Technical Annex - Aggregate effect of the intended nationally determined contributions: an update

A. Overall approach

1. The synthesis report aggregated all INDCs communicated by 4 April 2016 individually, country-by-country, and on a gas-by-gas basis. All INDCs communicated by 4 April 2016 were included in the analysis. This technical annex provides additional information regarding the methods used to aggregate the emission levels resulting from the INDCs.

2. Unless otherwise stated, the estimates of emission levels are medians and associated 20% to 80% percentile ranges of the distribution that account for uncertainties in the aggregation and take into account any ranges of effort provided in some INDCs as well as conditional and unconditional levels of effort included therein.

3. Unless otherwise stated, the resulting ranges for 2025 and 2030 comprise both a high and low variant of the INDCs from every country. The high variant aggregates all unconditional INDC targets (or the upper ends of any unconditional ranges) or, if a Party did not communicate an unconditional INDC target, the reference scenario. The low variant aggregates all conditional INDC targets (or the lower ends of any conditional ranges). If a Party did only communicate an unconditional INDC target, the unconditional INDC target (or the lower ends of any unconditional ranges) is taken for the aggregation in this low variant or, if no target is communicated, the reference scenario.

4. As a sensitivity case, the effect of the conditional targets is quantified. This requires a comparison between two cases: one in which the conditions specified in INDCs, if conditions are stipulated, are fulfilled (the conditional case); and one in which they are not (the unconditional case). The difference between emissions in the conditional case and in the unconditional case represents the effect of the conditional targets.

5. In the conditional case, for each INDC, the lower emission variant is determined as described in paragraph 3, while the higher emission variant also includes the conditional target, if one is provided (or higher end of a conditional target range). Where only an unconditional target is provided, the higher emissions variant includes the unconditional target (or upper end of an unconditional target range).

6. In the unconditional case, for each INDC, the higher emission variant is calculated as described in paragraph 3, while the lower emissions variant includes only the unconditional target (or the lower end of an unconditional target range). If only a conditional target is provided, the lower emissions variant includes the reference case scenario.

B. Sources of information

7. In order to arrive at a consistent aggregation using a single metric, the synthesis report is based on aggregation on gas-by-gas data for every country which communicated an INDC. The use of the single metric was applied consistently. Each INDC was considered individually for the aggregation. Thus, any assumptions underlying this synthesis report to arrive at global aggregate emissions numbers were taken without prejudice towards any Parties' actual emissions.

8. For Parties that specified emission levels by 2025 or 2030 using global warming potentials (GWP) with a 100-year time horizon according to the Fourth Assessment Report (AR4) metrics, as well as for those countries which did not specify any chosen metric, no changes were made to the indicated emission level prior to the aggregation in the default calculation.

9. For Parties that used a metric different from GWP AR4 to report emission levels by 2025 or 2030, a conversion towards GWP AR4 weighted greenhouse gas emissions was undertaken based on the gas-by-gas emission data basis. For historical emission trends, gas-by-gas estimates were taken from the national greenhouse gas inventory and/or the national communication of those countries, if available, including, where applicable, net land use, land-use change and forestry emissions as contained in the online UNFCCC database[1].

10. If a national greenhouse gas inventory and/or the national communication was not available, complementary data sources were used, namely data compiled by IPCC Working Group III to the Fifth Assessment Report for the purposes of deriving global emissions[2]. These complementary data sources are listed on the UNFCCC website[3] (in particular IEA data and EDGAR v.4.2 data).

11. Finally, in very rare cases where the data sources compiled in the IPCC Working Group III historical database were insufficient for individual countries, other data-sources that contained country-specific data from the sources listed on the UNFCCC website[4] were used.

12. In summary, the country-by-country aggregation relies on official UNFCCC data, complemented by the data contained in the historical IPCC Working Group III database, where necessary in order to arrive at gas-by-gas emission estimates. Sensitivity tests with alternative data sources, like the CAIT compilation[5] or PRIMAP compilation[6] were undertaken and confirmed that any particular's country data choices had only a very minor effect on the estimates of the global aggregate effect in terms of 2025 and 2030 emissions.

C. Global warming potentials

13. As mentioned above, Parties communicated their INDCs using different metrics, including GWP with a 100-year time horizon according to the Second IPCC Assessment Report (SAR) or AR4. The synthesis report aggregates all emissions covered by INDCs in a consistent manner using a single metric, namely the GWPs with a 100-year time horizon as set out in the Working Group I contribution to the Fourth Assessment Report of the IPCC (GWP-100 AR4, see table 1).

14. Consistent with the aggregation of the INDCs, all IPCC pre-INDC reference scenarios and 2°C mitigation scenarios as well as the 1.5°C scenarios were aggregated using the same GWP-100 year AR4 metric.

15. The respective GWP values applied under the different metrics for CO_2, CH_4, N_2O and SF_6 are presented in Table 1 below.

[1] Accessible here: <http://unfccc.int/di/FlexibleQueries.do>, status as of 1st October 2015.

[2] As displayed in global aggregate in Figure SPM.1 of IPCC Working Group III to the Fifth IPCC Assessment Report.

