaviour of people, with important positive or negative side-effects on a wide range of other, non-climate related aspects (such as energy security, competitiveness, employment, air pollution, agricultural policies, time budgets, etc.).

In this report the International Institute for Applied Systems Analysis (IIASA) presents an approach that aims at a coherent international comparison of greenhouse gas mitigation efforts among Annex 1 Parties in 2020. The scientific assessment has been facilitated by:

- IIASA's ample experience in systems analysis that brings together researchers from different disciplines to work in an interdisciplinary setting on policy-relevant topics. The systems perspective enables a comprehensive international comparison of mitigation efforts and an impartial assessment and quantification of the factors that lead to objective differences between countries.
- IIASA's neutrality, stemming from its international constituency and funding by non-governmental scientific organizations from 18 countries in Europe, North America, Asia, and Africa.
- IIASA's past experience in identifying cost-effective strategies to control air pollution and GHG emissions in Europe and Asia.

GAINS estimates emission reduction potentials and costs for a range of greenhouse gases and air pollutants and quantifies the resulting impacts on air quality and total greenhouse gas emissions considering the physical and economic interactions between different control measures. As a principle, the analysis employs only such input data that are available in the public domain and that appear credible and consistent in an international perspective. While the IIASA team collaborated with national experts to validate important input data and assumptions for individual countries, constraints on time and financial resources did not allow for an extensive validation of all input data. As IIASA has ample experience in consulting with national experts on input data to the GAINS model, inter alia in its function as the Centre for Integrated Assessment Modelling of the Convention on Long-range Transboundary Air Pollution, such a consultation process could be organized in the future if required.

In brief, the methodology (i) adopts exogenous projections of future economic activities as a starting point, (ii) develops a corresponding baseline projection of greenhouse gas emissions for 2020 with information derived from the national GHG inventories that have been reported by Parties to the UNFCCC for 2005, (iii) estimates, with a bottom-up approach, for each economic sector in each country the potential emission reductions that could be achieved in 2020 through application of the available mitigation measures, and (iv) quantifies the associated costs that would emerge for these measures under the specific national conditions. The approach includes all six gases that are included in the Kyoto protocol (i.e., CO_2, CH_4, N_2O, HFCs, PFCs, SF_6) and covers all anthropogenic sources that are included in the emission reporting of Annex 1 countries to UNFCCC (i.e., Energy, Industrial Processes, Agriculture, Waste, and from LULUCF).

2 Methodology

To assess mitigation potentials and costs in Annex 1 countries, IIASA has employed an extension of its Greenhouse gas – Air pollution Interactions and Synergies (GAINS) model. The GAINS (and its predecessor, the RAINS) models have been applied before in international negotiations to identify cost-effective air pollution control strategies, and to study the co-benefits between greenhouse gas mitigation and air pollution control in Europe and Asia (Hordijk and Amann, 2007, Tuinstra, 2007).

The GAINS approach provides a framework for a coherent international comparison of the potentials and costs for emission control measures, both for greenhouse gases and air pollutants. It estimates with which measures in which economic sector the emissions of the six greenhouse gases could be reduced to what extent, as well as the costs for such action. It identifies for each country the portfolio of measures that achieves a given reduction target in the most cost-effective way, and provides national cost curves that allow a direct comparison of mitigation potentials and associated costs across countries. Using a bottom-up approach that distinguishes a large set of specific mitigation measures, relevant information can be provided on a sectoral basis, and implied costs can be reported in terms of upfront investments, operating costs and costs (or savings) for fuel input.

Detailed documentation of the methodologies and assumptions that have been employed for the analysis of the various source sectors is available in companion documents (Cofala *et al.*, 2008, Cofala *et al.*, 2008, Borken-Kleefeld *et al.*, 2008, Höglund-Isaksson *et al.*, 2008, Böttcher *et al.*, 2008). Open access to all input data that are used for the assessment is provided through the on-line implementation of the GAINS model. In addition, a GAINS GHG mitigation efforts calculator which allows interactive exploration of mitigation efforts and costs using a range of indicators is freely accessible at http://gains.iiasa.ac.at/MEC.

3 Assumptions

This report presents an initial assessment of greenhouse gas mitigation potentials and costs within the Annex 1 countries in the year 2020. In addition to differences between countries in terms of the current sectoral structure of the sources of greenhouse gas emissions, in the greenhouse gas and energy intensities, and their assumed development over time, results are critically influenced by a number of assumptions. In particular, results presented in this report are derived with the assumptions of

- the economic and energy projections of the World Energy Outlook 2008 of the International Energy Agency (IEA, 2008),
- a private interest rate of 20 percent for annualizing capital investments, and
- that no premature scrapping of capital stock installations that was built before 2010 will take place, i.e., that less GHG emitting capital stock will be implemented at current replacement rates (or existing stock retro-fitted to the technically possible extent.

In addition, a range of other important assumptions is related to the chosen bottom-up methodology for the assessment. For instance, the methodology excludes consideration of possible macro-economic feedbacks, e.g., associated with increased prices for energy, and it neglects the mitigation potential that could result from changes in consumer's behaviour. These assumptions are discussed in more detail in Amann *et al.*, 2008.

4 Initial results

This section provides initial results for 10 (groups of) Annex 1 countries for the year 2020, i.e., for Australia, Canada, EU-25 (excluding Cyprus and Malta), Japan, New Zealand, Norway, Russia, Switzerland, Ukraine and USA. Implementations for the remaining countries are under way. While the analysis for the European Union is carried out for each Member States, initial results presented in this paper refer to the aggregate of 25 countries.

Results in terms of cost curves are presented for the total of the Annex 1 countries that have been analyzed to date, and for individual countries in form of "Data sheets on mitigation potentials" that summarize key features for each country.

Two sets of cost curves are presented: Figure 4.1 and Figure 4.2 display how marginal costs increase along tightened mitigation targets (for a 20 percent and 4 percent interest rate, respectively). Figure 4.3 and Figure 4.4 show curves of total mitigation costs in the Annex 1 countries relative to the costs of the baseline costs. The curves presented in these figures relate only to the mitigations potentials from energy use and industrial activities, but exclude the potential from LULUCF sources.

Overall, a technical mitigation potential of approximately 24 percent (4.5 Gt CO_2) in relation to 1990 is estimated. The economic potential, e.g., for a carbon price of €100 /t CO_2eq (as calculated with a four percent interest rate) is estimated at an 18 percent CO_2 reduction compared to 1990 (Figure 4.2). The market potential for the same carbon price amounts at 13 percent reduction compared to 1990 (Figure 4.1). It is noteworthy that, because of measures with negative costs, total costs to the economy turn positive beyond a three percent GHG reduction compared to 1990 for the 20% interest rate, and a 15 percent reduction for the interest rate of four percent.

Interactive evaluations of these cost curves along other criteria (e.g., comparison to 2005, per-capita emissions, per-capita costs, etc.) can be performed with the interactive Mitigation Efforts Calculator that is freely accessible at http://gains.iiasa.ac.at/MEC.

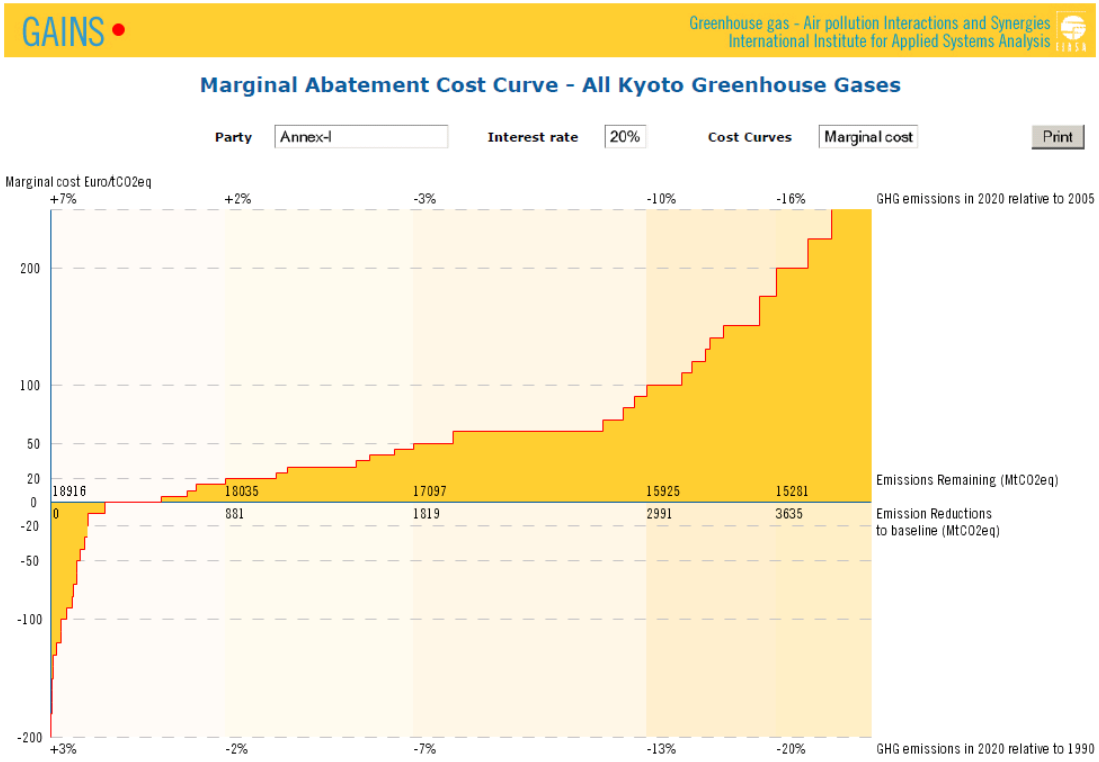

Figure 4.1: Marginal abatement cost curve for the analyzed Annex 1 countries for the year 2020, for a 20 percent interest rate.

