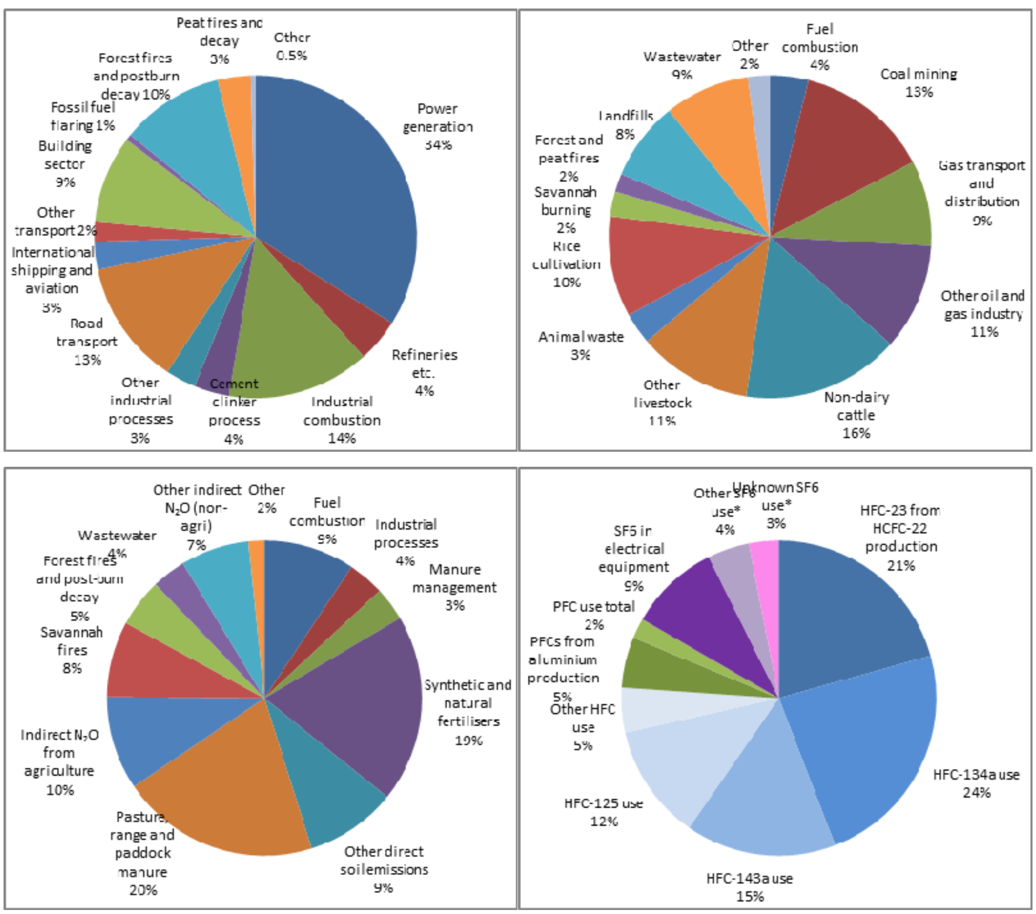
# Appendix 1:

# Methodology

## 1.1 Current global emissions of greenhouse gases

Providing further detail on current global emissions discussed in Chapter 1, Figure A1 shows the shares of sources of global emissions for each of the main greenhouse gases ($CO_2$, $CH_4$, $N_2O$, and F-gases) in 2010. The largest sources of $CO_2$ emissions accounting for two-thirds of the global total are the energy sector (power generation, etc. - 34%); industrial production (21%), and; road transport (13%) (see Figure A1.a). The 3% total emissions increase in 2010 (excluding LULUCF sources) was mainly due to a 6% increase in power generation emissions and a 5% global increase in emissions from industrial activities such as steel and cement production.

Livestock (30%), the oil and gas industry (19%), waste and wastewater (16%), coal mining (13%) and rice cultivation (10%) make up about two-thirds of global methane emissions (see Figure A1.b). The small increase in $CH_4$ emissions in 2010 was mainly due to a 5% increase in net emissions from coal mining and a 5% increase from gas production and distribution, which were partly compensated for by large decreases in forest fire and peat fire emissions.




* Figure A1(d): Other SF6 use is from known sources; unknown are sales for which no specific use could be determined

*Source: JRC/PBL, 2012, EDGAR 4.2 FT2010*

**Figure A1:** Shares of sources in global emissions in 2010: (a) $CO_2$ and (b) $CH_4$, (c) $N_2O$ and (d) HFCs, PFCs, SF6

Half of global $N_2O$ emissions stem directly from agricultural activities, of which 20% comes from fertiliser use and 20% from animal droppings. If indirect emissions are included, the share is about two-thirds of the total (see Figure A1.c). The small increase in $N_2O$ emissions in 2010 was mainly due to a 3% increase in emissions from synthetic fertiliser consumption and a 15% increase from nitrogen-fixing crops, which was partly offset by a 20% decrease in industrial emissions from the production of adipic acid (mainly used in the manufacture of nylon,) and large decreases in forest fire and peat fire emissions.

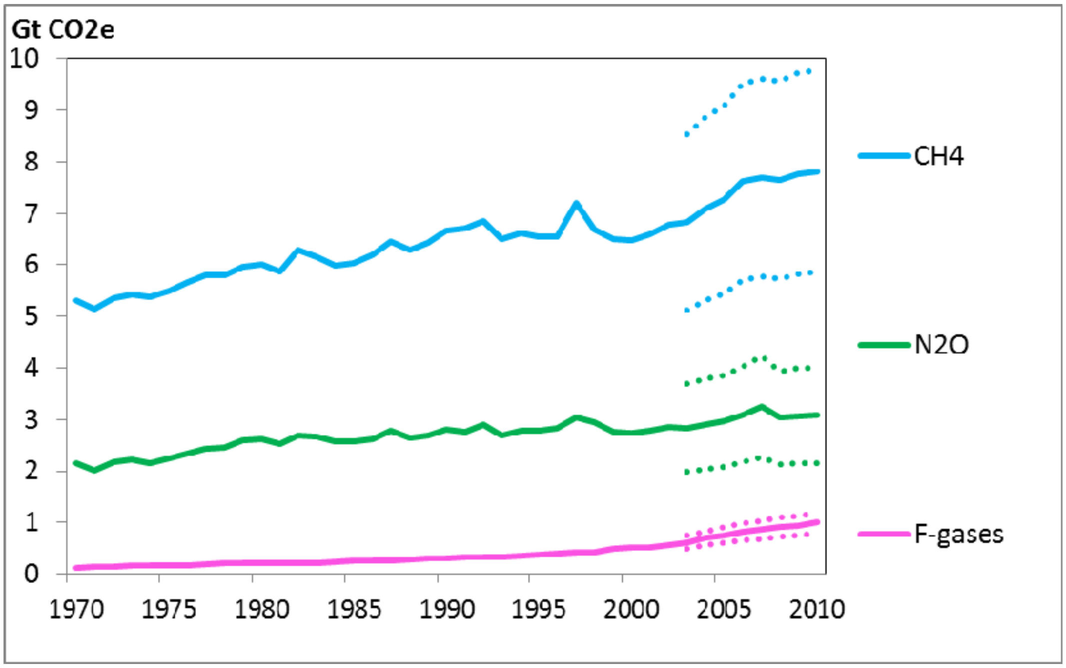



**Figure A2**: Trend of global emissions of methane, nitrous oxides and F-gases HFCs, PFCs and SF6. Dashed lines indicate the 95% uncertainty ranges of 25%, 30% and 20%, respectively (in $CO_2$-equivalents using GWP values as used for UNFCCC/Kyoto Protocol reporting). (Source: JRC/PBL, 2012, EDGAR 4.2 FT2010)

HFC emissions account for three-quarters of total F-gas emissions, with the largest sources being HFC-134a use (about 25%) and the production of HCFC-22 (about 20%) (see Figure A1.d). The 7% increase in fluorinated gas emissions in 2010 was mainly due to increasing emissions of the HFCs 134a and 125.

The consolidated estimate with its uncertainty range was prepared using global GHG emissions inventories from various sources (for $CO_2$, IEA, EDGAR, CDIAC; for other greenhouse gases, national submissions to the UNFCCC (2012a)).

Andres et al. (2011) made a comparison of datasets of global $CO_2$ emissions from fossil fuel production compiled by CDIAC, IEA, EDGAR, EIA, including a comparison with national submissions to the UNFCCC. They state that global emissions are known within 10% uncertainty (95% confidence interval (CI)). However, taking into account the differences between the datasets and the uncertainty estimates for the largest countries as discussed in Andres et al. (2011) and in Olivier et al. (2012), the overall uncertainty in global $CO_2$ emissions from fossil fuel combustion, flaring and cement production may be accurate to about ±5% (95% CI). The net $CO_2$ emissions from land use, land use change and forestry (LULUCF) are well known to be very uncertain. Comparisons made by IPCC (Denman et al., 2007) and more recently by Houghton et al. (2012) show that the uncertainty in decadal average $CO_2$ emissions as deduced from the range of values from several datasets is about 50% (95% CI). The average emissions of the EDGAR 4.2 dataset on $CO_2$ emissions from forest fires derived from the GFED 2 dataset (van der Werf et al. (2006)) and of post-burn decay of remaining biomass (emissions which continue for years after the fires have died out) are quite close to the middle of the range spanned by the landuse change datasets in the comparison by Houghton et al. (2012), but include inter-annual changes reflecting variations in weather and biomass moisture conditions. Moreover, EDGAR 4.2 LULUCF emissions include $CO_2$ emissions from decomposition of drained peat lands and fires, in 2010 accounting for 1.3 Gt $CO_2$. Adding all anthropogenic $CO_2$ emissions, the calculated uncertainty in the total ranges from about -10% to +10% (95% CI), including LULUCF. For global emissions of $CH_4$, $N_2O$ and the F-gases uncertainty estimates were assumed of ±25%, ±30% and ±20%, respectively (95% CI) (IPCC, 2006; Olivier, 2002; Olivier and Peters 2002, Olivier et al. 2010), which correspond with emissions estimates inferred from atmospheric concentration measurements (see below). The resulting uncertainty in total global greenhouse gas emissions, calculated using the IPCC good practice guidelines and assuming no correlation between emissions of different gases, is ±9% for the 95% confidence interval (IPCC, 2006).