[3] See <http://unfccc.int/ghg_data/ghg_data_non_unfccc/items/3170.php>

[4] See <http://unfccc.int/ghg_data/ghg_data_non_unfccc/items/3170.php>

[5] See <http://cait.wri.org>

[6] See <https://www.pik-potsdam.de/members/johannes/primaphist-dataset-description>

16. Table 2 provides a brief comparison of the main aggregation results using GWP-100 SAR and GWP-100 AR5 values with those presented in the synthesis report (based on GWP-100 AR4 values).

Table 1

Comparison of the GWPs used to aggregate emissions from different greenhouse gases[a]

	GWP-100 SAR	*GWP-100 AR4*	*GWP-100 AR5*[b]
CO_2	1	1	1
CH_4	21	25	28
N_2O	310	298	265
SF_6	23900	22800	23500

Abbreviation: GWP-100 SAR = ‘Global warming potentials with a 100-year time horizon according to the Second IPCC Assessment Report’, GWP-100 AR4 = ‘Global warming potentials with a 100-year time horizon according to the Fourth Assessment Report of the IPCC’, GWP-100 AR5 = ‘Global warming potentials with a 100-year time horizon according to the Fifth Assessment Report of the IPCC’

Notes: For the purpose of the synthesis report on the aggregate effect of INDCs values from the GWP-100 AR4 are used.

[a] Note that for most countries, no gas-by-gas disaggregation into individual HFC and PFC gases was available. Hence, for aggregate HFCs and PFCs, an approximate illustrative conversion was used that assigned 10% higher weight under GWP-100 AR4 than under GWP-100 SAR and likewise a 20% higher weight for GWP-100 AR5 compared to GWP-100 SAR. Although included in a number of INDCs, NF_3 emissions were not taken into account in this synthesis report due to a lack of country-by-country data.

[b] GWP-100 AR5 values are here those without carbon cycle feedback effects.

Table 2

Aggregate global emissions (including net emissions and removals from land-use change) in 2025 and 2030 resulting from INDCs, IPCC pre-INDC reference trajectories and 2°C mitigation pathways as well as 1.5°C scenarios under different GWPs with 100 year time horizon

	2025			*2030*		
GWP	*SAR*	*AR4*	*AR5*	*SAR*	*AR4*	*AR5*
INDC (full range of unconditional and conditional contributions)						
20%	50.1	51.4	52.4	50.9	52.0	53.0
Median	53.7	55.0	55.9	54.9	56.2	57.1
80%	56.0	57.3	58.3	58.0	59.3	60.3
IPCC pre-INDC reference scenarios[a]						
Median	56.5	57.7	58.3	59.5	60.8	61.4
2°C mitigation scenarios with >66% chance, starting in 2010 (P1)						
20%	37.0	38.2	38.8	37.0	38.3	38.8
Median	43.0	44.3	45.0	41.4	42.7	43.4
80%	45.3	46.6	47.3	42.4	43.6	44.3
2°C mitigation scenarios with >66% chance, starting in 2020 (P2)						

	2025			*2030*		
GWP	*SAR*	*AR4*	*AR5*	*SAR*	*AR4*	*AR5*
20%	45.0	46.2	46.7	29.1	30.3	30.8
Median	48.3	49.7	50.4	36.9	38.1	38.7
80%	50.4	51.6	52.2	43.7	45.0	45.7
2°C mitigation scenarios with >66% chance, starting in 2010 and 2020 (P1 & P2)						
20%	41.8	43.0	43.6	35.1	36.3	36.9
Median	44.2	45.4	46.0	41.3	42.5	43.1
80%	47.6	48.9	49.5	42.4	43.6	44.3
1.5°C mitigation scenarios with >50% chance by 2100, starting in 2010 (P1)[7]						
20%	33.1	34.3	34.8	28.0	29.2	29.7
Median	36.3	37.4	38.0	30.8	32.0	32.5
80%	39.8	40.9	41.5	34.7	35.9	36.4
1.5°C mitigation scenarios with >50% chance by 2100, starting in 2020 (P2)						
20%	43.5	44.8	45.5	36.1	37.4	38.0
Median	47.9	49.2	49.8	38.4	39.5	40.0
80%	49.1	50.3	51.0	40.1	41.2	41.7
1.5°C mitigation scenarios with >50% chance by 2100, starting in 2010 and 2020 (P1 & P2)						
20%	33.4	34.5	35.0	28.5	29.6	30.2
Median	37.2	38.4	39.0	32.8	33.9	34.4
80%	41.5	42.7	43.3	36.1	37.3	37.9

Abbreviation: GWP = 'Global warming potentials', SAR = Second IPCC Assessment Report', AR4 = 'Fourth Assessment Report of the IPCC', AR5 = 'Fifth Assessment Report of the IPCC'

Notes: The median is presented alongside with the 20% to 80% percentile range for the aggregate global emissions under INDCs and the 2°C mitigation scenarios.

[a] The IPCC pre-INDC reference scenarios are here weighted by the proportional usage within the INDC aggregation. Some of the IPCC reference scenarios did not present growth rates for all considered regions in the AMPERE database. Those particular scenarios are hence effectively weighted proportionally less. The difference due to the weighting is very small (<0.1 Gt), with unweighted IPCC reference scenario medians being 56.5, 57.8, 58.4 Gt for 2025 and the SAR, AR4 and AR5 GWP-100 year metrics and 59.5, 60.9 and 61.5 Gt for 2030 and the SAR, AR4, and AR5 GWP-100 year metrics, respectively.