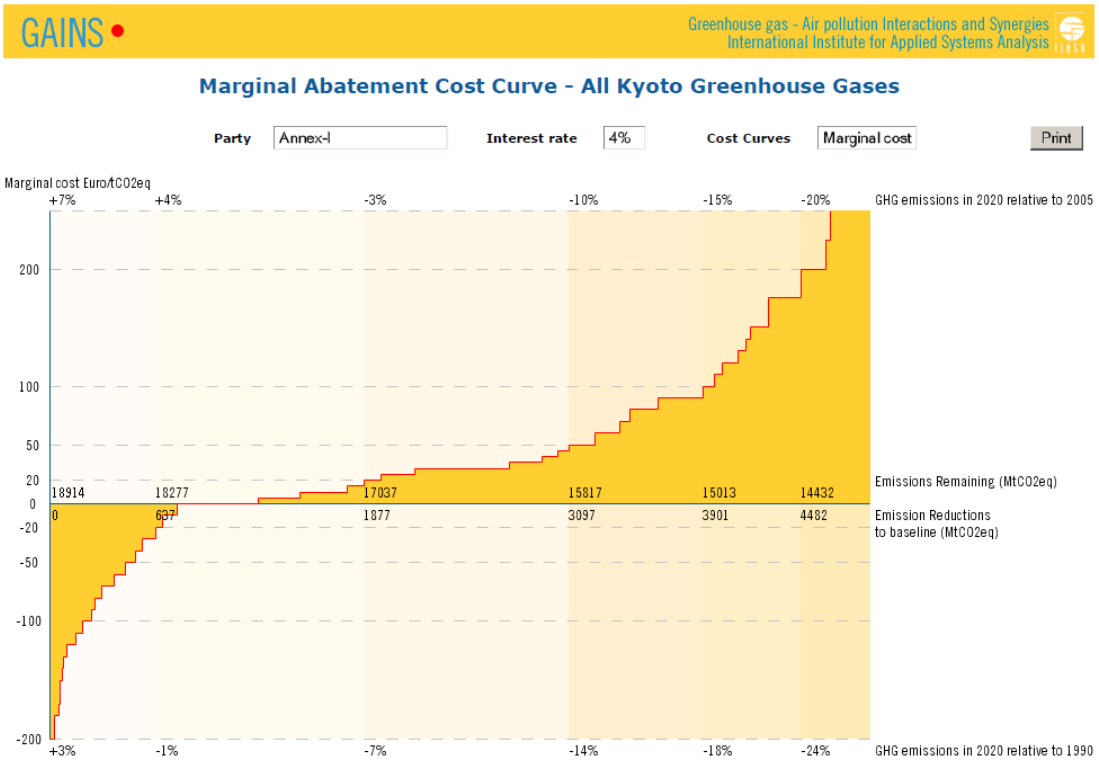

Figure 4.2: Marginal abatement cost curve for the analyzed Annex 1 countries for the year 2020, for a 4 percent interest rate.

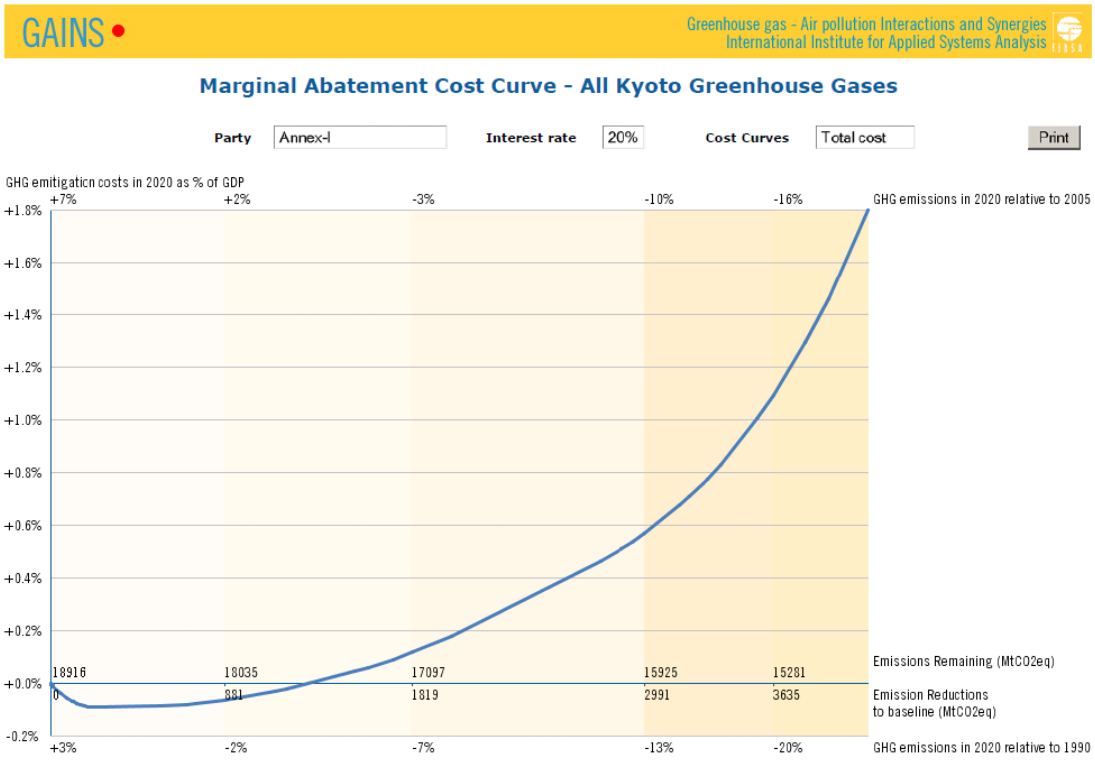

Figure 4.3: Cost curve displaying total mitigation costs relative to the costs of the baseline (as % of GDP) in 2020, for a 20% interest rate

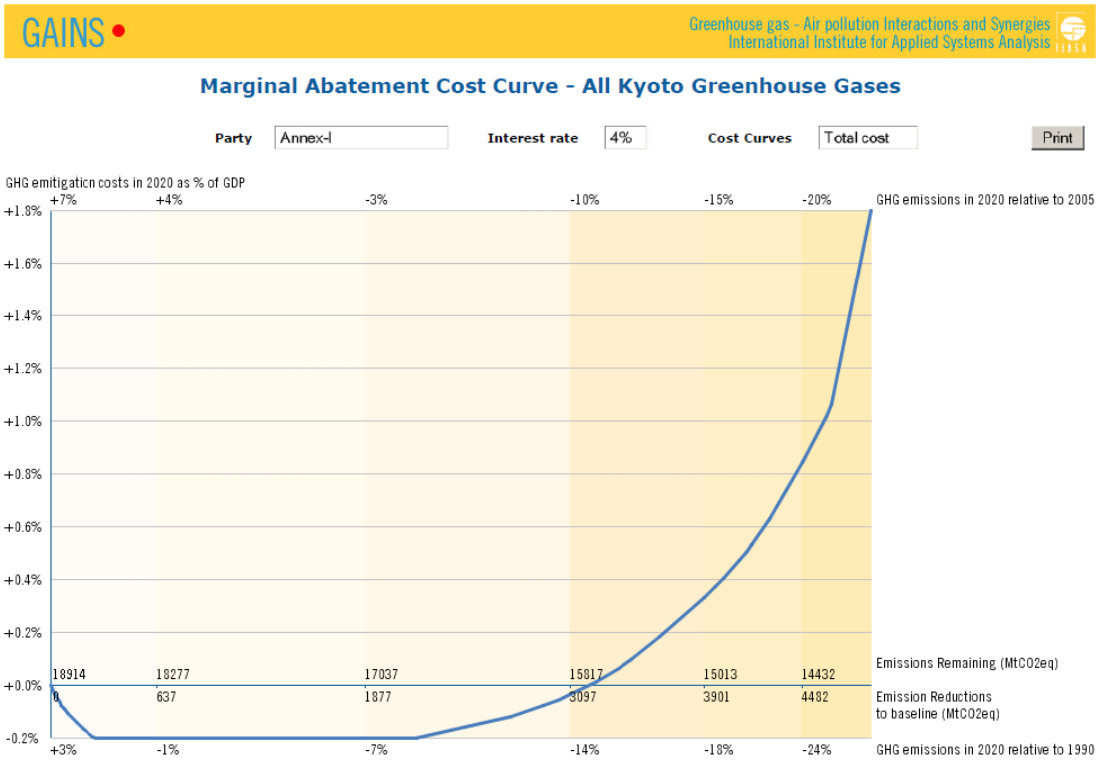

Figure 4.4: Cost curve displaying total mitigation costs relative to the costs of the baseline (as % of GDP) in 2020, for a 4 percent interest rate

5 Data sheets on GHG mitigation potentials and costs

This section presents, for the Annex 1 countries that are analyzed to date, data sheets that summarize key features that determine mitigation potentials and costs.

In particular, each data sheets provides trends from 1990 to 2020 on

- macro-economic drivers, i.e., development of
    - population,
    - gross domestic product GDP (in purchasing power parities PPP),
    - total primary energy consumption,
    - livestock units;
- the resulting baseline projection of greenhouse gases
    - by economic sector,
    - by gas;
- indicators for GHG intensities, in terms of
    - per-capita emissions of greenhouse gases,
    - GHG intensity of industrial GDP,
    - CO_2 emissions per capita from transport,
    - CO_2 emissions per capita from the domestic sector;
- cost curves (for 20% interest rate, excluding the LULUCF sector)
    - marginal costs (carbon prices) in € 2005 (per ton CO_2eq),
    - total mitigation costs in relation to the baseline projection.

These data sheets are available over the Internet at http://gains.iiasa.ac.at/Annex1,html. In addition, this web site provides for each country detailed listings of all mitigation measures that are calculated for each level of carbon prices.

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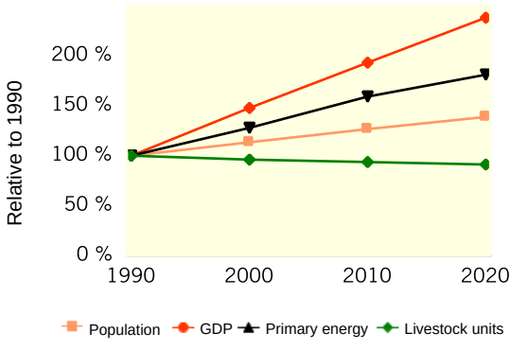
Activity projection: IEA WEO 2008

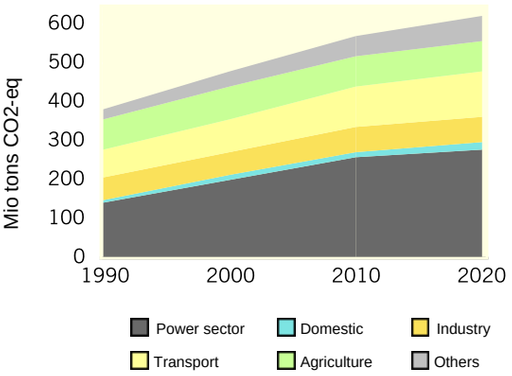
Australia

MACRO-ECONOMIC DRIVERS AND BASELINE GHG EMISSIONS

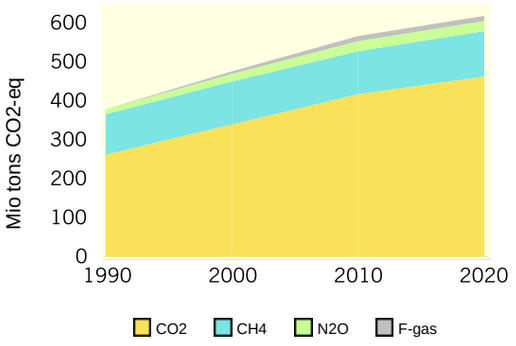
MACRO-ECONOMIC ASSUMPTIONS



GHG EMISSIONS BY SECTOR

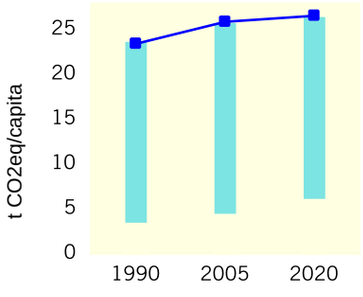


TOTAL GHG EMISSIONS BY GAS

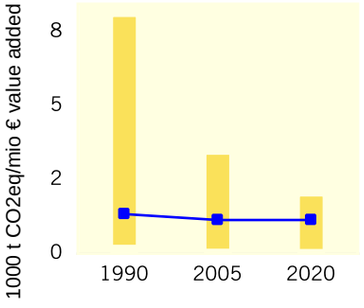


GHG INTENSITIES (bars indicate ranges for Annex 1)