EDGAR 4.2 estimates for $CH_4$ and $N_2O$ emissions are based on IPCC methodologies with activity data (which are the basis for calculating emissions from a particular sector) mostly taken from international statistical data sources and emission factors selected mostly from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) to ensure a consistent approach across countries. The EDGAR 4.2 Fast Track 2010 (FT2010) dataset extends the EDGAR 4.2 time series 1970-2008 by adding emissions for 2009 and 2010. For the main sources of each greenhouse gas as proxy of the emissions trend in these years the official national reported emissions trend was used (from UNFCCC (2012b)), or the trend in the new statistics of the activity data for 2008 to 2010, or statistics of an activity that was assumed to be a good proxy for that source. These proxies – sometimes adjusted to include significant trends in the emission factors – were applied for most sources, comprising per gas more than 95% of the global total. To account for the impact of emissions control technology trends in Annex I countries (mainly countries that were members of the OECD in 1990), the 2008-2010 trends in their officially reported emissions were used (UNFCCC, 2012b). For developing countries the impact of CDM projects in reducing $CH_4$, $N_2O$ and HFC-23 emissions was taken into account. This applies to sources such as coal mines and landfills ($CH_4$ recovery), nitric acid and adipic acid production ($N_2O$) and the production of HCFC-22 (HFC-23), which is now starting to significantly influence global emission trends. However, although the starting date and full impact of projects is known, the exact trend over time in national reductions had to be estimated due to lack of information. More information on data sources and methodologies applied can be found in Olivier and Janssens-Maenhout (2012) and at the EDGAR 4 website (JRC/PBL, 2012).

The uncertainty in the resulting EDGAR 4.2 FT2010 dataset may be substantial at national level. However, a comparison of total $CH_4$ and $N_2O$ emissions per country with national reporting to the UNFCCC showed for $CH_4$ that EDGAR 4.2 FT2010 totals of Annex I countries for 2010 were only 6% higher than official reported emissions. For $N_2O$, EDGAR's Annex I emissions in 2010 are 7% lower than national submissions (excluding indirect $N_2O$ emissions which were calculated using different guidelines). In both cases these differences were mainly due to differences in the totals for the group of Economies-In-Transition; differences in total OECD countries' emissions were very small. However, for the individual countries the difference can be much larger with average differences of 25% for $CH_4$ and 20% for $N_2O$. The standard deviation in the differences for the group of 38 countries compared was about 20% for $CH_4$ as well as $N_2O$. The differences at source category level due to the uncertainty in the methods used is generally higher, in particular for sources such as CH4 emissions from fugitive sources (IPCC category 1B) and waste (6),

$N_2O$ emissions from agriculture (4) and F-gases as by-product from industrial processes (2C, 2E). These differences are caused by the limited accuracy of international activity data used and in particular of emission factors selected for calculating emissions on a country level (Olivier et al., 1999, 2001; Olivier and Berdowski, 2001; Olivier, 2002; Olivier et al., 2005). However, since the methods used are either 2006 IPCC methodologies or comparable with these, this dataset provides a sound basis as reference dataset for comparisons. For the F-gases HFCs, PFCs and SF6 another approach often had to be used for emissions from F-gas usage since international consumption statistics are often not available (Olivier and Janssens-Maenhout, 2012). HFCs included are: HFC-134a, -152a, -143a, -125, -23, -227ea, -365mfc, -245fa, -236fa, -32 and 43-10-mee; PFCs included are: $CF_4$, $C_2F_6$, $C_3F_8$, $C_4F_{10}$, $C_5F_{12}$, $C_6F_{14}$, $C_7F_{16}$ and c-$C_4F_8$.

For global emissions of $CH_4$, $N_2O$ and the F-gases uncertainty estimates of 25%, 30% and 20%, respectively, were assumed based on default uncertainty estimates for the 2006 IPCC methodologies (IPCC, 2006). More information on uncertainties in global and national emissions of non-$CO_2$ greenhouse gases can be found in e.g. Olivier (2002); Olivier and Peter (2002); Olivier et al. (2002). The global non-$CO_2$ greenhouse gas emissions, as discussed above and shown in Figure A3, comply within their uncertainties with emissions estimates inferred from atmospheric concentration measurements (see Figure A3 and Table A1). However, the increasing trend in global $CH_4$ emissions since the early 2000s in EDGAR 4.2 as shown in Figure A2 is not reflected in the inferred emissions shown in Figure A3.

**Table A1:** Global anthropogenic emissions in 2010 in $GtCO_2e$ from EDGAR 4.2 FT2010 and uncertainties (Source: JRC/PBL, 2012)

| Substance | 2010 emissions (95% CI) | Uncertainty (%) (95% confidence interval) |
|---|---|---|
| **$CO_2$ (including LULUCF)** | 38.2 (-3.8, +3.8) | ±10% |
| **$CH_4$** | 7.8 (-2.0, +2.0) | ±25% |
| **$N_2O$** | 3.1 (-0.9, + 0.9) | ±30% |
| **F-gases** | 1.0 (-0.2, +0.2) | ±20% |
| Total GHG | **50.1 (-4.5, +4.5)** | **±9%** |

The resulting uncertainty in total global greenhouse gas emissions, calculated using the IPCC good practice guidelines and assuming no correlation between emissions of different gases, is ±10% for the 95% uncertainty range (IPCC, 2006).

Emission estimates for 2010 for long-lived greenhouse gases inferred from atmospheric measurements are an update of Montzka et al. (2011a). These estimates are derived from a simple 1-box inverse analysis of global mean mixing ratios and lifetime. The techniques are identical to those typically used in the WMO Scientific Assessment of Ozone Depletion reports (see Daniel et al., 2011). The estimates are derived from the independent measurements by the NOAA and AGAGE groups for years up through 2008 based on previously published data[1]. These two groups sample the atmosphere with a range of techniques at a suite of remote measurement sites. Although the groups and calibration scales are independent, there is some overlap in techniques used and remote locations sampled. AGAGE data are typically from high frequency measurements (multiple samples per day) at 4-5 sites (Cape Grim, Samoa, Barbados, Trinidad Head, Mace Head) (see Prinn et al., 2000). Non-polluted monthly means are derived from filtering out samples with recent emission input. The NOAA data is derived from flask measurements alone or, for some gases, from a combination of

[1] NOAA stands for National Oceanicand Atmospheric Administration, and AGAGE is the Advanced Global Atmospheric Gases Experiment.

flask measurements and high frequency in situ measurements. Global means are derived from measurements at as many as 50 remote flask sampling sites (for $CH_4$), and as few as 7 sites (some HFCs) (see Dlugokencky et al., 2009; Montzka et al., 1996).

2010 global emissions were derived from 1-box mass balance consideration of background atmospheric changes from the beginning of 2010 to the beginning of 2011. Emissions by compound were converted to $CO_2$e emissions by multiplying by 100-yr GWPs agreed to in the first commitment period of the Kyoto Protocol, or updated values provided in Daniel et al. (2011). Only anthropogenic contributions are included here; for $CH_4$, a constant natural emission of 200 Tg $CH_4$/yr was subtracted from the total global inverse emission derived from atmospheric changes. For $CF_4$, only emissions associated with increases above the natural background of 37.4 ppt were considered in deriving anthropogenic emissions. A constant natural emission for $N_2O$ of 15 Tg N/yr was subtracted.

HFCs include: HFC-134a, -152a, -143a, -125, -23, -227ea, -365mfc, -245fa, -32. Both groups measure HFC-134a, 152a, -142a, -125, and -23, but only AGAGE data are available for the other HFCs.

PFCs include $CF_4$, $C_2F_6$, $C_3F_8$, (an update of Muhle et al., 2010); no NOAA measurements of these gases are currently made.

Ozone-depleting substances include 5 CFCs, 3 HCFCs, $CCl_4$, $CH_3CCl_3$, 3 halons, and methyl bromide.

In Figure A3, uncertainties derived from lifetime considerations are included only in the 2010 estimates and are smaller than the symbols for HFCs, SF6, and PFCs (see Table A2 for more details on lifetime uncertainties used here). The different colours represent different chemicals or chemical classes, and the multiple lines given for a single chemical or chemical class are derived from independent global sampling networks (NOAA—update of Montzka et al.(2011a); and AGAGE (Prinn et al., 2000) updated through 2008 in Montzka et al. (2011b)). PFC measurements are only made by AGAGE (Mühle et al., 2010).

**Table A2:** Global anthropogenic emissions in 2010 in $GtCO_2e$ derived from global background atmosphere observations from NOAA (updates to Montzka *et al*., 2011a except as indicated)

| | 2010$^{\Psi}$ | 2010* |
|---|---|---|
| **$CH_4$** | 7.3 (+1.4, -1.2) | 8.7 |
| **$N_2O$** | 3.9 (+1.5, -1.2) | 3.7 |
| **HFCs** | 0.50 (+0.03, -0.02) | 0.56 |
| **PFCs** | n.d. ** | n.d.** |
| **$SF_6$** | 0.16 (+/-0.01) | 0.15 |
| **ODSs** | 1.4 (+0.5, -0.4) | 1.8 |

$^{\Psi}$ $CO_2$-eq emissions are derived here with GWPs from the first commitment period of the Kyoto Protocol. Uncertainties given reflect 68% CI uncertainties[2] in trace-gas lifetimes of a factor of 20% except for the following gases: for $N_2O$ the uncertainty 122 +/- 24 yrs as in Volk et al. (1997) for; and the uncertainties given in Clerbaux et al. (2007) for many halocarbons. For $SF_6$, the uncertainty is insensitive to lifetime, so that given is the average difference between the global annual emissions derived from the two global networks from 2000-2008.