D. National emissions and removals from LULUCF

17. Parties used a variety of approaches to account for emissions and removals from LULUCF. Some Parties used approaches that are similar to those established under the Kyoto Protocol, that is, through credits and debits from eligible LULUCF activities. In case Parties did not specify the suggested specific rule set, reported emissions and removals in the following activities were taken as the basis to calculate future net credits: forest management, grazing land management, cropland management and wetland management, as well as afforestation, reforestation and deforestation. It was assumed that emissions and

[7] Erratum: In footnote 75 of the Updated Synthesis Report, the footnote should start with "For P1 scenarios, the emission level in 2030 is 32.0 (29.2 to 35.9) Gt CO_2 eq, …" consistent with the table above.

removals from those activities remain constant in the future – unless the Party reported a ‘with-measures’ scenarios specifically for the LULUCF sector, in which case that scenario was used.

18. Other Parties included the LULUCF sector like any other sector (e.g. full carbon or land-based accounting). Similarly to the activity-based approach outlined above, unless a ‘with-measures’ scenario was communicated as part of the INDC, or was available for that Party, for example from the national communication or biennial update report, it was assumed that emissions and removals from LULUCF remained constant in the future at a level that corresponds to the latest reported historical level.

E. Global land use, land-use change and forestry emissions and removals

19. Under the UNFCCC, emissions and removals from LULUCF reported by Parties include substantial carbon uptakes in managed forests. In the scenarios contained in the IPCC AR5 scenario database, such uptakes tend not to be represented. This is largely a definitional issue in terms of which CO_2 removals are considered to be anthropogenic, which in the case of the IPCC scenarios is limited to net emissions from land-use change.

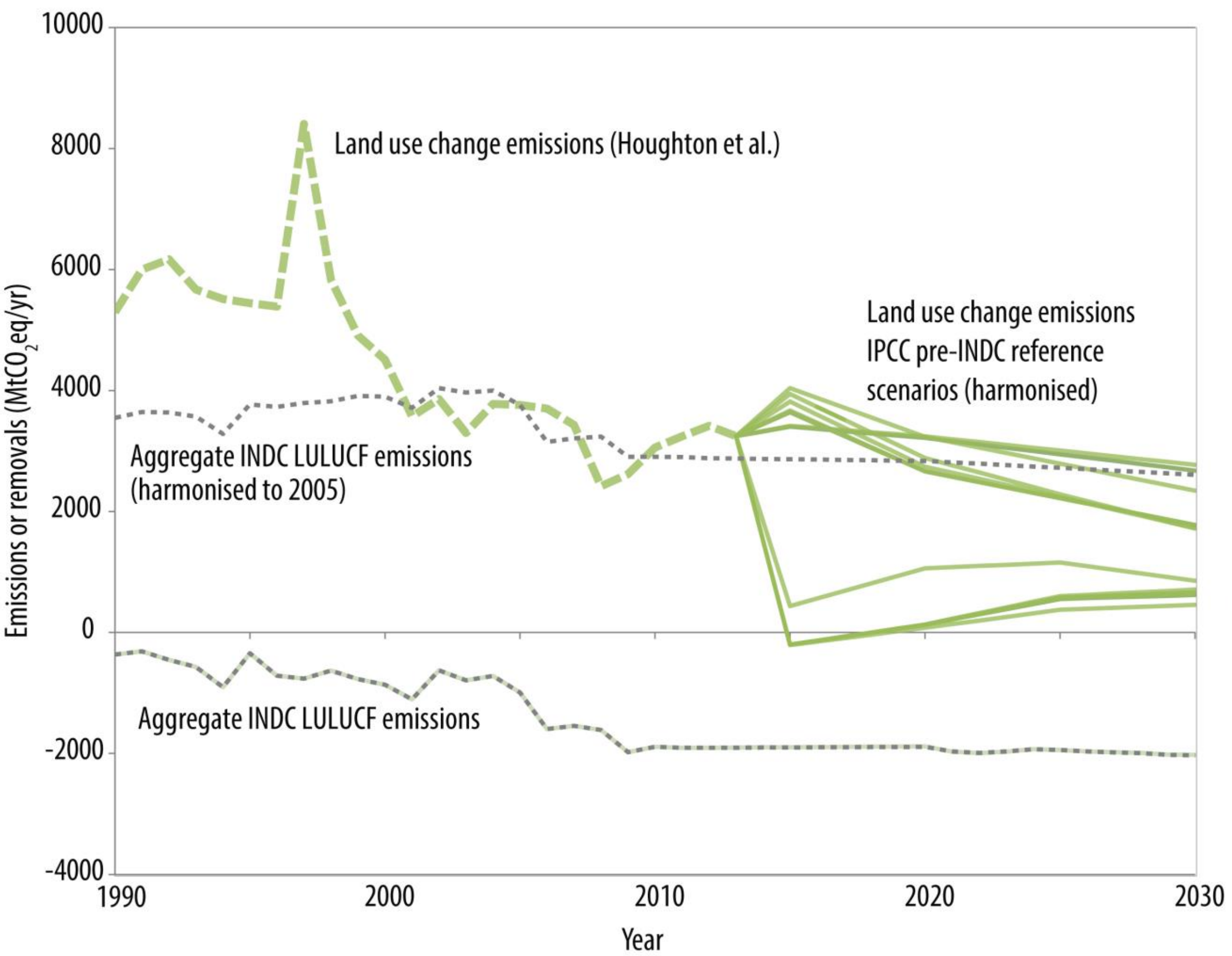
20. In order to arrive at global emission estimates reflecting INDCs by Parties that are consistent with the trajectories within the IPCC AR5 scenario database, this synthesis report complemented the aggregated global non-LULUCF emissions aggregated from countries INDCs with the global land-use change emission projections from the IPCC pre-INDC reference scenarios (see Table 3).