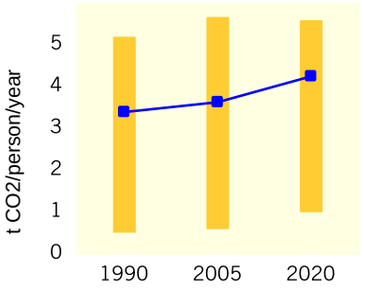
TOTAL GHG EMISSIONS/CAPITA



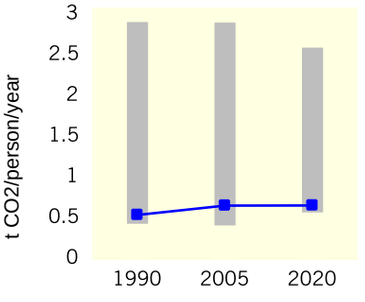
GHG INTENSITY OF INDUSTRIAL GDP



CO2/CAPITA FROM ROAD TRANSPORT

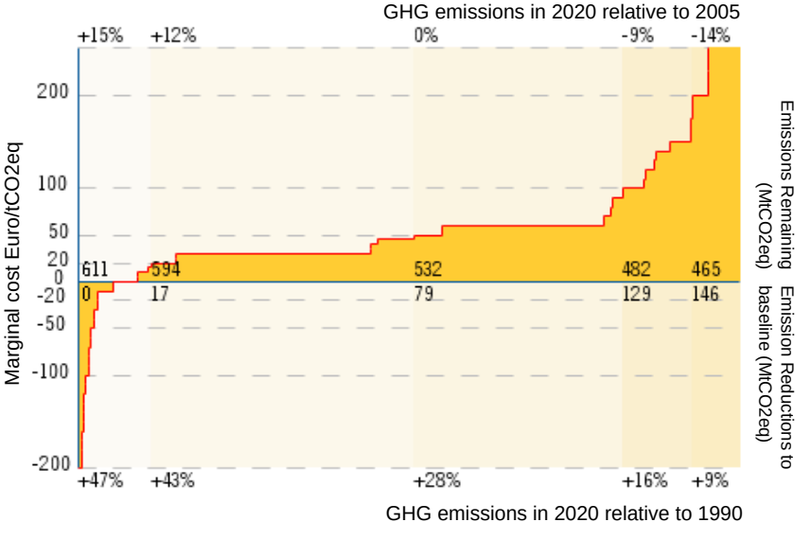


CO2/CAPITA FROM HOUSEHOLDS

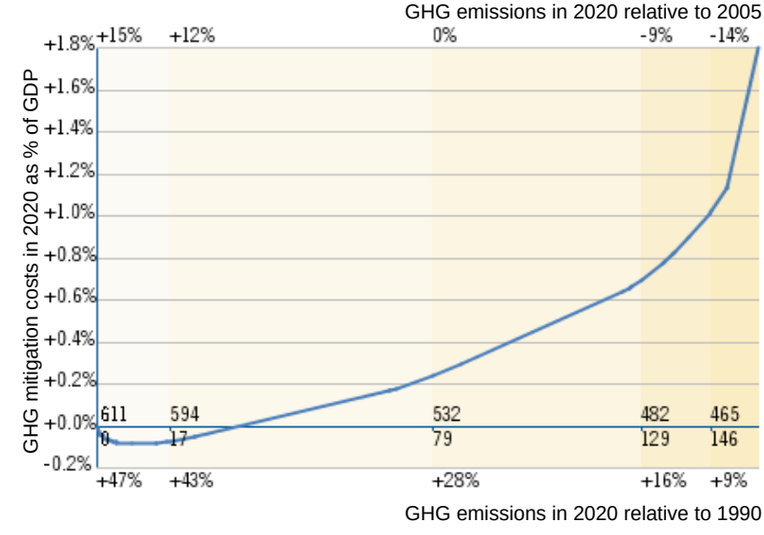


MITIGATION POTENTIALS AND COSTS IN 2020 (for 20% interest rate)

MARGINAL COST CURVE



TOTAL COSTS OF GHG MITIGATION

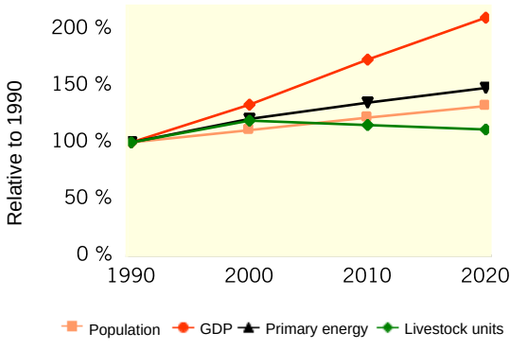


Activity projection: IEA WEO 2008

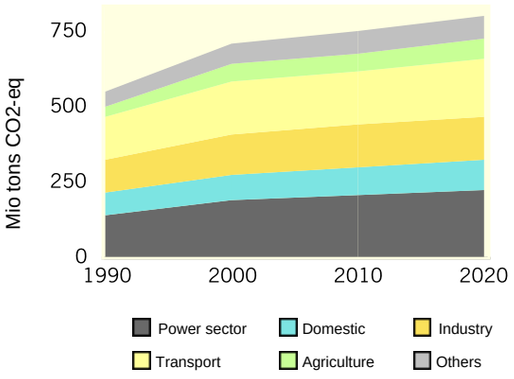
Canada

MACRO-ECONOMIC DRIVERS AND BASELINE GHG EMISSIONS

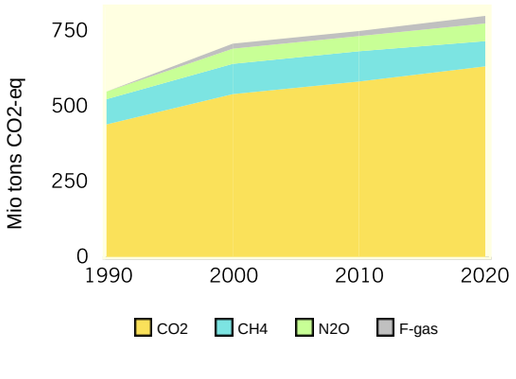
MACRO-ECONOMIC ASSUMPTIONS



GHG EMISSIONS BY SECTOR

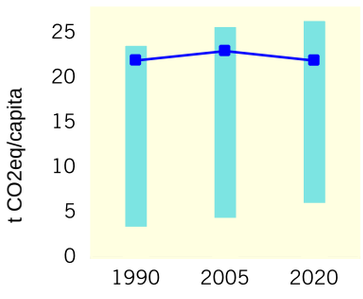


TOTAL GHG EMISSIONS BY GAS

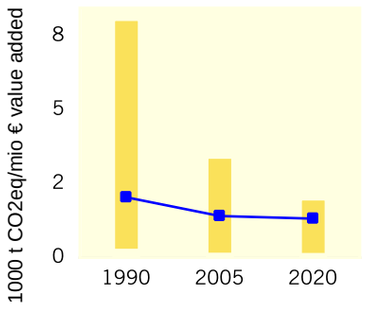


GHG INTENSITIES (bars indicate ranges for Annex 1)

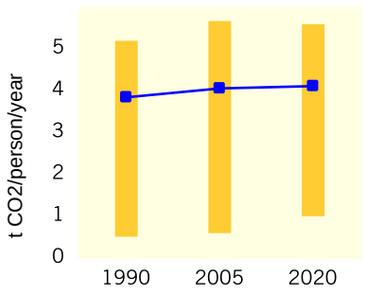
TOTAL GHG EMISSIONS/CAPITA



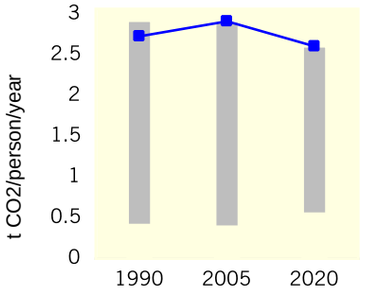
GHG INTENSITY OF INDUSTRIAL GDP



CO2/CAPITA FROM ROAD TRANSPORT

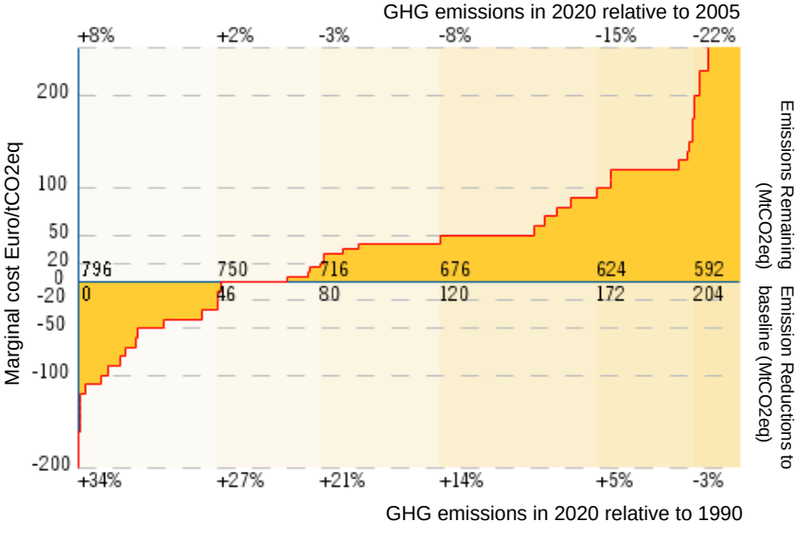


CO2/CAPITA FROM HOUSEHOLDS

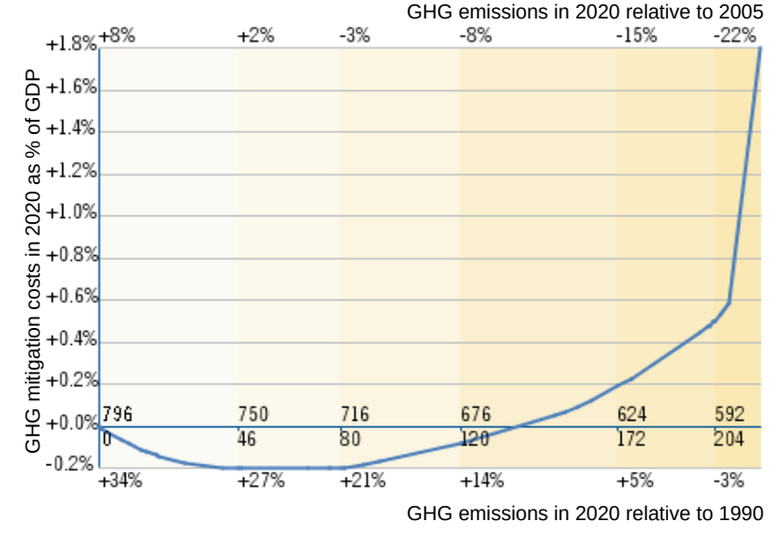


MITIGATION POTENTIALS AND COSTS IN 2020 (for 20% interest rate)