* $CO_2$-eq emissions are derived using updated GWP estimates given in the latest WMO Scientific Assessment of Ozone Depletion (Daniel et al., 2011).

** n.d. = not determined for 2010. PFC emissions derived from AGAGE global trace gas observations (Mühle et al., 2010) suggest $CO_2$-eq emissions from the three most abundant PFCs ($CF_4$, $C_2F_6$, and $C_3F_8$) of 0.09 $GtCO_2$-eq for the average of 2005-2008 (0.1 $GtCO_2$-eq with the updated GWPs from Daniel et al., 2011), with uncertainties amounting to about 3% of these values (68% CI).

[2] An approximation of 1-sigma (68% CI) uncertainties based on lifetime considerations alone are used above and in table 2 and figure 3.

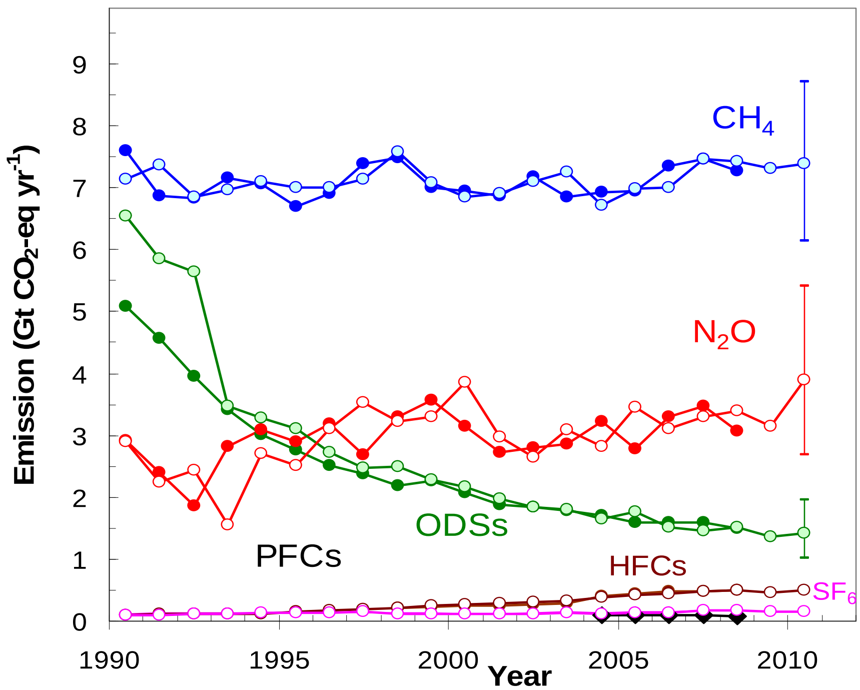



**Figure A3:** $CO_2$-equivalent emissions of non-$CO_2$ greenhouse gases derived from measured global atmospheric burdens and trends and lifetime estimates of annual losses.

## 1.2 Analysis of pledges

For the assessment of the pledges, the analyses of seven modelling groups were reviewed (see Table A3). The results of other modelling groups that were used in the Bridging the Emissions Gap report (UNEP, 2011)[3] were not updated and, therefore, not included here.

For studies with less than global coverage, the median estimate of the other modelling groups' findings for any missing countries or sectors was added to ensure a consistent comparison across studies. For the studies that estimated global emissions, but did not include emission estimates for international transport emissions, the median estimate of other modelling groups for those emissions (2020 emissions of about 1.6 $GtCO_2e$) was added. Some modelling groups included such emissions in the individual country emissions data, which explains part of the range between modelling groups in emission estimates at a regional and country level.

In order to ensure consistent comparison of the present work with the results of recent emission pathways, the historical emissions data from the pledge analysis needed to be harmonised. The emissions data used in the seven global studies were harmonised around consistent 2005 levels of 45 $GtCO_2e$ (except for Grantham where values for 2005 were not collected). The harmonisation included an absolute adjustment for each study's data set for 2005, which was kept constant for all subsequent years. (For further work on harmonisation see Rogelj et al., 2011). The results of the harmonisation led to changes in 2020 of between –0.3 $GtCO_2e$ and +1.0 $GtCO_2e$ (median, BAU and four cases) but larger adjustments for individual studies (–2.8 $GtCO_2e$ to +1.5 $GtCO_2e$).

The results of the pledge analysis for Annex I and non-Annex I countries are provided in Table A4, whereas Table A5 gives an overview of the reductions compared to 1990 and BAU emissions for Annex I and Non-Annex I countries.

[3] Other modelling groups included in UNEP (2011) were: AVOID programme, (UK Met Office, project lead), Climate Strategies, IIASA (GAINS model), Peterson Institute for International Economics, Project Catalyst (Climate Works Foundation), and World Resources Institute.

**Table A3:** Overview of studies assessed in this paper

| Organisation | Date of last update | Reference |
|---|---|---|
| Climate Action Tracker (Ecofys, Climate Analytics, & PIK) | August 2012 | www.climateactiontracker.org, updated based on Climate Action Tracker, 2009, Rogelj et al., 2010b, Rogelj et al., 2010a |
| Climate Interactive (C-ROADS) | June 2012 | www.climateinteractive.org/scoreboard<br>Sterman et al., under review |
| Fondazione Eni Enrico Mattei (FEEM) | June 2012 | http://www.feem.it/<br>Carraro and Massetti |
| Grantham Research Institute, London School of Economics | Aug 2012 | Updated based on Stern and Taylor, 2010 |
| OECD | March 2012 | OECD Environmental Outlook to 2050, OECD (2012) |
| PBL Netherlands Environmental Assessment Agency | June 2012 | www.pbl.nl/en,see den Elzen et al. (2012) |
| UNEP Risoe centre | August 2012 | www.unep.org/climatechange/pledgepipeline |

**Table A4:** Results of the pledge analysis for Annex I and Non-Annex I countries

| **Unharmonised adjusted results** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Historic emissions | | | Emissions in 2020 | | | | |
| **Mt $CO_2$ eq. Including LULUCF if available otherwise excluding** | | 1990 | 2005 | 2010 | BAU | Unconditional pledge | | Conditional pledge | |
| | | | | | | Lenient rules **(case 1)** | Strict rules **(case 2)** | Lenient rules **(case 3)** | Strict rules **(case 4)** |
| **Global** | N | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| | High | 39,595 | 47,209 | 51,487 | 63,401 | 62,584 | 59,055 | 57,454 | 53,854 |
| | 80th | 37,896 | 45,730 | 49,080 | 59,465 | 57,466 | 54,760 | 55,763 | 52,202 |
| | **Median** | **36,547** | **44,656** | **48,855** | **58,718** | **56,681** | **54,408** | **55,098** | **51,764** |
| | 20th | 35,536 | 44,532 | 48,240 | 56,468 | 56,038 | 53,790 | 54,748 | 51,157 |
| | Low | 34,584 | 44,517 | 48,148 | 55,265 | 55,265 | 53,081 | 53,313 | 49,713 |
| | | | | | | | | | |
| **AI** | N | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| | High | 19,910 | 18,786 | 19,386 | 22,509 | 22,509 | 20,480 | 18,535 | 16,435 |
| | 80th | 19,461 | 18,720 | 18,664 | 20,167 | 19,440 | 18,422 | 18,294 | 16,302 |
| | **Median** | **19,206** | **18,424** | **17,609** | **19,189** | **18,854** | **18,194** | **18,128** | **16,180** |
| | 20th | 19,169 | 18,358 | 17,050 | 18,913 | 0 | 17,915 | 18,025 | 15,966 |
| | Low | 17,913 | 17,838 | 15,411 | 18,019 | 0 | 17,546 | 17,903 | 15,803 |
| | | | | | | | | | |
| **NAI** | N | 7 | 7 | 7 | 7 | n/a | 7 | n/a | 7 |
| | High | 19,487 | 27,366 | 31,993 | 39,236 | n/a | 36,918 | n/a | 36,168 |
| | 80th | 17,334 | 26,922 | 30,599 | 39,227 | n/a | 35,571 | n/a | 35,268 |
| | **Median** | **16,552** | **25,731** | **29,993** | **38,033** | **n/a** | **35,114** | **n/a** | **33,926** |
| | 20th | 15,610 | 25,003 | 29,401 | 36,362 | n/a | 34,761 | n/a | 33,565 |
| | Low | 14,184 | 22,606 | 29,139 | 33,842 | n/a | 32,594 | n/a | 31,650 |
| | | | | | | | | | |
| **Global** | N | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| | High | 38,354 | 45,000 | 49,612 | 61,192 | 60,376 | 56,846 | 55,888 | 52,288 |
| | 80th | 37,816 | 45,000 | 49,264 | 59,933 | 57,140 | 54,854 | 55,693 | 52,277 |
| | **Median** | **36,547** | **45,000** | **48,630** | **57,969** | **56,579** | **54,251** | **55,245** | **51,645** |
| | 20th | 35,970 | 45,000 | 48,446 | 56,695 | 56,438 | 53,898 | 54,291 | 50,691 |
| | Low | 33,596 | 44,699 | 47,867 | 55,748 | 55,748 | 53,560 | 53,792 | 50,192 |

**Table A5:** Reductions compared to 1990 and BAU emissions for Annex I and Non-Annex I countries

| Annex I | Percent below BAU 2020 emission levels* | | Percent below 1990 emission levels* | |
|---|---|---|---|---|
| | **Median** | **Range**** | **Median** | **Range**** |
| Case 1 - **Unconditional pledges, lenient rules** | -0.3% | (-3.4% to 7.8%) | 0.0% | (0% to 0%) |
| Case 2 - **Unconditional pledges, strict rules** | -6.3% | (-7.8% to 0.5%) | -6.4% | (-8.6% to -3.8%) |
| Case 3 - **Conditional pledges, lenient rules** | -6.0% | (-6.7% to -4.7%) | -5.7% | (-9.6% to -3.1%) |
| Case 4 - **Conditional pledges, strict rules** | -16.5% | (-17.4% to -15%) | -16.7% | (-20.1% to -14.2%) |