21. Compared with the aggregate LULUCF emissions and removals based on data from Parties’ inventories or national communications,[8] most IPCC pre-INDC reference scenarios present either a higher or equal decrease of global net emissions until 2025 and 2030 relative to 2005 levels. Specifically, the Parties’ aggregate LULUCF emissions and removals show a decrease of approximately 1 Gt CO_2 between 2005 and 2030 (see green and grey dashed line in Figure 1 below). Similarly, most global IPCC pre-INDC reference scenarios show a decrease of 1 $GtCO_2$ or more for the same period.

22. In summary, the aggregate global emissions levels estimated for 2025 and 2030 reflecting INDCs, the IPCC pre-INDC reference scenarios and 2°C mitigation scenarios as well as the historical emission levels all account for land-use change related emissions. This enables a comparison of emission scenarios that are consistent and assessment of the aggregate effect of INDCs.

[8] The last reported historical datapoint has been assumed constant, if no “with measures” projection was available.

Figure 1
Comparison of aggregate land use, land-use change and forestry emissions and removals and land-use change emissions from the IPCC pre-INDC reference scenarios



Notes: IPCC pre-INDC reference scenarios are extended backwards using the Houghton et al. emissions. For comparison, the aggregate LULUCF emissions from UNFCCC national inventories, biennial update reports, and biennial reports (green dashed line) is shifted (grey dashed line) to the same 2005 emission level as the IPCC AR5 pre-INDC reference scenarios (see Table 3).

The used dataset for pre-2012 emissions to extent the IPCC AR5 scenarios is one of the most frequently used dataset within the IPCC Assessment and compilations like the Global Carbon Project. The data is available at <http://www.globalcarbonproject.org/carbonbudget/14/data.htm> and the reference is: Houghton, RA, van der Werf, GR, DeFries, RS, Hansen, MC, House, JI, Le Quéré, C, Pongratz, J and Ramankutty, N 2012. Chapter G2 Carbon emissions from land use and land-cover change, Biogeosciences, 9, 5125-5142. Doi: 10.5194/bgd-9-835-2012.

F. Interpolations and extrapolations

23. Parties submitted their INDCs for different target years, primarily 2025 and 2030. In order to arrive at a 2025 global emission level, emissions for countries with only a 2030 INDC target year were interpolated linearly with two starting points, namely the latest available historical emissions and emission levels consistent with the 2020 Cancun pledge

levels, when available. Results for both linear interpolations were weighted equally in the final results in order to arrive at aggregate global 2025 emission levels.

24. In order to arrive at a 2030 global emission level, emissions for countries that did not communicate a 2030 level were obtained through a linear extrapolation from the difference between 2020 and 2025 emission levels. Two options in turn have been used to obtain 2020 emission levels for the purposes of this extrapolation, namely a linear interpolation between historical emission levels and 2025 or an assessment of the emission levels in 2020 with the Cancun pledges, when available. Both options of this extrapolation for Parties without a 2030 INDC target year are calculated and are part of the uncertainty range. The exception are Parties that have also a 2050 target year, in which case the linear interpolation between 2025 and 2050 emissions levels has been applied to obtain 2030 emission levels instead of the extrapolation.

G. Consideration of emission levels not covered by INDCs

25. The synthesis report aggregates emissions that are covered under the INDCs and adds emissions not covered by INDCs (i.e. emissions from Parties that did not submit an INDC or emissions that are not covered by an INDC) in order to arrive at a global total emission estimate.

26. As there are uncertainties in regard to the changes over time of emissions outside the scope of the presented INDCs, this synthesis report uses a wide range of IPCC pre-INDC reference scenarios from the IPCC AR5 Scenario database. For the purposes of this synthesis report, 22 reference scenarios under the AMPERE project have been chosen, which reflect the effect from the efforts communicated by Parties for the pre-2020 period and assumed no change in climate policies thereafter until 2030.[9] Thus, these scenarios are considered as IPCC “pre-INDC reference scenarios”, with various technological sensitivity cases (see Table 3 below). This set of scenarios can differ slightly from so-called ‘current policy’ scenarios that are used in other studies, the UNEP Emission Gap report for example, as currently implemented policies might or might not be sufficient to achieve individual countries’ Cancun pledges for 2020.

27. All 22 pre-INDC scenarios from the IPCC AR5 database were used individually in several calculations, leading to a number of quantifications for 2025 and 2030 emission levels (see section L below). In a later step of the aggregation, the ranges were then calculated across the ensemble of INDC quantifications. These IPCC pre-INDC reference scenarios reflected in detail 14 of the world regions. In order to derive a range of possible quantifications for emissions outside the INDCs, for downscaling to country-level information, the gas-by-gas specific emission growth or decline rate for the appropriate region was applied to the countries’ latest historical emission profile.