MARGINAL COST CURVE



TOTAL COSTS OF GHG MITIGATION

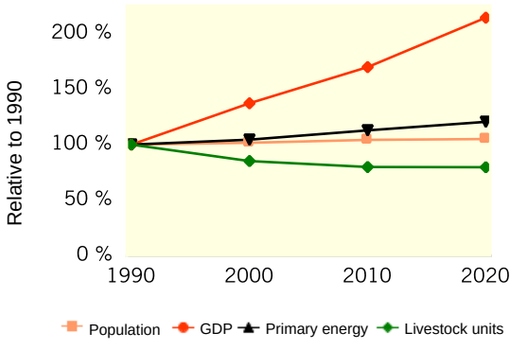


Activity projection: IEA WEO 2008

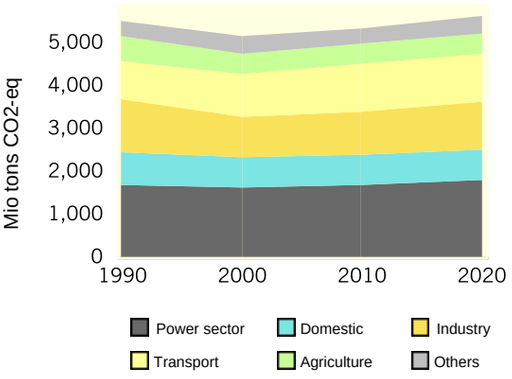
EU 27

MACRO-ECONOMIC DRIVERS AND BASELINE GHG EMISSIONS

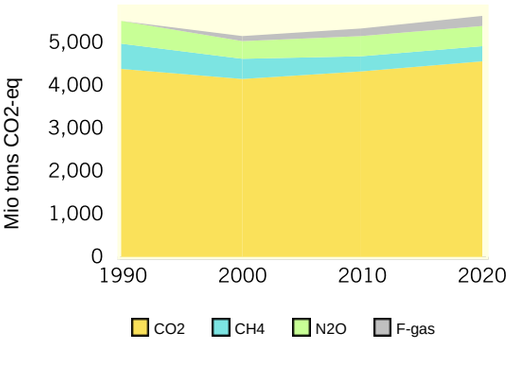
MACRO-ECONOMIC ASSUMPTIONS



GHG EMISSIONS BY SECTOR

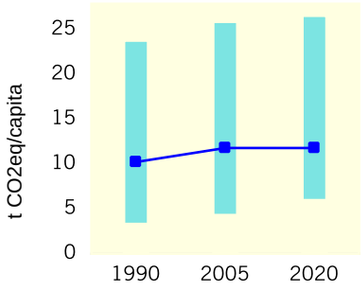


TOTAL GHG EMISSIONS BY GAS

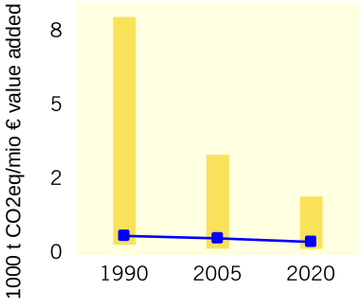


GHG INTENSITIES (bars indicate ranges for Annex 1)

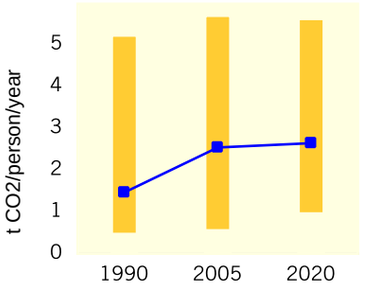
TOTAL GHG EMISSIONS/CAPITA



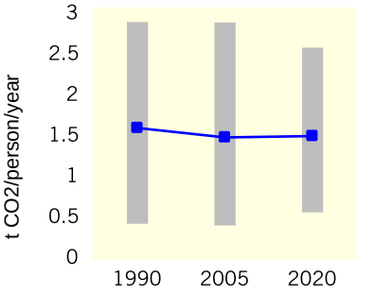
GHG INTENSITY OF INDUSTRIAL GDP



CO2/CAPITA FROM ROAD TRANSPORT

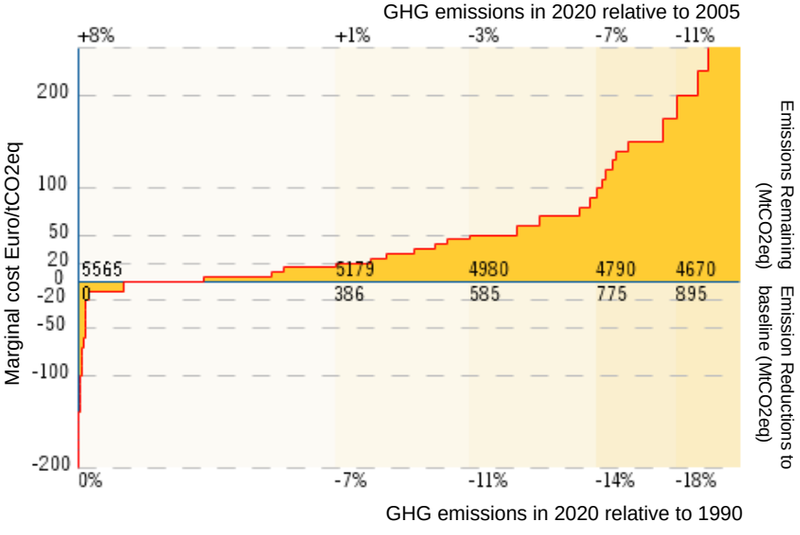


CO2/CAPITA FROM HOUSEHOLDS

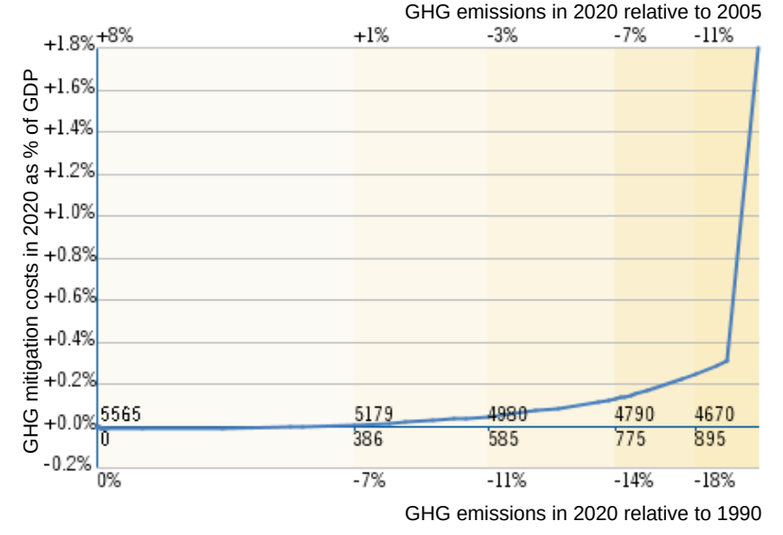


MITIGATION POTENTIALS AND COSTS IN 2020 (for 20% interest rate)

MARGINAL COST CURVE



TOTAL COSTS OF GHG MITIGATION

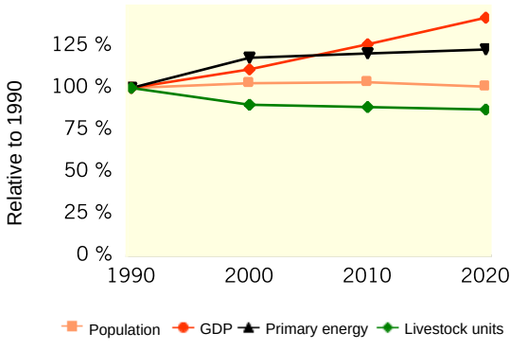


Activity projection: IEA WEO 2008

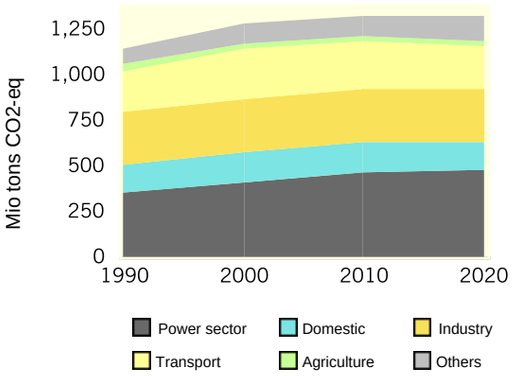
Japan

MACRO-ECONOMIC DRIVERS AND BASELINE GHG EMISSIONS

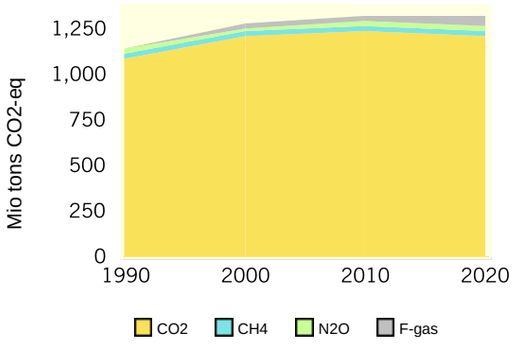
MACRO-ECONOMIC ASSUMPTIONS



GHG EMISSIONS BY SECTOR

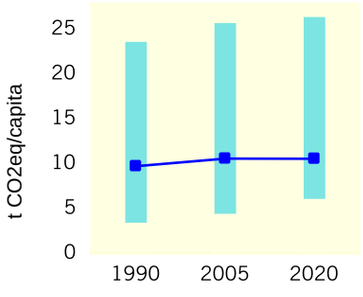


TOTAL GHG EMISSIONS BY GAS

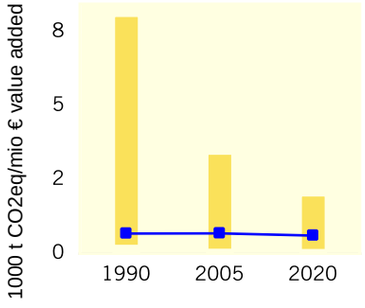


GHG INTENSITIES (bars indicate ranges for Annex 1)