* Negative numbers reflect a decrease relative to the comparison year; positive numbers, an increase
** Range is the 20th - 80th percentile range

| Non-Annex I | Percent below BAU 2020 emission levels* | |
|---|---|---|
| | **Median** | **Range**** |
| Case 1 - **Unconditional pledges, lenient rules** | -6.3% | (-9.8% to -4.1%) |
| Case 2 - **Unconditional pledges, strict rules** | -6.3% | (-9.8% to -4.1%) |
| Case 3 - **Conditional pledges, lenient rules** | -7.9% | (-13% to -6.7%) |
| Case 4 - **Conditional pledges, strict rules** | -7.9% | (-13% to -6.7%) |

* Negative numbers reflect a decrease relative to the comparison year; positive numbers, an increase
** Range is the 20th - 80th percentile range

## Appendix 2:

# Detailed information on pledges of G20 countries

This appendix gives detail on current emissions, pledges and BAU as used in studies on pledges for the countries included in the G20 that have submitted a pledge[4], based on the analysis of six research groups[5] . Note that many groups also analysed the pledges of smaller countries, particularly other Annex I countries, but they are not detailed in this appendix due to their small impact on the global emission levels that are the focus of this report.

### Australia

Australia has proposed to decrease its emissions by at least 5% and up to 15 or 25% below the 2000 level. Adoption of the most ambitious target of 25% is conditional on the agreement of a global deal "capable of stabilising greenhouse gases in the atmosphere at 450 ppm $CO_2$ or lower". If a global deal is agreed that falls short of the 450 ppm objective but under which "major developing economies commit to substantially restrain emissions and advanced economies take on commitments comparable to Australia's", Australia will reduce emissions by up to 15%. Otherwise the 5% target will be implemented, unconditionally. Australia also has a pledge to reduce emissions to 60% below 2000 levels by 2050.

Major uncertainties in the allowed emissions in 2020 under the proposed target are (see Figure A1):

- **Conditionality** of the more ambitious end of the range, in particular the legal status of other countries' commitments required for Australia to move to a more ambitious target than the unconditional 5% reduction.
- **Accounting for LULUCF:** Australia is a particularly complicated case with specific rules negotiated in the Kyoto Protocol. For the first KP commitment period Australia can include deforestation emissions in the base year (1990), because it had a net source of emissions from the LULUCF sector[6]. Some Parties have proposed deleting this provision, while Australia wishes to retain it. Other general accounting for LULUCF in 2020 would also have a major influence on the effective emission limit for Australia (e.g., Grassi et al., 2012; Macintosh, 2011). Adding both issues to the least ambitious pledge could result in an effective limit for emissions excluding LULUCF above the 2005 level in 2020.

### Brazil

Brazil has announced that it will reduce its emissions by about 36% to 39% compared to BAU in 2020. Brazil provided specific goals for a number of actions related to deforestation, agriculture and energy. The actions will be implemented in accordance with the principles and provisions of the UNFCCC. The most significant measure is a plan to reduce the deforestation rate in the Amazon region by 80% between 2005 and 2020.

Major uncertainties in the emissions in 2020 under the proposed target are (see also Figure A2):

- **Conditionality:** The target will be implemented "in accordance with the principles and provisions of the UNFCCC." In this assessment we have assumed that this pledge is an unconditional pledge, i.e. not conditional on financing, however, this is a source of uncertainty.
- **Emissions from deforestation:** The majority of the emissions and reductions come from (reducing) deforestation, which is inherently difficult to monitor and control, although Brazil

[4] Of the G20, Argentina, Saudi Arabia and Turkey did not submit a pledge.

[5] The same research groups as in Chapter 1, except OECD, i.e. Climate Action Tracker by Ecofys, Climate Analytics and Potsdam Institute for Climate Impact Research, PIK, www.climateactiontracker.org, Climate Interactive (C-ROADS), www.climateinteractive.org/scoreboard, Fondazione Eni Enrico Mattei (FEEM), http://www.feem.it/, Grantham Research Institute, London School of Economics, PBL Netherlands, www.pbl.nl/en and UNEP Risoe centre, www.unep.org/climatechange/pledgepipeline.

[6] This is stated in Article 3.7 of the Kyoto Protocol

has implemented an elaborate deforestation monitoring system. This explains the large uncertainty of the modelling group's estimates of 1990 and 2005 emissions and particularly of the BAU in 2020.

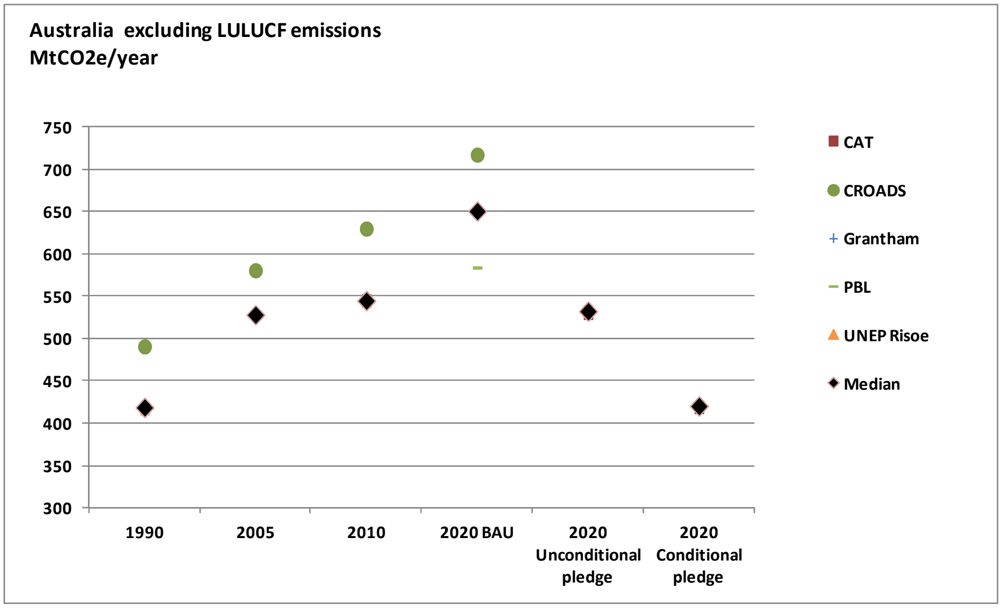



**Figure A1:** Historical emissions and pledges according to different modelling groups for Australia

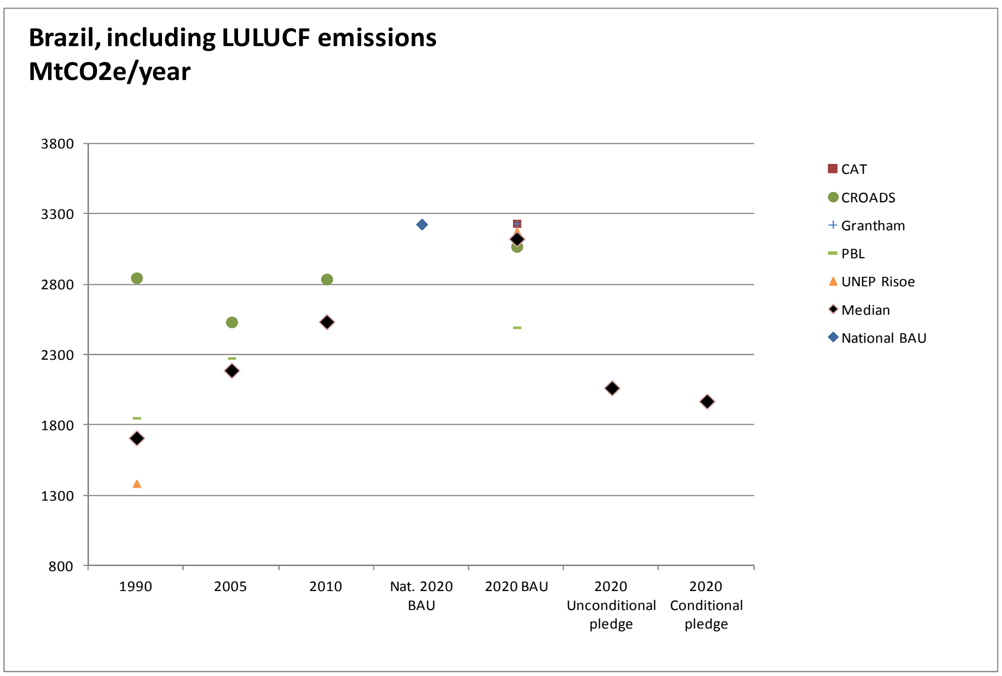



**Figure A2:** Historical emissions and pledges according to different modelling groups for Brazil

- **Change in BAU:** In the national implementation of the pledge in 2011,[7] Brazil uses a higher BAU scenario as a basis for the 36% to 39% reduction than the BAU that was the basis of the original pledge made in November 2009. With higher BAU emissions, the international pledge will result in significantly higher emissions. All modelling groups have used the new BAU.

## Canada

Canada has pledged to reduce its emissions by 17% below 2005 levels (this is assumed to exclude emissions from the LULUCF sector), which mirrors the target proposed by the USA. The Canadian pledge is conditional on the passing of domestic legislation. Up until the announcement under the Cancun Agreements, Canada had proposed to decrease its emissions to 20% below 2006 by 2020, which was more ambitious. In the long term Canada proposes to reduce emissions to 60-70% below 2006 by 2050.