[9] See <https://secure.iiasa.ac.at/web-apps/ene/AMPEREDB/static/download/WP2_study_protocol.pdf>

Table 3
IPCC pre-INDC reference scenarios used in the synthesis report from the IPCC AR5 database

IPCC AR5 Database model group and scenario name
GCAM 3.0 | AMPERE2-450-Conv-HST
GCAM 3.0 | AMPERE2-450-EERE-HST
GCAM 3.0 | AMPERE2-450-FullTech-HST
GCAM 3.0 | AMPERE2-450-LimBio-HST
GCAM 3.0 | AMPERE2-450-LimSW-HST
GCAM 3.0 | AMPERE2-450-LowEI-HST
GCAM 3.0 | AMPERE2-450-NoCCS-HST
GCAM 3.0 | AMPERE2-450-NucOff-HST
IMAGE 2.4 | AMPERE2-450-LowEI-HST
MESSAGE V.4 | AMPERE2-450-FullTech-HST
MESSAGE V.4 | AMPERE2-450-LimSW-HST
MESSAGE V.4 | AMPERE2-450-LowEI-HST
MESSAGE V.4 | AMPERE2-450-NucOff-HST
REMIND 1.5 | AMPERE2-450-Conv-HST*
REMIND 1.5 | AMPERE2-450-FullTech-HST*
REMIND 1.5 | AMPERE2-450-LimBio-HST*
REMIND 1.5 | AMPERE2-450-LimSW-HST*
REMIND 1.5 | AMPERE2-450-LowEI-HST*
REMIND 1.5 | AMPERE2-450-NucOff-HST*
WITCH_AMPERE | AMPERE2-450-FullTech-HST
WITCH_AMPERE | AMPERE2-450-LowEI-HST
WITCH_AMPERE | AMPERE2-450-NucOff-HST

Notes: These IPCC AR5 scenarios are used in this synthesis report in the regional detail as provided in the AMPERE database, accessible here: <https://secure.iiasa.ac.at/web-apps/ene/AMPEREDB/dsd?Action=htmlpage&page=about>
Scenarios marked with a star did not contain sufficient regional detail for two of four of the applied harmonisation options in this report and are hence weighted only half when aggregating global emissions according to the full set of scenarios as displayed in table 2.

H. Cumulative CO_2 emissions calculation

28. Cumulative CO_2 emissions are calculated in two steps. Firstly, annual CO_2 emissions are defined as a time-varying fraction of the GHG emission trajectories. The non-land-use part of these GHG trajectories is linearly interpolated between 2012, 2020, 2025 and 2030. More specifically, a linear interpolation was applied for two periods, namely, between the latest available historical data, e.g. 2012, and 2020 and 2020-2025/2030 using country-by-country assessment of emission levels in 2020 in accordance with the Cancun pledges, when available, or for one period, namely, the latest historical data point and 2025/2030 when no such assessment for 2020 was available. Secondly, the cumulative amount of the annual CO_2 emissions is obtained for the period between 2012 and 2025/2030. The time-varying fraction of CO_2 emissions of total GHG emissions was derived from the IPCC pre-INDC reference scenarios (Table 3). The applied GHG emission harmonisation steps (see Section M) towards IPCC reference scenario levels in year 2010 are applied consistently for CO_2 emissions.

I. Global emissions in 1990, 2000 and 2010

29. The contribution of Working Group III to the AR5 estimated emission for 1990–2010 using GWPs from the IPCC Second Assessment Report for aggregation (see figure SPM.1 in the contribution of Working Group III to the AR5). As mentioned above, for the synthesis report, 100-year GWPs from the AR4 were used.

30. In order to estimate emissions for 1990, and 2000 that are consistent and comparable with the provided future INDC emission estimates, the historical emission estimates were derived from the contribution of Working Group III to the AR5 that were harmonised with 2005 emissions from the set of 22 IPCC pre-INDC reference scenarios (Table 3) and adjusted for the different GWP values. Estimated 2010 emission levels were harmonised against the 2010 emissions from the 22 IPCC pre-INDC reference scenarios.

31. Specifically, historical emission estimates are derived by backwards extending IPCC pre-INDC reference scenarios on the basis of UNFCCC inventory data for Parties included in Annex I to the Convention, IPCC historical data for Parties not included in Annex I to the Convention, the Houghton et al. emissions used by the IPCC for land-use change emissions (see Figure 1) and any remainder emission differences in 2010. Those remainder emission differentiates between the bottom-up emission estimates and the IPCC scenarios in 2010 vary from scenario to scenario (–0.1 (–0.2 to 0.8) Gt CO_2 eq), but are small when compared with global emissions (–0.3 (–0.4 to 1.5) per cent). To capture the uncertainty, those remainder differences were backcast by a range of four different methods: (1) keeping the remainder emissions constant, or making them proportional to the other emissions at a (2) global, (3) regional or, where IPCC scenario information was available, (4) country level.

J. Per-capita emissions

32. Per-capita emissions have been derived using the low, medium and high fertility variant scenarios projected by the 2015 revision of the World Population Prospects[10] by the Population Division of the United Nations.