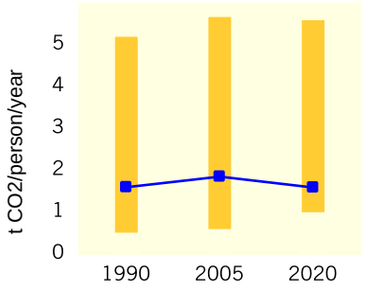
TOTAL GHG EMISSIONS/CAPITA



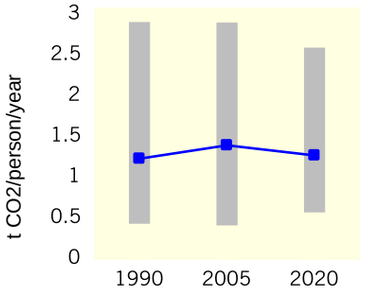
GHG INTENSITY OF INDUSTRIAL GDP



CO2/CAPITA FROM ROAD TRANSPORT

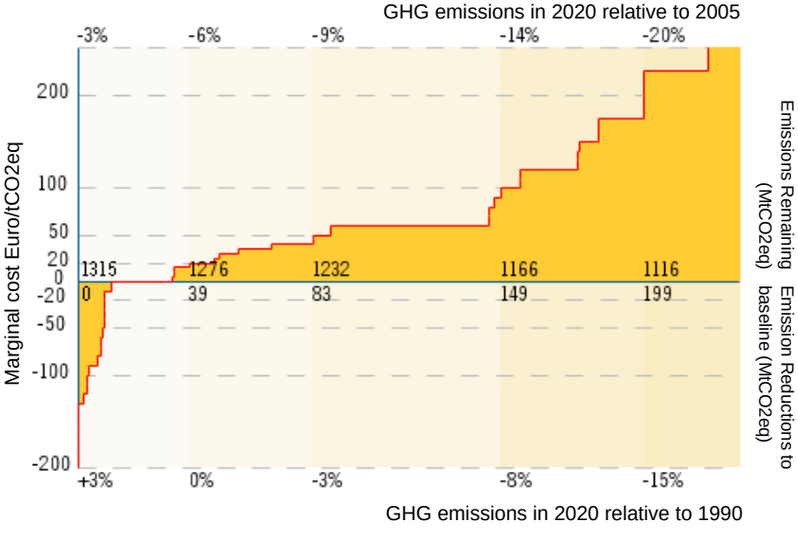


CO2/CAPITA FROM HOUSEHOLDS

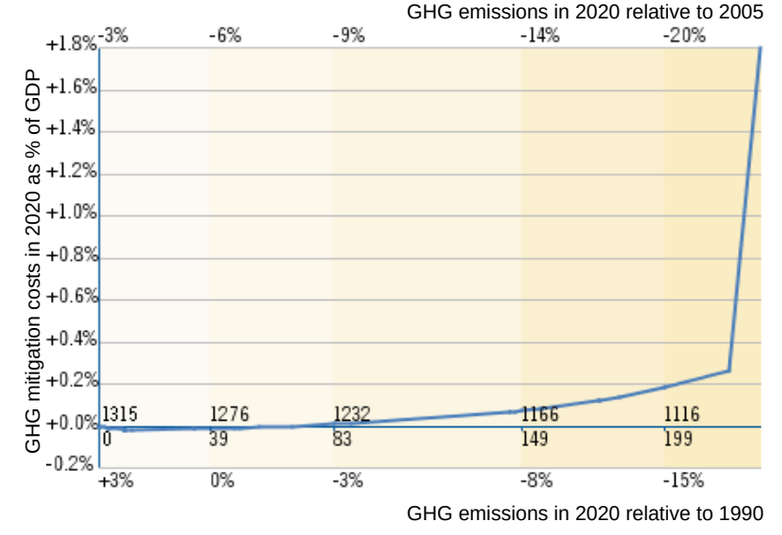


MITIGATION POTENTIALS AND COSTS IN 2020 (for 20% interest rate)

MARGINAL COST CURVE



TOTAL COSTS OF GHG MITIGATION

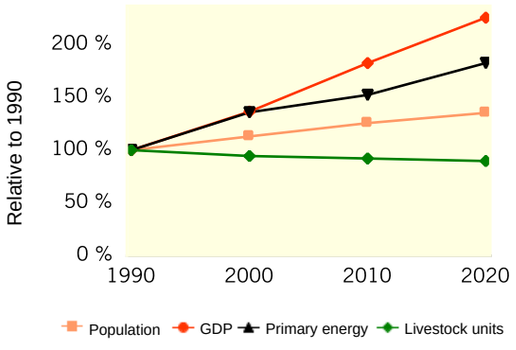


Activity projection: IEA WEO 2008

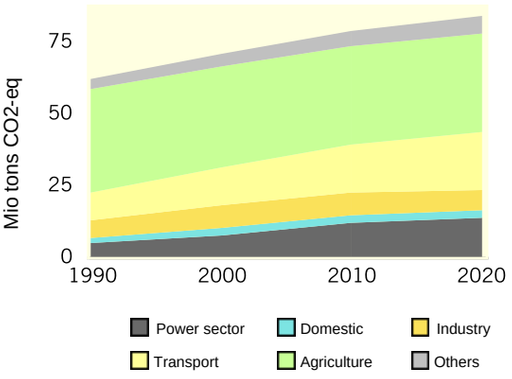
New Zealand

MACRO-ECONOMIC DRIVERS AND BASELINE GHG EMISSIONS

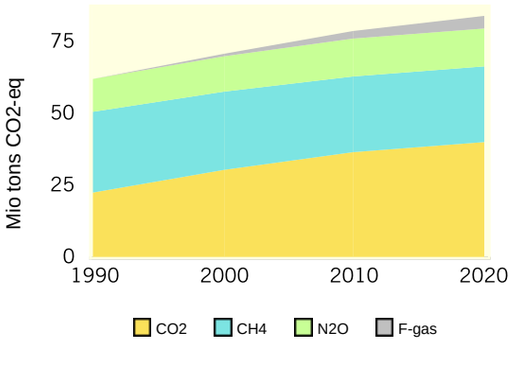
MACRO-ECONOMIC ASSUMPTIONS



GHG EMISSIONS BY SECTOR

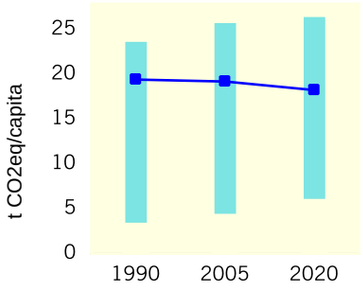


TOTAL GHG EMISSIONS BY GAS

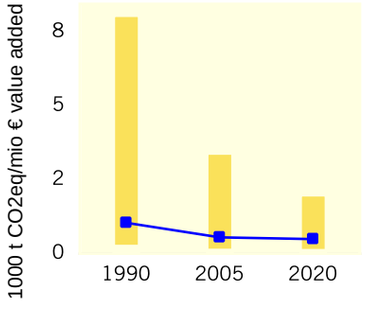


GHG INTENSITIES (bars indicate ranges for Annex 1)

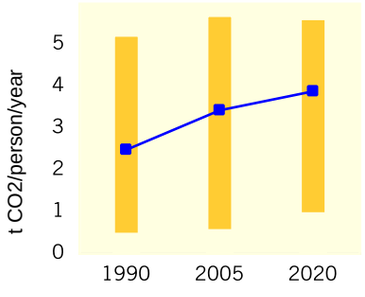
TOTAL GHG EMISSIONS/CAPITA



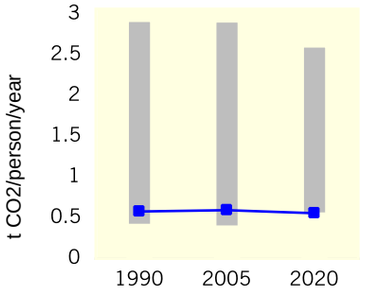
GHG INTENSITY OF INDUSTRIAL GDP



CO2/CAPITA FROM ROAD TRANSPORT

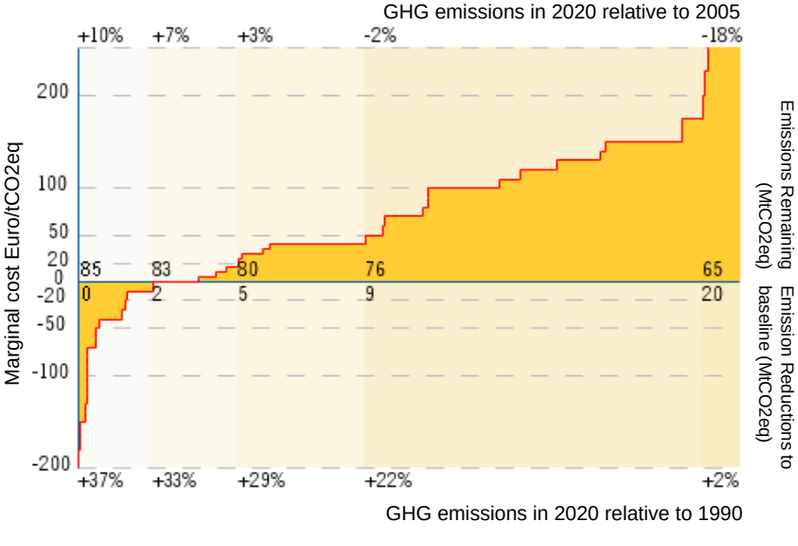


CO2/CAPITA FROM HOUSEHOLDS

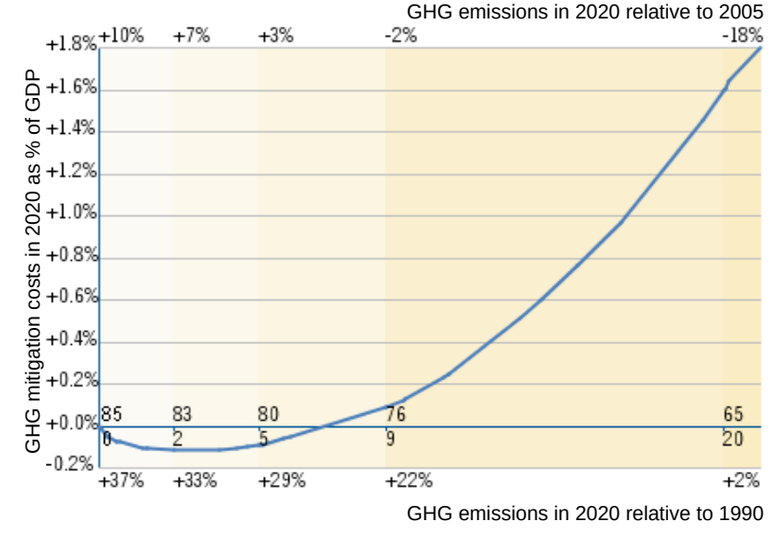


MITIGATION POTENTIALS AND COSTS IN 2020 (for 20% interest rate)