Major uncertainties in the allowed emissions in 2020 under the proposed target are:

- **Conditionality**: Canada states that the target will be aligned with that of the USA enacted in its legislation. As the USA has not passed federal legislation, this target is taken to be conditional in this assessment, in which the unconditional case for Canada, which is needed to compute the pledge cases in Chapter 3, is assumed to be the BAU emissions trajectory as projected by the modelling groups. This could be considered as an upper bound, as Canada may implement policies to deviate from this level.

- **Accounting for LULUCF:** Canada has very large forest areas and, therefore, potentially large uptake of $CO_2$; hence accounting rules for LULUCF can make a large difference. For Canada, LULUCF may contribute up to about 9 $MtCO_2$ (1.6 % of 1990 emissions) following the LULUCF accounting rules as agreed in Durban (Grassi et al., 2012), whose impact on forest management may be excluded with the rules agreed in Durban. The Canadian Government's Environment Department, Environment Canada, (2012) produced a higher estimate of LULUCF credits of about 25 MtCO2 (about 4 % of 1990 emissions).

## China

China proposed three elements under the Cancun Agreements: to lower its carbon dioxide emissions per unit of GDP by 40-45% by 2020 compared to the 2005 level, increase the share of non-fossil fuels in primary energy consumption to around 15% by 2020 and increase forest coverage by 40 million hectares and forest stock volume by 1.3 billion cubic meters by 2020 from the 2005 levels. These actions are taken on a voluntary basis and are unconditional.

In addition, China is implementing domestic energy efficiency targets and emission intensity targets and various other measures with effect on greenhouse gas emissions. Discussions on additional national policies are ongoing, e.g. on an absolute national energy target.

Major uncertainties in the allowed emissions in 2020 under the proposed target are (see also Figure A3):

- **Quantifying actions submitted to the Cancun Agreements**: China did not provide an official quantification of emissions as a result of its actions. There remains uncertainty over how a baseline should be defined to measure the emission deviations relative to what would otherwise happen without strong programmes and matching actions. In addition, given the global economic situation, there are uncertainties for China's future economic growth and energy consumption. There is a significant variation in modelling groups' assumptions on the BAU trajectory for China's emissions (ranging 2 $GtCO_2e$ in 2020), which translates into a wide range of expectations on the impact of China's unconditional pledge.

- **Stronger actions or measures:** China is moving towards strong implementation of national policies and measures in step with its response strategies that are to be continued in the long run to realize its low-carbon and environmentally sound goals. The recently released more ambitious targets for renewable energy deployment over the 12th Five Year Plan period in the July 2012 version of China's

[7] http://www.planalto.gov.br/ccivil_03/_Ato2007-2010/2010/Decreto/D7390.htm

development plan represent another highlight of such efforts; furthermore hydroelectricity potential is planned to be exploited and nuclear power projects are expected to continue subject to government-enforced stricter checks, despite the aftermath of the Fukushima accident. All of these indications offer reassurance that the country is well on track to achieve the objectives described by its international pledge - or even more.

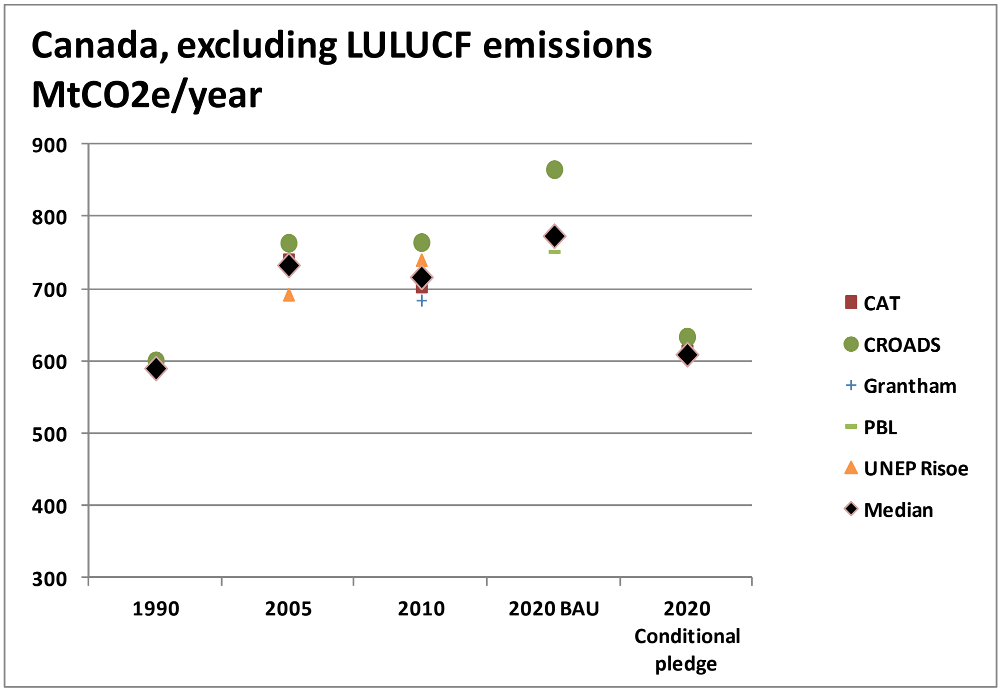



**Figure A3:** Historical emissions and pledges according to different modelling groups for Canada

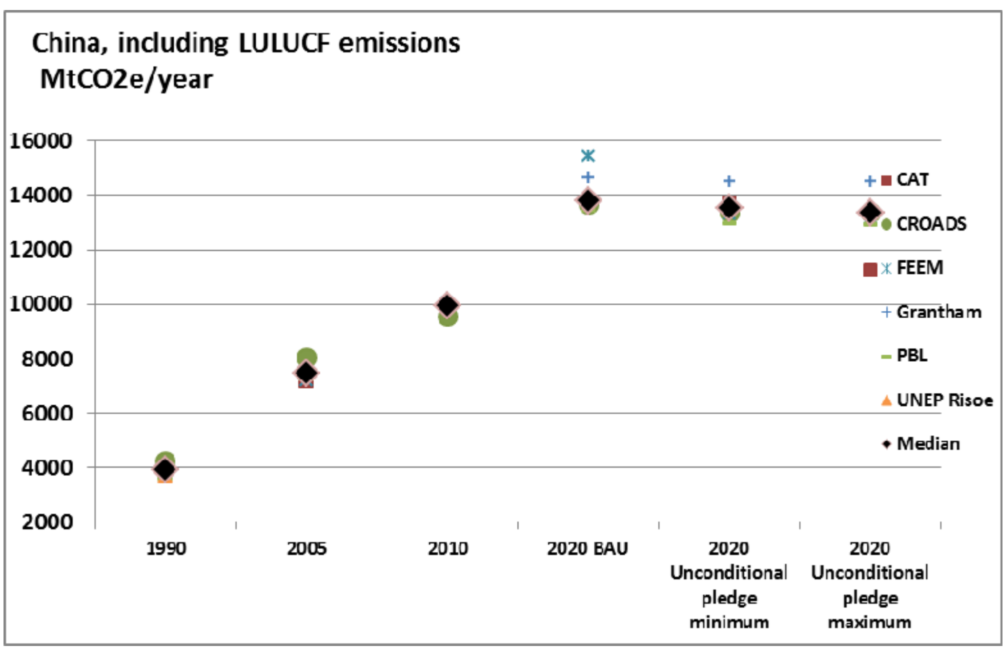



**Figure A4:** Historical emissions and pledge according to different modelling groups for China

## EU 27

The EU27 has proposed to decrease emissions in the range of 20 to 30% below 1990 by 2020 with the ambition level being dependent on other countries' actions and to reduce emissions by 80-95% below 1990 by 2050. The EU's ambitious reduction target for 2020 of 30% is conditional "on a global and comprehensive agreement post-2012 provided other developed countries commit to comparable reductions and developing countries contribute according to their capacities."

Major uncertainties in the allowed emissions in 2020 under the proposed target are

- **Conditionality**: Although the conditions for a comprehensive post 2012 agreement have not so far been met, the EU is currently discussing whether to increase its ambition level to 30%, with LULUCF accounting to be added to this.

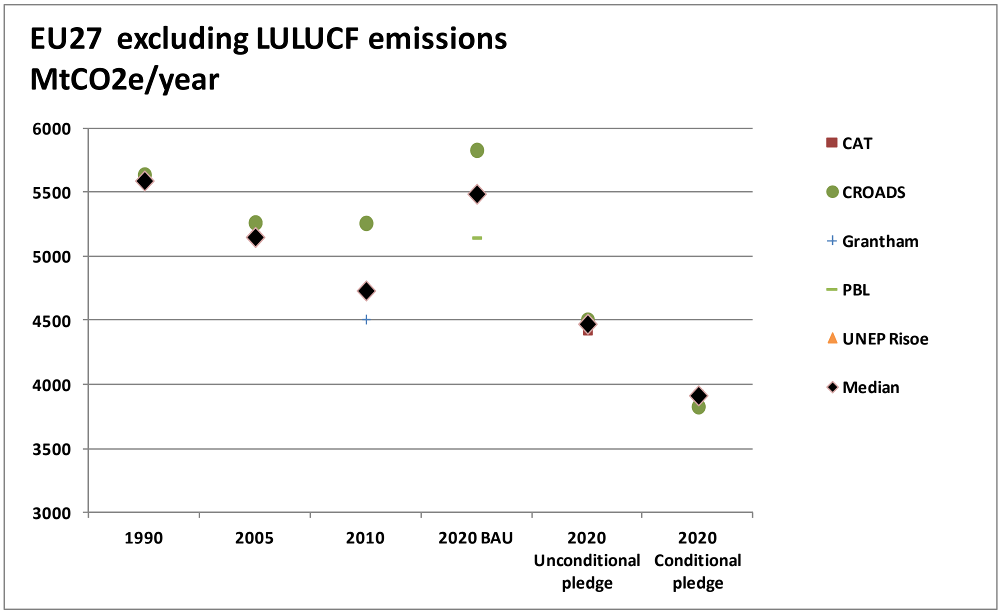



**Figure A5:** Historical emissions and pledges according to different modelling groups for EU 27

## India

India has pledged to "reduce the emission intensity of its GDP by 20 to 25% by 2020 in comparison to the 2005 level. The emissions from the agriculture sector will not form part of the assessment of emissions intensity."