K. The IPCC 2°C mitigation scenarios

33. The synthesis report compares the aggregate global total emissions ranges in relation to INDCs with the sets of mitigation scenarios that allow to keeping the increase in the global mean temperatures below 2°C warming by the end of the century (2°C mitigation scenarios). The synthesis report distinguishes three sets of such scenarios: the group of P1 policy scenarios assumes an immediate (e.g. as of 2010) global mitigation action that is sufficient to achieve a least-cost emission trajectory over the course of the 21st century. The P2 scenarios assume global mitigation action that is sufficient to achieve a least-cost emission trajectory over the course of the 21st century only as of 2020. The P3 scenarios assume further delay of such global mitigation action until 2030.

34. The IPCC AR5 scenarios were filtered according to their respective probabilities of keeping the increase in the global mean temperatures below 2°C warming by the end of the century. The respective probabilities are taken from the part of the IPCC AR5 scenario database. For the P1 and P2 scenarios shown in this synthesis report, all scenarios with a 66% or higher probability of remaining below 2°C over the course of the 21st century were selected. For the P3 scenarios that assume a delay of global mitigation action sufficient to

[10] available at <http://esa.un.org/unpd/wpp>, accessed 1st October 2015

achieve a least-cost emission trajectory over the course of the 21st century until 2030, all scenarios with at least 50% probability of remaining below 2°C were selected. The specific scenarios are shown in Table 4 below.

Table 4

2°C mitigation scenarios used in the synthesis report from the IPCC AR5 database.

P1 scenarios with >66% chance of staying below 2°C warming
GCAM 3.0 | EMF27-450-FullTech
GCAM 3.1 | LIMITS-500
IMAGE 2.4 | AME 2.6 W/m2 OS
IMAGE 2.4 | AMPERE2-450-FullTech-OPT
IMAGE 2.4 | AMPERE3-CF450
IMAGE 2.4 | EMF27-450-FullTech
IMAGE 2.4 | LIMITS-450
MERGE-ETL_2011 | AMPERE2-450-FullTech-OPT
MERGE-ETL_2011 | AMPERE2-450-LimSW-OPT
MERGE-ETL_2011 | AMPERE2-450-LowEI-OPT
MERGE-ETL_2011 | AMPERE2-450-NucOff-OPT
MERGE-ETL_2011 | AMPERE3-CF450
REMIND 1.5 | EMF27-450-FullTech
REMIND 1.5 | LIMITS-450
P2 scenarios with >66% chance of staying below 2°C warming
GCAM 3.1 | LIMITS-RefPol-450
GCAM 3.1 | LIMITS-StrPol-450
GCAM 3.1 | LIMITS-StrPol-500
IMAGE 2.4 | LIMITS-RefPol-450
REMIND 1.5 | LIMITS-RefPol-450
REMIND 1.5 | LIMITS-StrPol-450
P3 scenarios with >50% chance of staying below 2°C warming
GCAM 3.1 | LIMITS-RefPol2030-500
IMAGE 2.4 | AMPERE2-450-LowEI-HST
IMAGE 2.4 | AMPERE2-450-LowEI-LST
MERGE-ETL_2011 | AMPERE2-450-FullTech-HST
MERGE-ETL_2011 | AMPERE2-450-FullTech-LST
MERGE-ETL_2011 | AMPERE2-450-LimSW-HST
MERGE-ETL_2011 | AMPERE2-450-LimSW-LST
MERGE-ETL_2011 | AMPERE2-450-LowEI-HST
MERGE-ETL_2011 | AMPERE2-450-LowEI-LST
MERGE-ETL_2011 | AMPERE2-450-NucOff-LST
MESSAGE V.4 | AMPERE2-450-LimBio-LST
MESSAGE V.4 | AMPERE2-450-LimSW-LST
REMIND 1.4 | ROSE WEAK-2030 DEF
REMIND 1.5 | AMPERE2-450-Conv-HST
REMIND 1.5 | AMPERE2-450-Conv-LST
REMIND 1.5 | AMPERE2-450-FullTech-HST
REMIND 1.5 | AMPERE2-450-FullTech-LST
REMIND 1.5 | AMPERE2-450-LimBio-HST
REMIND 1.5 | AMPERE2-450-LimBio-LST
REMIND 1.5 | AMPERE2-450-LimSW-HST
REMIND 1.5 | AMPERE2-450-LimSW-LST
REMIND 1.5 | AMPERE2-450-LowEI-HST
REMIND 1.5 | AMPERE2-450-LowEI-LST
REMIND 1.5 | AMPERE2-450-NucOff-HST
REMIND 1.5 | AMPERE2-450-NucOff-LST
REMIND 1.5 | LIMITS-RefPol2030-500

L. The 1.5°C mitigation scenarios

35. The synthesis report also compares the aggregate global total emissions ranges in relation to INDCs with the sets of mitigation scenarios that allow to keeping the increase in the global mean temperatures below 1.5°C warming by the end of the century (1.5°C mitigation scenarios). Scenarios used in the report are taken from original scientific literature and not from an IPCC database, given that the AR5 database was predominantly compiled from model inter-comparison exercises that did not envisage a 1.5 °C temperature goal. There are a large number of emission scenarios in the scientific literature of limiting or returning global temperature increase to below 1.5 °C by 2100 with at least a 50 per cent likelihood.