MARGINAL COST CURVE



TOTAL COSTS OF GHG MITIGATION

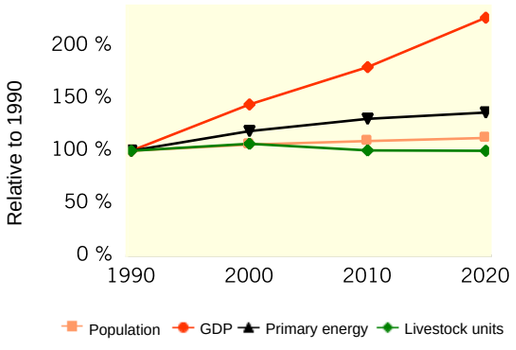


Activity projection: IEA WEO 2008

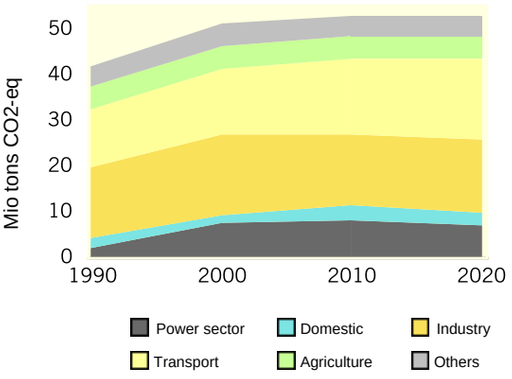
Norway

MACRO-ECONOMIC DRIVERS AND BASELINE GHG EMISSIONS

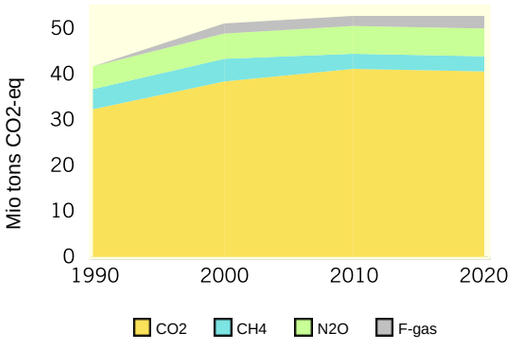
MACRO-ECONOMIC ASSUMPTIONS



GHG EMISSIONS BY SECTOR

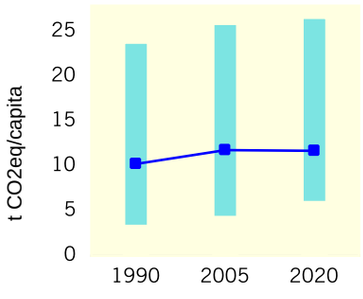


TOTAL GHG EMISSIONS BY GAS

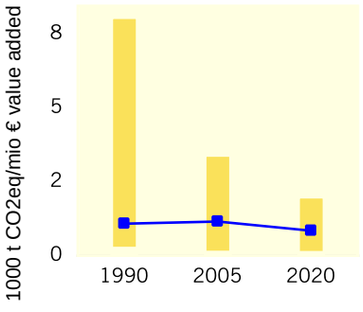


GHG INTENSITIES (bars indicate ranges for Annex 1)

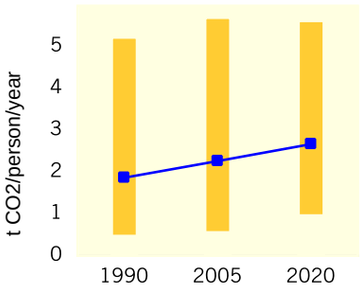
TOTAL GHG EMISSIONS/CAPITA



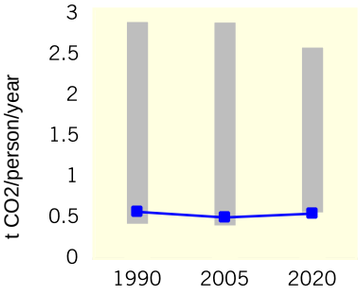
GHG INTENSITY OF INDUSTRIAL GDP



CO2/CAPITA FROM ROAD TRANSPORT

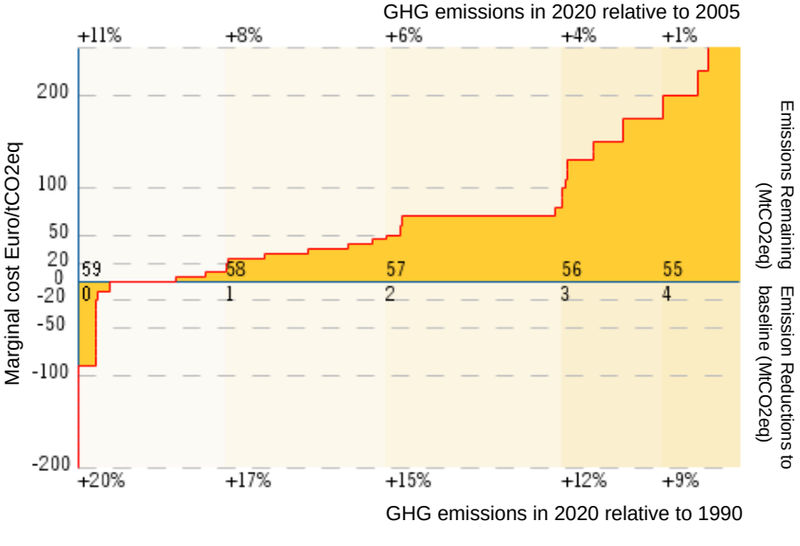


CO2/CAPITA FROM HOUSEHOLDS

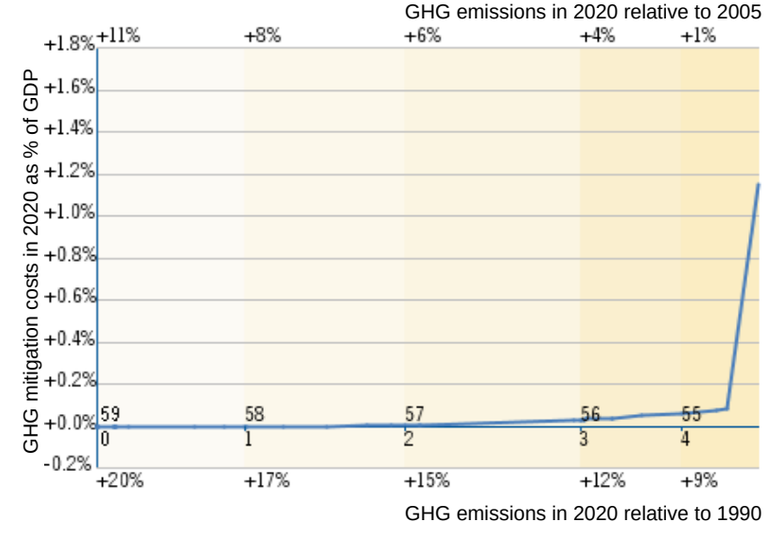


MITIGATION POTENTIALS AND COSTS IN 2020 (for 20% interest rate)

MARGINAL COST CURVE



TOTAL COSTS OF GHG MITIGATION

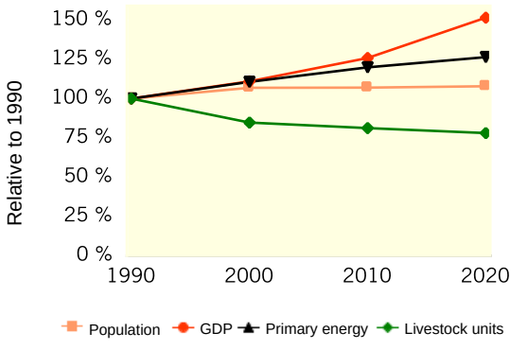


Activity projection: IEA WEO 2008

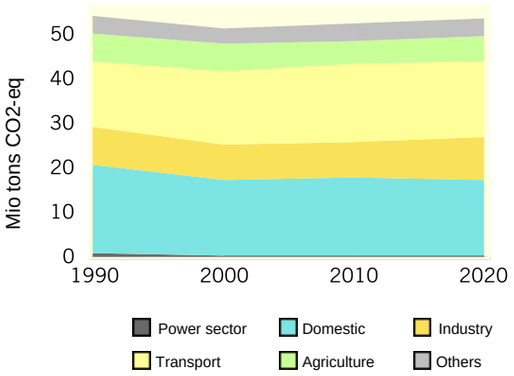
Switzerland

MACRO-ECONOMIC DRIVERS AND BASELINE GHG EMISSIONS

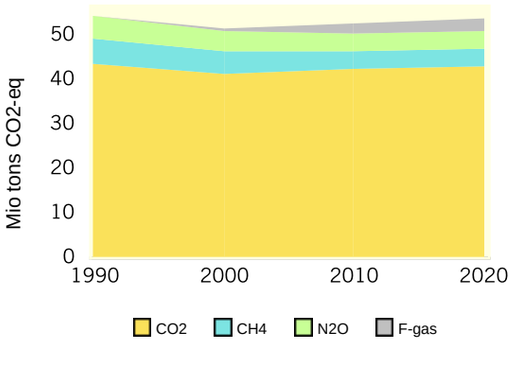
MACRO-ECONOMIC ASSUMPTIONS



GHG EMISSIONS BY SECTOR

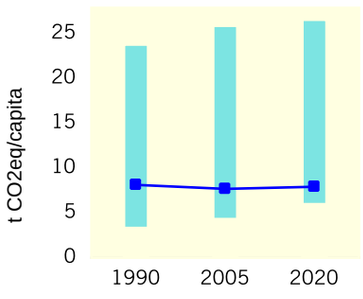


TOTAL GHG EMISSIONS BY GAS

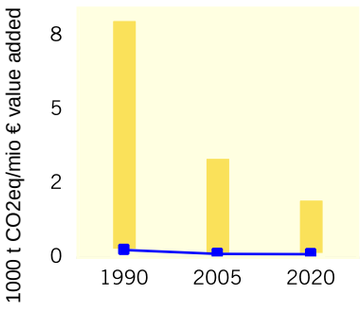


GHG INTENSITIES (bars indicate ranges for Annex 1)