India earlier announced a National Action Plan on Climate Change, which provides eight national missions in key areas.[8] In addition, detailed targets on the electricity sector are contained in the 11th 5-year plan.

Major uncertainties in the allowed emissions in 2020 under the proposed target are (see also Figure A6):

- **Quantifying actions submitted to the Cancun Agreements**: India recently provided an official quantification of emissions as a result of its actions based on two possible forecasts of GDP growth of 8 and 9% per year.[9] One team (PBL) has incorporated the national emission estimate of the intensity target for India. Other modelling groups have performed their own quantifications and find a wide range of forecasts on the BAU and hence emissions impact of the pledge. Using different data sources and future GDP growth rates, many modelling groups find the proposed reduction in emissions per GDP to be close to the BAU. In the case where modelling groups found the emissions intensity target to result in emissions higher than the BAU, some modelling groups

[8] A summary document is available from the Ministry of Environment and Forests at http://moef.nic.in/downloads/public-information/India%20Taking%20on%20Climate%20Change.pdf

[9] http://moef.nic.in/downloads/public-information/Interim%20Report%20of%20the%20Expert%20Group.pdf.

took the BAU emissions level as the pledge, others; (Climate Action Tracker) took the higher case.

- **Additional actions not in the Copenhagen pledge:** India's National Action Plan on Climate Change includes additional actions that are not part of the pledge submitted to the Cancun Agreements. These could result in reductions additional to the international pledge.

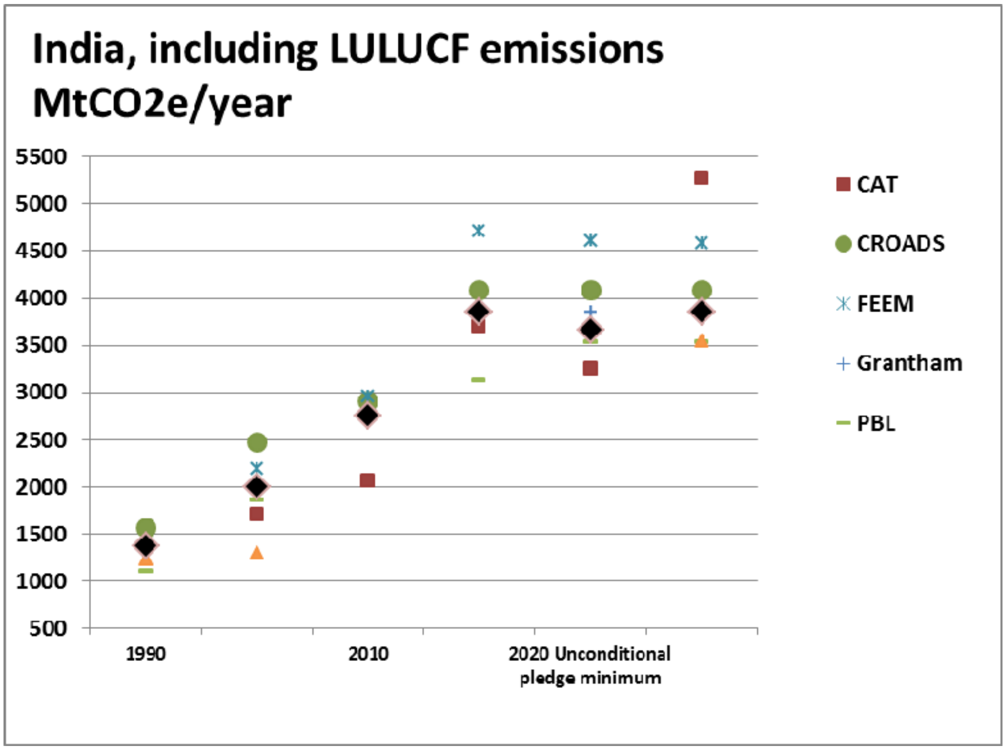



**Figure A6:** Historical emissions and pledges according to different modelling groups for India

## Indonesia

Indonesia has submitted a pledge to the Cancun Agreements to cut emissions by 26% by 2020 from BAU levels. Earlier announcements noted that with international support, Indonesia could cut its emissions by as much as 41%, although these announcements have not been inscribed in the Cancun Agreements. In this assessment we have taken the 26% pledge as an unconditional pledge, and the 41%, if modelled by the modelling groups, to be conditional.

Major uncertainties in the emissions in 2020 under the proposed target are (see also Figure A7)

- **Historical and future business-as-usual emissions from deforestation and peat:** Indonesia did not provide historical emissions and a BAU projection directly with the target. A number of studies used a BAU as provided in a separate report of the Indonesian government[10]. In that report 80% of the emissions come from deforestation and peat, which have a high degree of uncertainty. There is a large discrepancy between emissions levels assumed for Indonesia both historically and projected for the BAU (range of almost 2 $GtCO_2e$ in 2020).

[10] Indonesia's greenhouse gas abatement cost curve. Dewan Nasional Perubahan Iklim, Indonesia. August 2010 http://www.dnpi.go.id/report/DNPI-Media-Kit/reports/indonesia-ghg_abatement_cost_curve/Indonesia_ghg_cost_curve_english.pdf

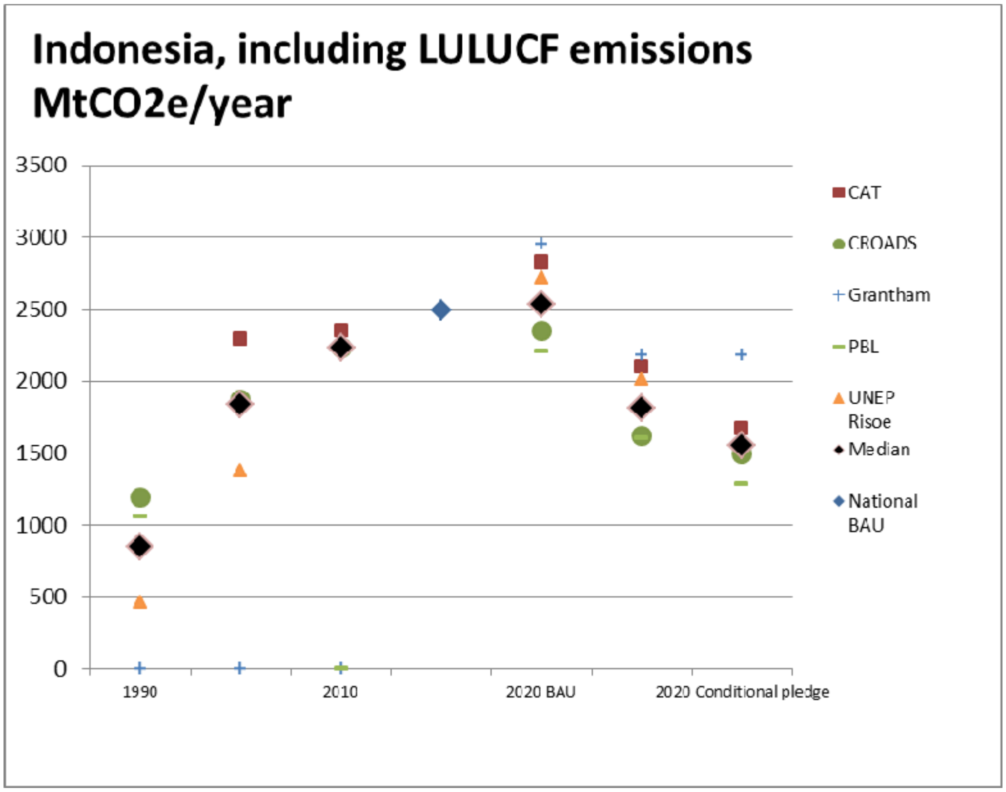



**Figure A7:** Historical emissions and pledges according to different modelling groups for Indonesia

## Japan

Japan proposed to decrease emissions to 25% below 1990 levels by 2020. The 2020 target is explicitly conditional on an effective international framework. Japan has not proposed an alternative (unconditional) target for 2020.

Major uncertainties in the allowed emissions in 2020 under the proposed target are (see also Figure A8):

- **Conditionality**: In particular, the absence of an unconditional target makes it difficult to assess the likely emissions in 2020. For the pledge cases constructed in the UNEP Emissions Gap Report 2012, we have assumed the BAU emissions as the unconditional pledge, although this is likely to be an upper bound of expected emissions in 2020.

## Mexico

In its submission under the Cancun Agreements, "Mexico aims at reducing its GHG emissions up to 30% with respect to the BAU scenario by 2020 provided the provision of adequate financial and technological support from developed countries as part of a global agreement."

Mexico has a detailed Special Climate Change Program up to 2012, which includes measures and their effects on emissions. The resulting emission reductions up to 2012 are a first unconditional step. This Program claims to be in line with an overall strategy to reduce emissions by 50% by 2050, which assumes moderate reductions in the early years and more ambitious reductions later. Funding is secured for the reductions up to 2012.

Major uncertainties in the allowed emissions in 2020 under the proposed target are:

- **Conditionality**: The 2020 pledge is conditional on financial support from developed countries. It is, however, unclear how much financial support is needed to achieve the 2020 conditional target. Over the next few years, the international community will have to agree on the eligibility criteria to qualify for support.