36. The original scientific literature from which 1.5 °C scenarios were taken is: (1) Luderer G, Pietzcker RC, Bertram C, Kriegler E, Meinshausen M, Edenhofer O. 2013. Economic mitigation challenges: how further delay closes the door for achieving climate targets. Environmental Research Letters 8:034033); (2) Rogelj J, McCollum DL, O'Neill BC and Riahi K. 2013. 2020 emissions levels required to limit warming to below 2°C. Nature Climate Change. 3(4): pp.405–412; (3) Rogelj J, McCollum DL, Reisinger A, Meinshausen M and Riahi K. 2013. Probabilistic cost estimates for climate change mitigation. Nature. 493(7430): pp.79–83; assessed and compiled in (4)Rogelj J, Luderer G, Pietzcker RC, Kriegler E, Schaeffer M, Krey V, Riahi K. 2015. Energy system transformations for limiting end-of century warming to below 1.5 °C. Nature Climate Change. 5(6): pp.519–527.

37. As for the 2 °C scenarios, the synthesis report distinguishes two sets of these 1.5 °C scenarios: the group of P1 policy scenarios that assumes an immediate (e.g. as of 2010) global mitigation action that is sufficient to achieve a least-cost emission trajectory over the course of the 21st century. The P2 scenarios assume global mitigation action that is sufficient to achieve a least-cost emission trajectory over the course of the 21st century only as of 2020. However, unlike with 2°C scenarios, there are currently no 1.5°C scenarios in the literature that assume further delay of such global mitigation action until 2030 (P3 scenarios).

38. The scenarios from the scientific literature were filtered according to their respective probabilities of keeping the increase in the global mean temperatures below 1.5°C warming by the end of the century. The respective probabilities were reported for each of the used scenarios following the same method as applied in the IPCC AR5 scenario database for 2°C and other scenarios. For the P1 and P2 scenarios shown in this synthesis report, all scenarios with a 50% or higher probability of remaining below 1.5°C in 2100 were selected. The specific scenarios are shown in Table 5 below. The next generation of sets of 1.5 °C scenarios is expected to include a larger number of 1.5°C scenarios from a wider set of modelling groups and likely form the basis of the forthcoming IPCC Special Report on 1.5°C. Thus, results of this synthesis report in regard to 1.5°C should be seen indicative and only representative of the current state of the scientific literature.

Table 5
1.5°C mitigation scenarios used in the synthesis report from original scientific literature.

P1 scenarios with >50% chance of staying below 1.5°C warming
MESSAGE | BACCESSC30
MESSAGE | BACCESSC31
MESSAGE | BACCESSC32
MESSAGE | BC30
MESSAGE | BC31
MESSAGE | BC32
MESSAGE | RSNCO231
MESSAGE | RSNCO232
MESSAGE | RSNCO233
MESSAGE | RSNCO234
MESSAGE | RSNCO235
MESSAGE | NONUKE30
MESSAGE | L15BCD
MESSAGE | L15BCE
MESSAGE | L15BCF
MESSAGE | L15BCGTRIS
MESSAGE | M15ADVTRANSD
MESSAGE | M15ADVTRANSE
MESSAGE | M15ADVTRANST
MESSAGE | M15RSNONCO2D
MESSAGE | M15RSNONCO2E
MESSAGE | M15RSNONCO2T
REMIND | FFRUN115
REMIND | FFRUN134
REMIND | FFRUN135
REMIND | FFRUN145
REMIND | FFRUN155
REMIND | FFRUN515
REMIND | FFRUN535
REMIND | FFRUN545
REMIND | FFRUN555
REMIND | FFRUN155
P2 scenarios with >50% chance of staying below 1.5°C warming
MESSAGE | L15BCA
MESSAGE | L15BCC
REMIND | FFRUN215
REMIND | FFRUN235
REMIND | FFRUN245
REMIND | FFRUN255

M. Uncertainty ranges

The presented uncertainty ranges for the global emissions in 2025 and 2030 are 20 to 80 per cent ranges and medians across a large number of calculations that intend to capture the main uncertainties associated with an analysis of the aggregate effect. For several analytical steps in the aggregation, where multiple variations best reflect the inherent uncertainties, the synthesis report quantified two or more options. Similarly, the analysis was undertaken for multiple metrics and two cases, one including and one excluding any conditional INDCs. The combination of those variations leads to a quantification of a large number of cases for both the 2025 and 2030 global emission levels. The variations are presented in .

Table 6.

Table 6

Calculated variations underlying the uncertainty ranges of the aggregated global GHG emission levels

Number of calculated variations	*Name*	*Description*
22 (16+6)	pre-INDC reference scenarios	All reference scenarios as listed in Table 3 with 16 of those reference scenarios containing sufficient regional information for 4 harmonisation methods, and 6 containing sufficient regional information for 2 harmonisation methods.
4 (2+2)	Harmonisation methods	This harmonisation method relates to how 2010 emission differences between selected IPCC AR5 pre-INDC reference scenarios and aggregate 2010 global emissions are accounted for in the future. The four methods are (1) scaling with global emission growth; (2) scaling with regional emission growth; (3) scaling with sub-regional growth and (4) a constant adjustment. Methods (2) and (3) are applicable to 16 out of the 22 above reference scenarios.
2	Interpolation method for 2025 emissions	This interpolation choice refers to the two options, either (1) to infer 2025 emission levels as a linear interpolation between 2030 INDC target levels and historical emission levels or (2) with quantified Cancun 2020 pledge levels.
2	Low and high	The low and high sensitivity cases capture the range of presented INDC targets, if any.
2	Conditional vs. unconditional	In the conditional option, all INDC targets, conditional and unconditional, are included in the quantification. In the unconditional option, only the unconditional targets are taken into account. Runs with only unconditional targets are considered as a sensitivity case.
3	Metrics	The calculations underlying this online Annex and the synthesis report calculate results for three metrics, namely GWP-100 SAR, GWP-100 AR4 and GWP-100 AR5 metric levels (without carbon cycle feedbacks). Runs with different metrics are considered separately.