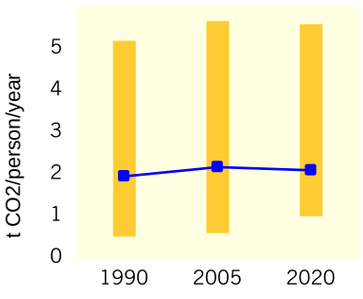
TOTAL GHG EMISSIONS/CAPITA



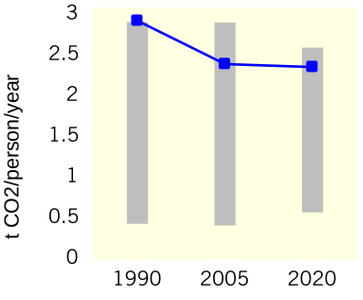
GHG INTENSITY OF INDUSTRIAL GDP



CO2/CAPITA FROM ROAD TRANSPORT

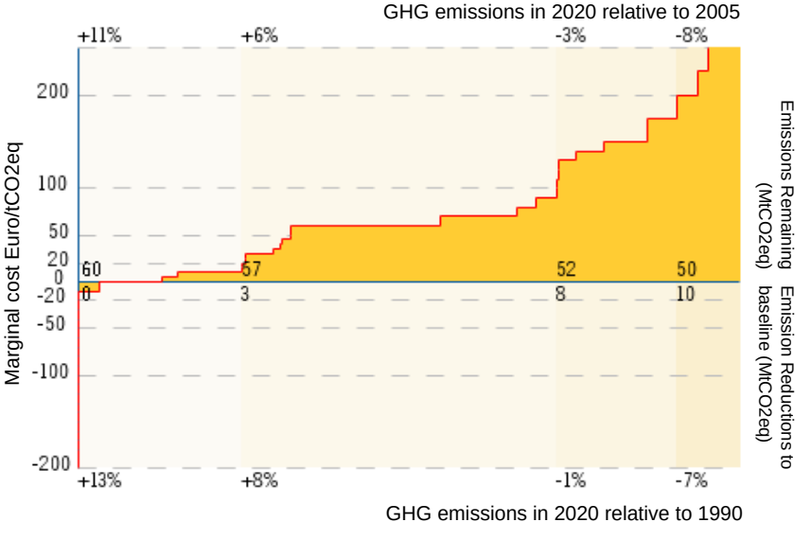


CO2/CAPITA FROM HOUSEHOLDS

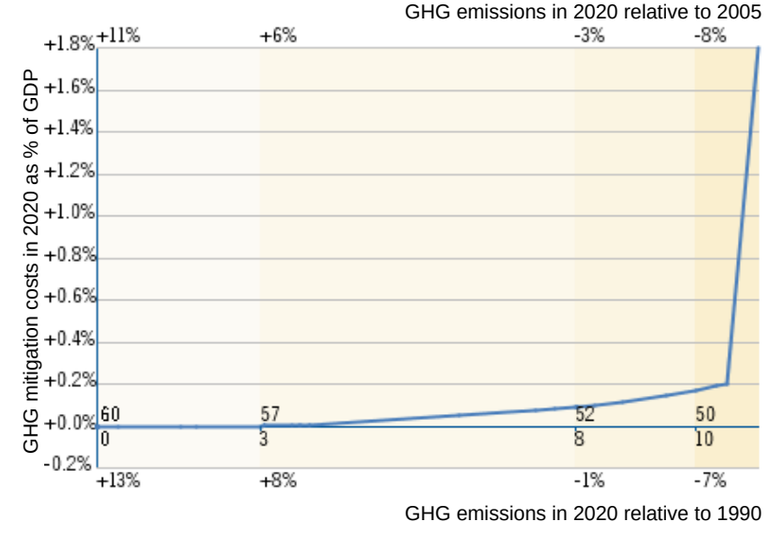


MITIGATION POTENTIALS AND COSTS IN 2020 (for 20% interest rate)

MARGINAL COST CURVE



TOTAL COSTS OF GHG MITIGATION

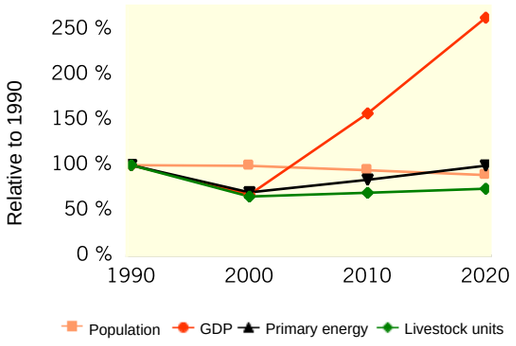


Activity projection: IEA WEO 2008

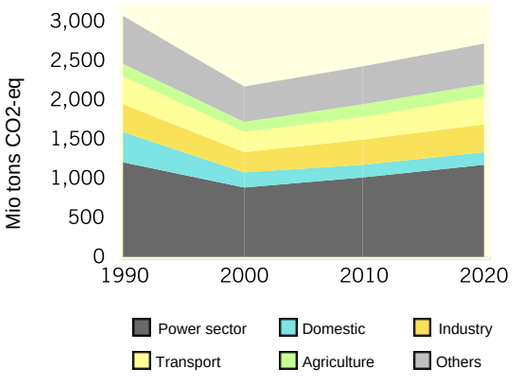
Russian Federation

MACRO-ECONOMIC DRIVERS AND BASELINE GHG EMISSIONS

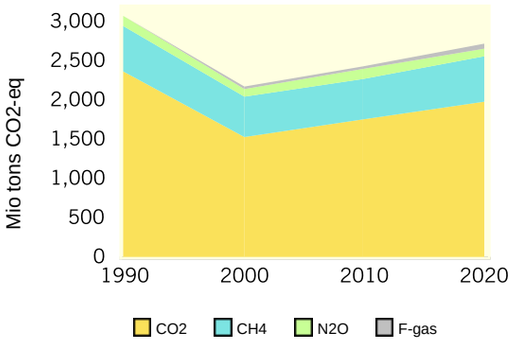
MACRO-ECONOMIC ASSUMPTIONS



GHG EMISSIONS BY SECTOR

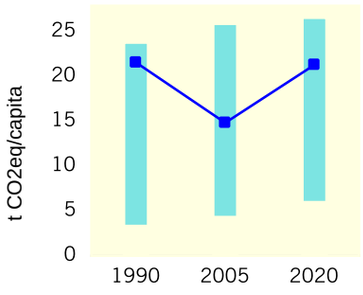


TOTAL GHG EMISSIONS BY GAS

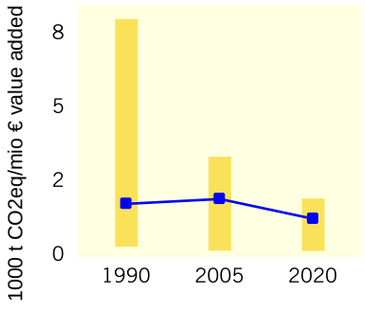


GHG INTENSITIES (bars indicate ranges for Annex 1)

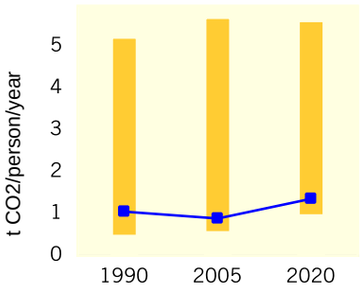
TOTAL GHG EMISSIONS/CAPITA



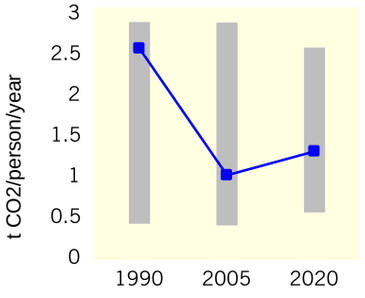
GHG INTENSITY OF INDUSTRIAL GDP



CO2/CAPITA FROM ROAD TRANSPORT

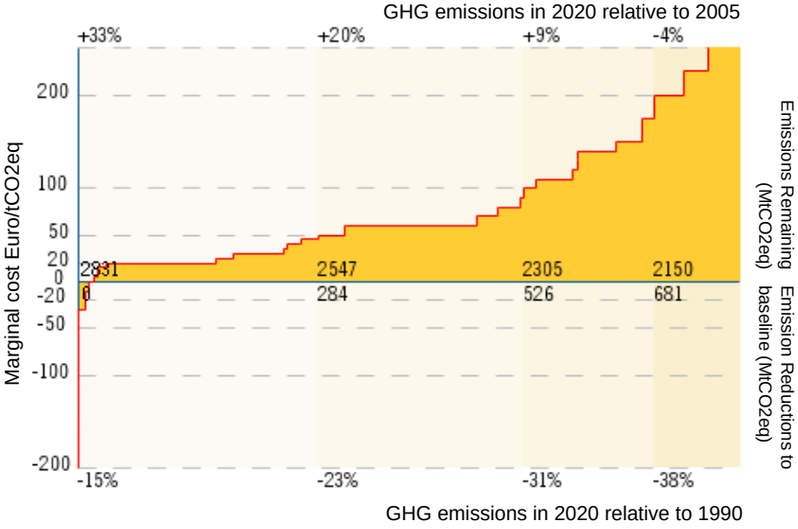


CO2/CAPITA FROM HOUSEHOLDS

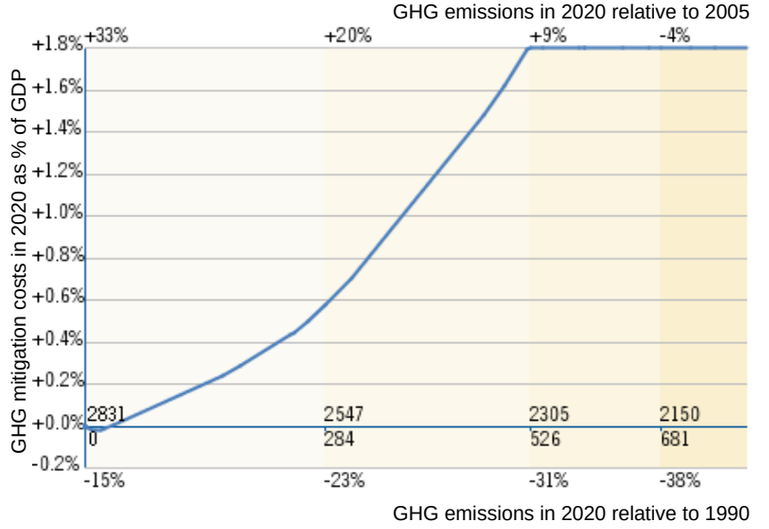


MITIGATION POTENTIALS AND COSTS IN 2020 (for 20% interest rate)