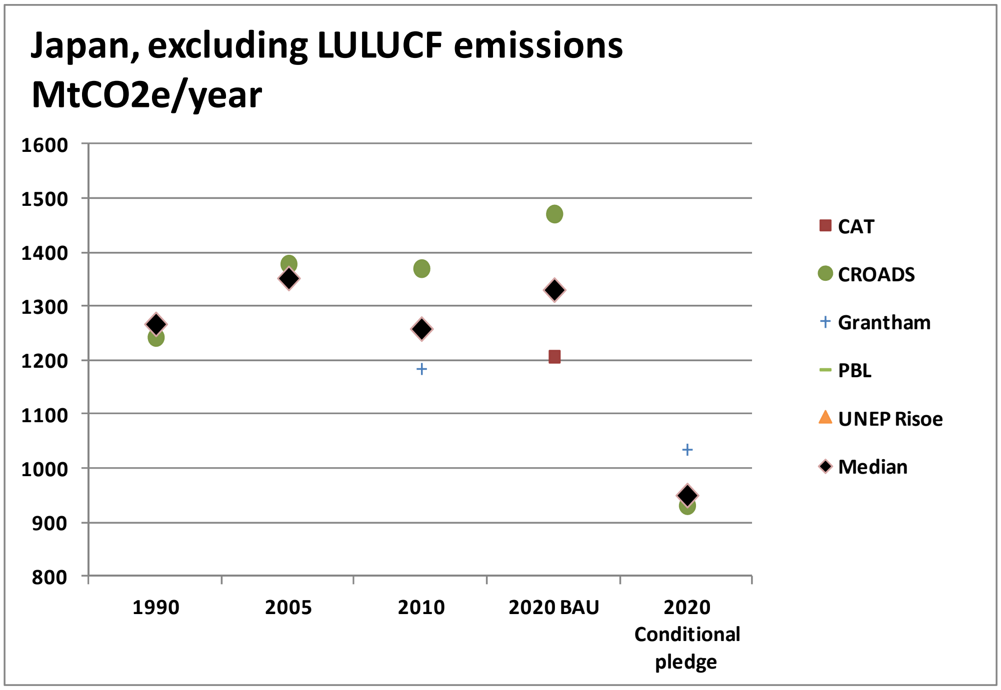



**Figure A8:** Historical emissions and pledges according to different modelling groups for Japan

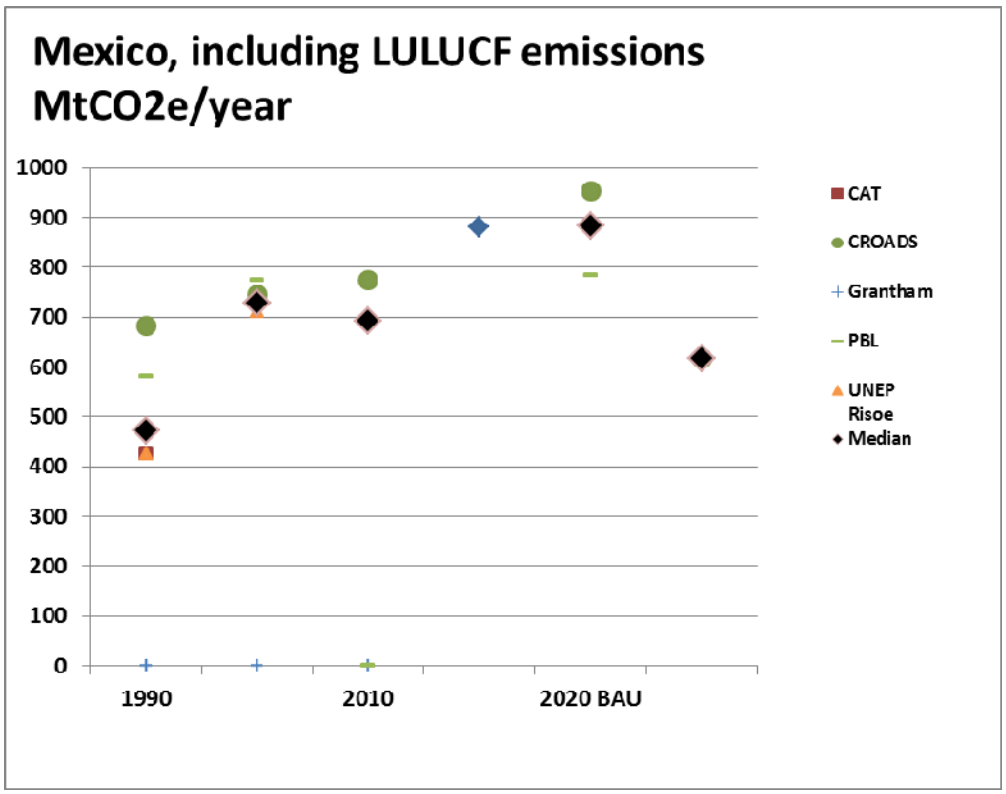



**Figure A9:** Historical emissions and pledges according to different modelling groups for Mexico

## Russian Federation

The Russian Federation proposes to reduce emissions by 15-25% below 1990 by 2020, conditional on appropriate accounting of LULUCF and major emitters accepting legally binding obligations. For the purposes of this assessment, the 15% pledge is, therefore taken to be unconditional, and the 25% to be conditional.

Major uncertainties in the allowed emissions in 2020 under the proposed target are:

- **Conditionality**: the conditions for the application of the target are unclear.
- **Accounting for LULUCF**: Russia has very large forest areas and, therefore, large potential $CO_2$ uptake from them. Accounting for LULUCF can have a significant impact on reaching the target.
- **Carryover of allowances**: Russia's emissions are substantially below its Kyoto target. Russia, therefore, has excess allowances. If these are carried over to be used in a second commitment period of the Kyoto Protocol then the effective emissions limit for Russia would be far less ambitious. The current position of Russia is not to take part in the second commitment period of the Kyoto Protocol, but Russia stands for the transfer of unused quotas for the period after 2012.
- **New surplus allowances:** In addition, many modelling groups calculate Russia's 2020 pledge will result in higher emissions than the BAU projection, leading to new surplus allowances generated by 2020. In this assessment we have excluded these surplus emissions allowances from the 'strictly applied' pledge cases presented in the Emissions Gap Report, and included them in the 'leniently applied' pledge cases only. The chart below, however, displays the excess emission allowances (shown by results of unconditional and conditional pledges higher than the BAU).

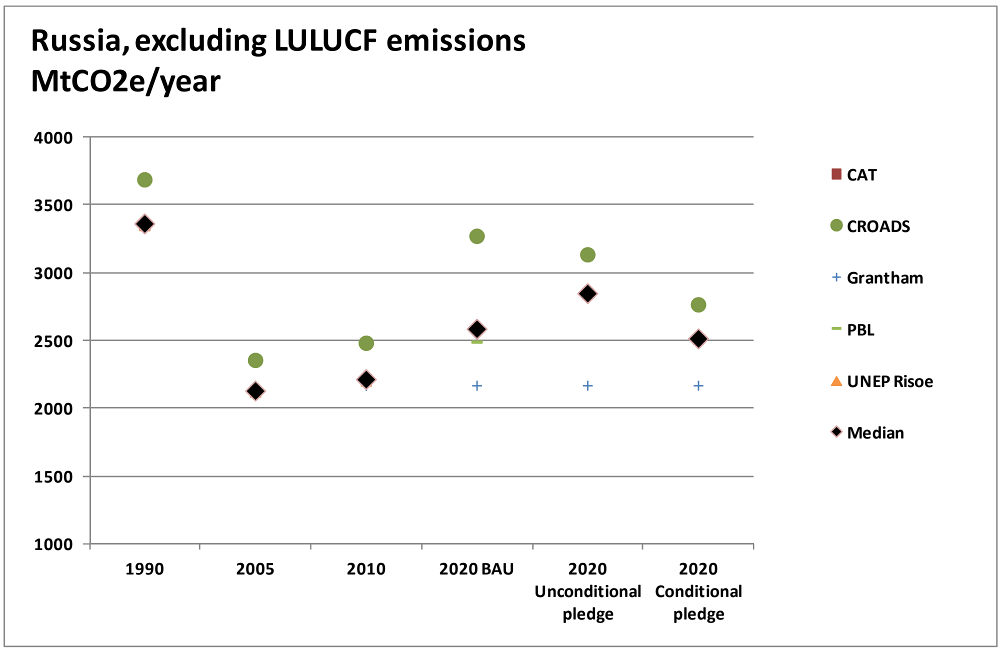



**Figure A10:** Historical emissions and pledges according to different modelling groups for the Russian Federation

## South Africa

South Africa has pledged to undertake mitigation actions which will result in a deviation below the BAU emissions growth trajectory of "around" 34% by 2020 and by "around" 42% by 2025. This level of effort enables South Africa's emissions to peak between 2020 and 2025, plateau for approximately a decade and decline in absolute terms thereafter. This undertaking is conditional on a fair, ambitious and effective agreement in the international climate change negotiations under the UN Framework Convention on Climate Change and its Kyoto Protocol and the provision of support from the international community.

For the purposes of this assessment, South Africa's pledge is taken to be conditional. For the unconditional case, the BAU projections were assumed due to the absence of an official unconditional estimate, unless modelling groups had modelled something separately. However, the BAU projections could be considered an upper bound to the country's emissions in 2020 given the domestic climate policies that the country is expected to implement.