MARGINAL COST CURVE



TOTAL COSTS OF GHG MITIGATION

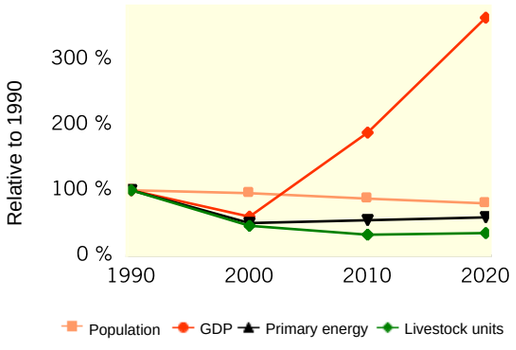


Activity projection: IEA WEO 2008

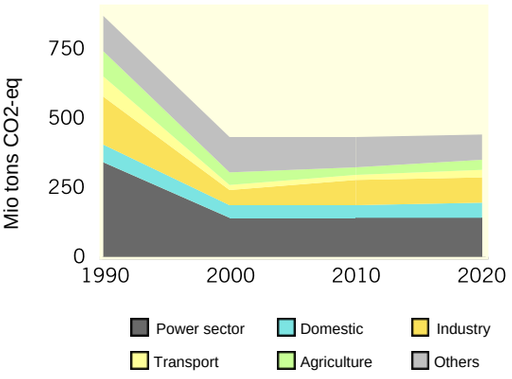
Ukraine

MACRO-ECONOMIC DRIVERS AND BASELINE GHG EMISSIONS

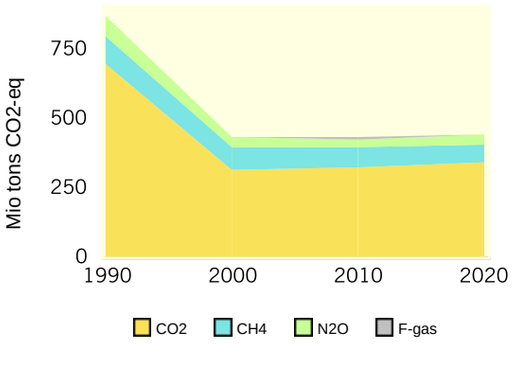
MACRO-ECONOMIC ASSUMPTIONS



GHG EMISSIONS BY SECTOR

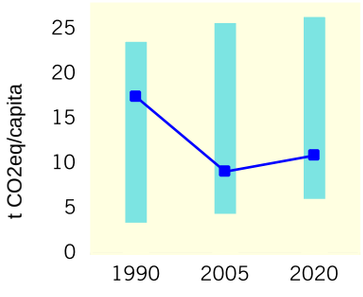


TOTAL GHG EMISSIONS BY GAS

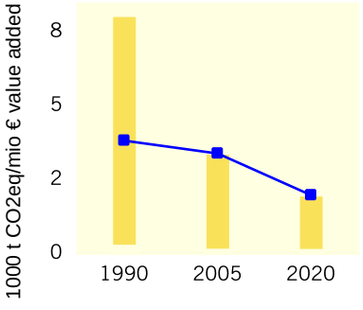


GHG INTENSITIES (bars indicate ranges for Annex 1)

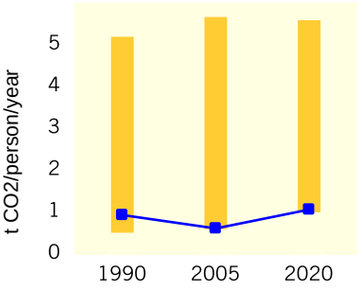
TOTAL GHG EMISSIONS/CAPITA



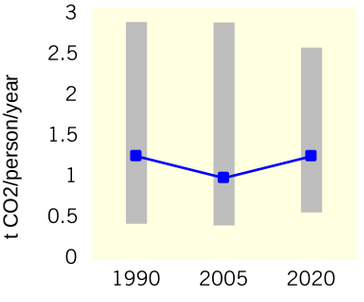
GHG INTENSITY OF INDUSTRIAL GDP



CO2/CAPITA FROM ROAD TRANSPORT

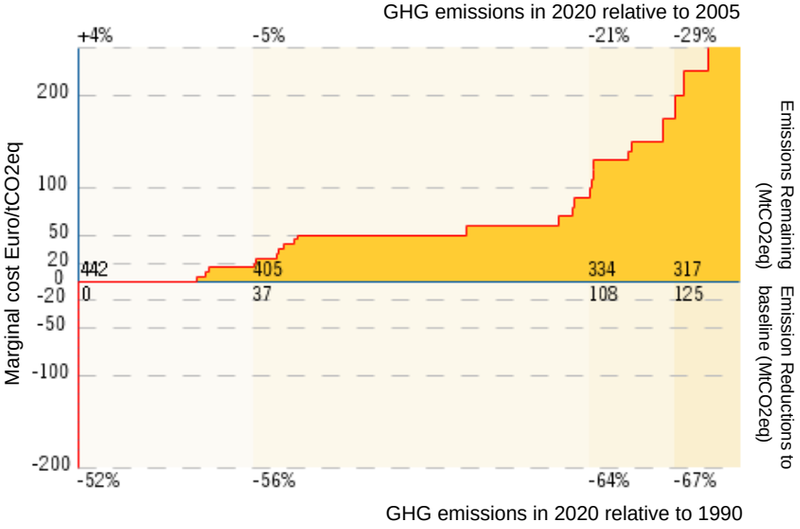


CO2/CAPITA FROM HOUSEHOLDS

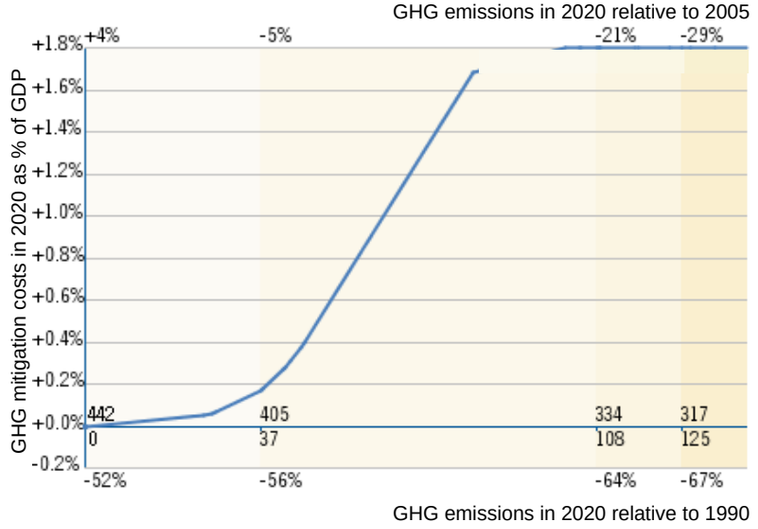


MITIGATION POTENTIALS AND COSTS IN 2020 (for 20% interest rate)

MARGINAL COST CURVE



TOTAL COSTS OF GHG MITIGATION

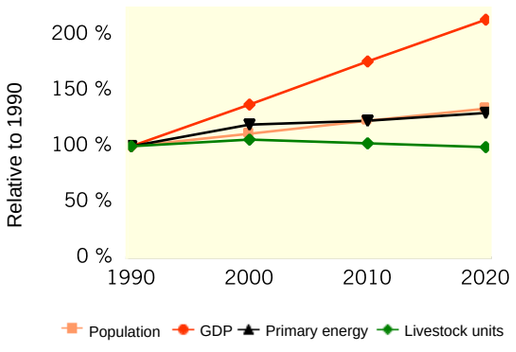


Activity projection: IEA WEO 2008

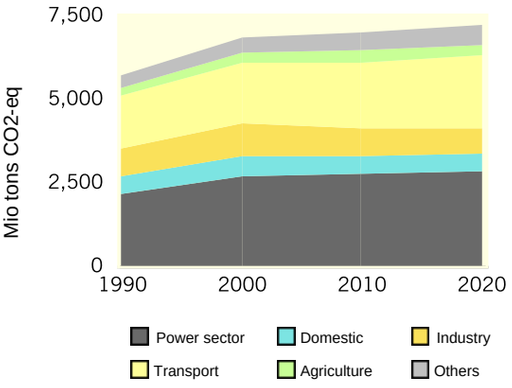
United States of America

MACRO-ECONOMIC DRIVERS AND BASELINE GHG EMISSIONS

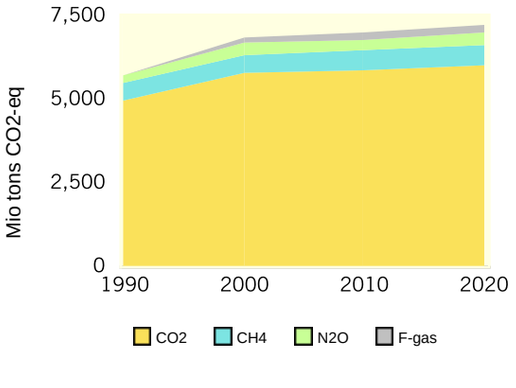
MACRO-ECONOMIC ASSUMPTIONS



GHG EMISSIONS BY SECTOR

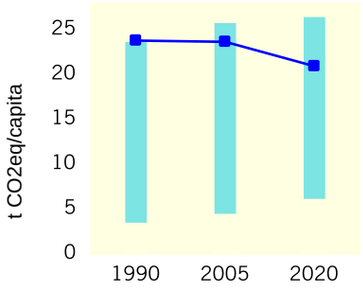


TOTAL GHG EMISSIONS BY GAS

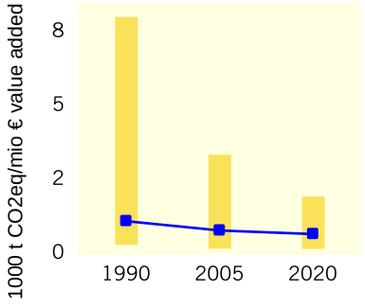


GHG INTENSITIES (bars indicate ranges for Annex 1)

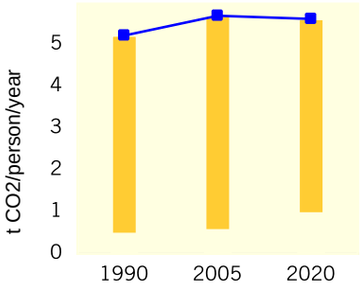
TOTAL GHG EMISSIONS/CAPITA



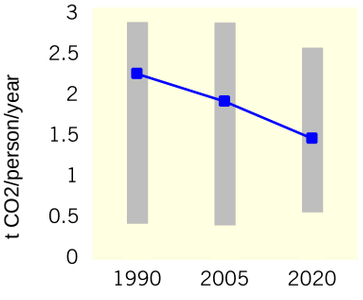
GHG INTENSITY OF INDUSTRIAL GDP



CO2/CAPITA FROM ROAD TRANSPORT

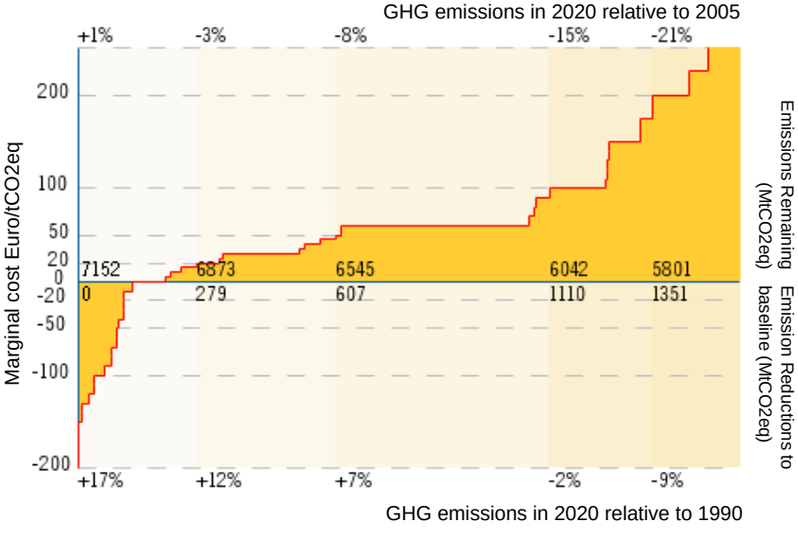


CO2/CAPITA FROM HOUSEHOLDS



MITIGATION POTENTIALS AND COSTS IN 2020 (for 20% interest rate)

MARGINAL COST CURVE



TOTAL COSTS OF GHG MITIGATION