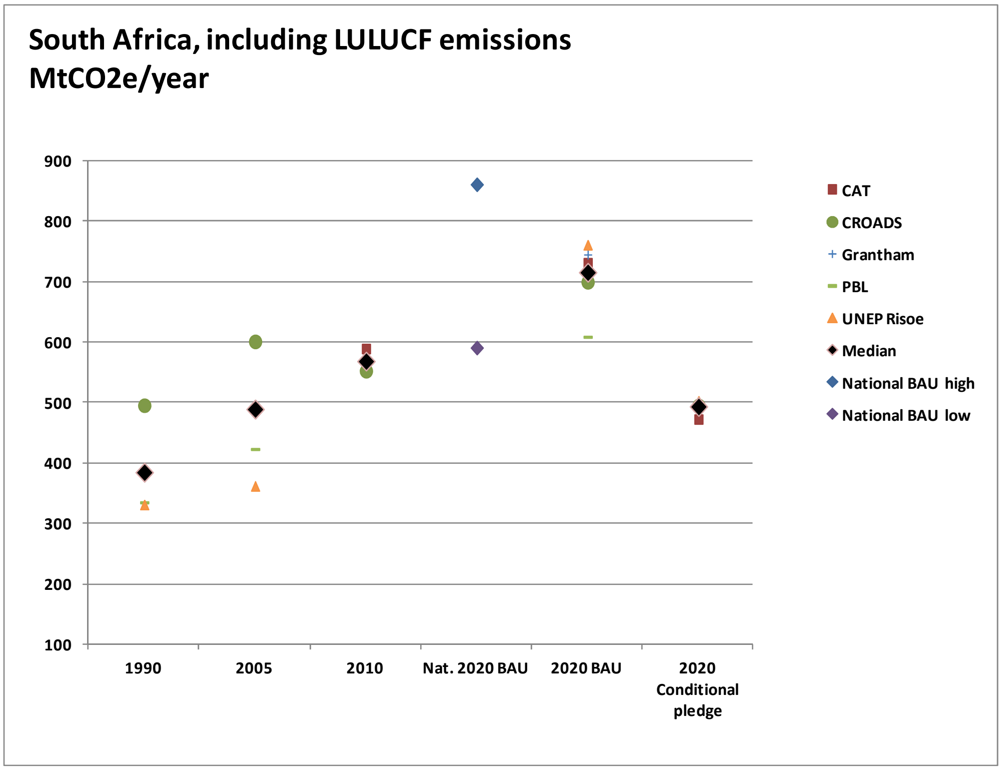



**Figure A11:** Historical emissions and pledges according to different modelling groups for South Africa

South Africa had already provided a comprehensive study of long-term mitigation pathways and options up to 2050 in 2007.[11] This served as a basis for their announcement. A policy process to further define South Africa's response to climate change is underway, and a White Paper (policy document) was approved by Cabinet in October 2011 after public consultation.

Major uncertainties in the allowed emissions in 2020 under the proposed target are:

- Business-as-usual: South Africa provided a BAU baseline emissions trajectory with a significant uncertainty range.[12] As displayed in the chart, the range used by modelling groups is smaller.
- Conditionality: Further work is needed to define how much financial support is needed to achieve the conditional target.

## South Korea

South Korea has pledged to reduce its emissions to 30% below reference emissions in 2020.

Major uncertainties in the allowed emissions in 2020 under the proposed target are:

- Defining the business-as-usual emission level: An official BAU emissions level was not provided with the pledge, but an official BAU level exists in the national communication. As displayed in the chart, modelling groups have used a significant range of BAU projections through to 2020 for their analyses (range of 300 $MtCO_2e$ in 2020), leading to significant uncertainty in the impact of the pledge (range of 200 $MtCO_2e$ in 2020).

[11] Long Term Mitigation Scenarios. Strategic Options for South Africa. Technical Summary, Scenario Building Team, Department of Environment, Affairs and Tourism, Pretoria, South Africa. (2007)

[12] A benchmark National GHG Emissions Trajectory Range was specified in the White Paper that was approved in Oct 2011.

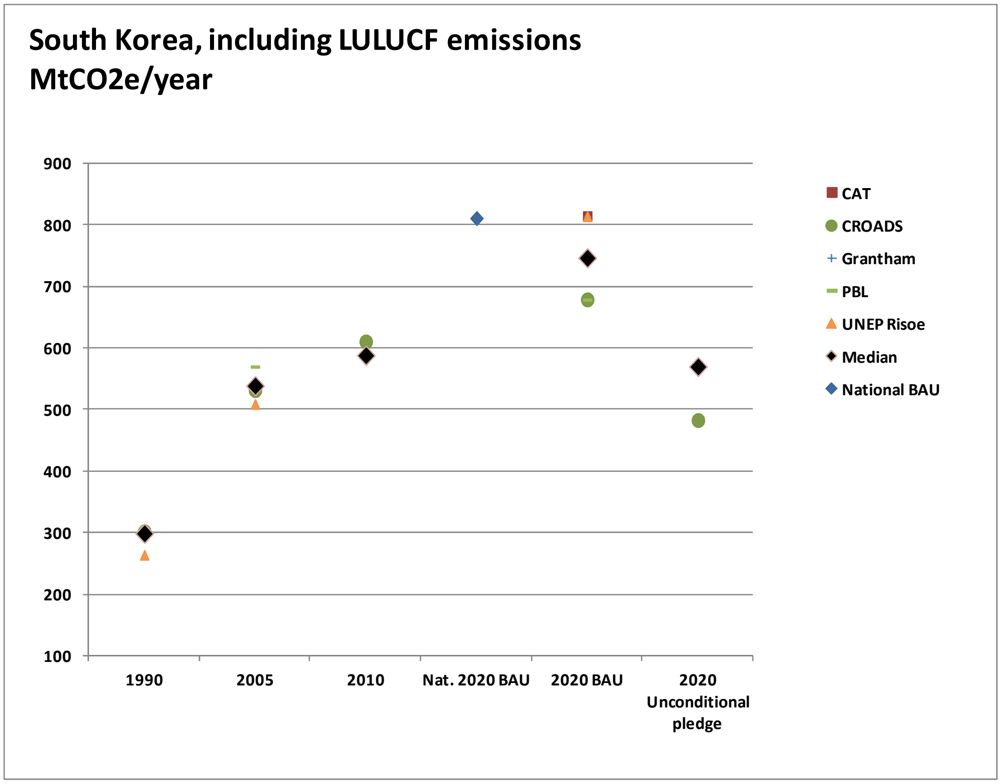



**Figure A12:** Historical emissions and pledges according to different modelling groups for South Korea

### United States of America

The United States of America pledged to reduce emissions in the range of 17% below 2005 levels by 2020, in conformity with anticipated U.S. energy and climate legislation. While this specific legislation is no longer under discussion in the Senate, the US has reaffirmed the 17% commitment. In Cancun, and again in Durban, the USA reiterated its commitment to this pledge, anchoring it in decisions taken in Cancun and Durban. It has provided clarification of the scope and assumptions of the economy-wide target, which includes comprehensive coverage of emissions and removals from the land use, land-use change and forestry sector, and a land-based accounting methodology.

Although the USA has confirmed its pledge, modelling groups have considered it to be conditional because it is stated to be contingent upon domestic legislation. Major uncertainties in the allowed emissions in 2020 under the proposed target are:

- **Conditionality**: For the purposes of the unconditional cases shown in the main report we have assumed BAU emissions as the unconditional pledge level, although this is likely to be an upper bound of expected emissions in 2020, given that there is action on state and regional levels, as well as regulatory control of greenhouse gas emissions. For example, new emissions standards for power plants and for light-duty vehicles exist.
- **Definition of a BAU emissions level:** As displayed in the chart, there is a range among modelling groups' estimations of BAU emissions in 2020 (a range of 1.5 $GtCO_2e$). While this does not affect the emissions levels resulting from the conditional pledge, it does impact the emissions levels resulting from the unconditional pledge for which the BAU estimate is used as a proxy, and is used in the two 'unconditional' pledge cases.

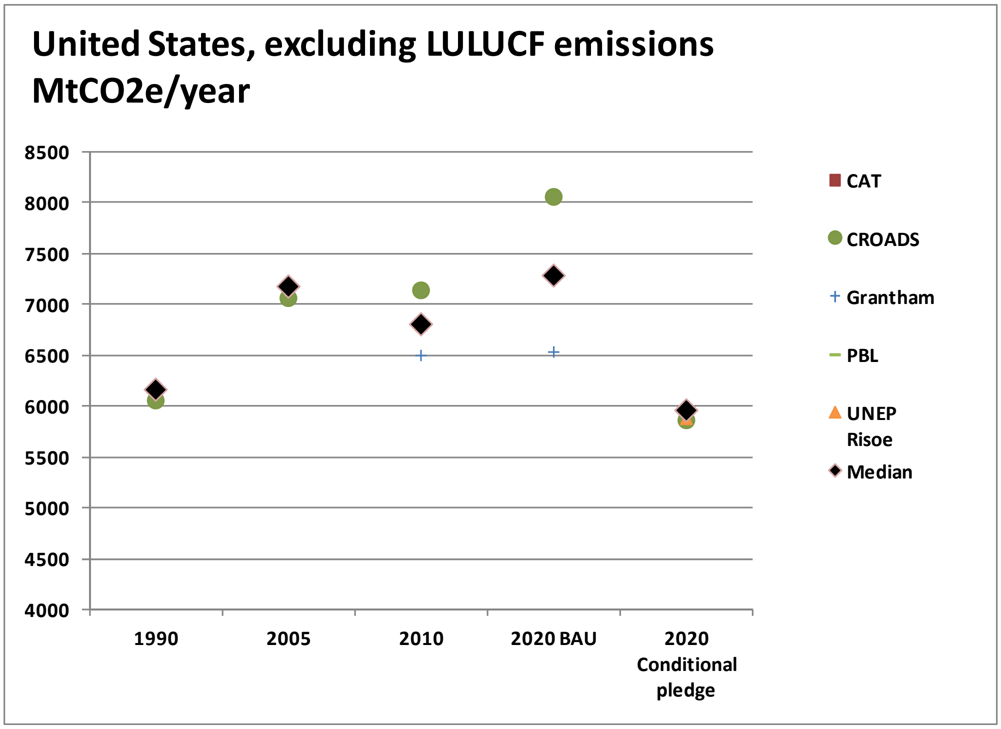



**Figure A13:** Historical emissions and pledges according to different modelling groups for the United States of America

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