Number of calculated variations	*Name*	*Description*
1824	Total ensemble size	The total ensemble size of quantifications investigated in this study (16*4 + 6 *2) * 2* 2* 2* 3 = 1824, cycling through the options listed above. For a single metric range, including the conditional INDCs, a subset of 304 (=1824/3/2) was investigated.

N. Summary of results from other studies

39. The synthesis report of the aggregate effect on INDCs is a single study undertaken by the secretariat. The results reflect the methodological approach chosen as well as the underlying data provided by Parties in their INDC submissions. The synthesis report does not provide any estimates of expected temperature rise as a result of the implementation of INDCs, as such estimation requires the use of assumptions on the level of mitigation effort and related policies beyond 2030. Making such assumptions is outside of the scope of this report.

40. Several organizations and institutions have undertaken similar exercises. Owing to the use of different methods and data, these studies show somewhat different results albeit broadly consistent in terms of the general messages. For example, all the studies conclude that INDCs have a sizeable impact on expected emission levels in 2025 and 2030 and represent an unprecedented effort in slowing down the growth in global emissions. However, the INDCs are not deemed sufficient to bend the emission curve and to bring emissions to the levels that are in accordance with the cost optimal scenarios to keep temperature rise below 2°C above preindustrial levels. Most of these studies made assumptions of the post 2025 and 2030 climate policy development and arrived at estimates of the temperature increases in relation to INDCs. A summary of these studies is presented in table 6 below.

Table 6
Key quantitative results from selected studies

	Year	UNEP Gap report[a]	CAT[b]	ESRC Centre for Climate Change Economics and Policy[c]	IEA[e]	MIT[e]	JRC[f]
Expected global emission levels resulting from INDCs (GtCO2eq)	2025	54 (53 to 58)* 53 (52 to 56)	52 to 54	Not provided	41	54	55* 54
	2030	56 (54 to 59)* 54 (52 to 57)	53 to 55	54 to 57	42	56	57* 54
Reference Scenarios (GtCO2eq)	2025	57 (55 to 58)	55 to 57	Not provided	44	61	57
	2030	60 (58 to 62)	58 to 61	64	47	64	60
2C scenarios (GtCO2eq)	2025	48 (46 to 50)	39 to 43	Not provided	35	38 to 52	49
	2030	42 (31 to 44)	36 to 40	36	30	37 to 53	46
Emission reductions resulting from INDCs (GtCO2eq)	2025	Not provided	Not provided	Not provided	3	Not provided	4* 6
	2030	4 to 6	Not provided	8 to 10	5	Not provided	7* 9
Difference between expected global emission levels and emission levels consistent with 2C scenarios (GtCO2eq)	2025	7 (5 to 9) 5 (4 to 8)	11 to 13	Not provided	6	Not provided	6* 5
	2030	14 (12 to 17)* 12 (10 to 15)	15 to 17	18 to 21	12	Not provided	11* 8.5
Temperature estimates considering the effects of INDCs (GtCO2eq)	2100	3.5°C*/ 3°C	2.7°C	Not provided	2.7°C	3.7°C	around 3°C

Notes: [a] See < http://www.unep.org/publications/>

[b] See <http://climateactiontracker.org/global/173/CAT-Emissions-Gaps.html>

[c] See <http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2015/08/Boyd-et-al-policy-paper-August-2015.pdf>, Figures taken from scenario 1

[d] See <http://www.iea.org/newsroomandevents/pressreleases/2015/november/low-prices-should-give-no-cause-for-complacency-on-energy-security-iea-says.html> ; This IEA analysis includes all energy-related GHG emissions and process-related CO2 emissions.; The INDC scenario corresponds to the evaluation of all climate pledges up to mid-October and includes the latest official data on energy use in China (World Energy Outlook Special Briefing for COP21, 2015). The Reference Scenario and the 2°C Scenario correspond respectively to the Current Policies Scenario and the 450 Scenario (World Energy Outlook 2015); The IEA's World Energy Model was used to project the impact of INDCs on energy demand, supply, emissions and investment trends through to 2030, using the economic and energy price assumptions of WEO-2015. The analysis also takes into account domestic energy sector policies that are currently in place or under discussion across all countries. The analysis is based upon the full implementation of unconditional INDC pledges. Some countries have also indicated that they might agree to a more ambitious INDC under certain conditions, but such additional pledges are not included here. Total GHG emissions have been assessed using global warming potentials from the Intergovernmental Panel on Climate Change's Fifth Assessment Report (IPCC, 2014). Non CO2 non-energy related emissions were assessed with the OECD ENV-Linkages model. For LULUCF emissions, FAO data and national estimates, where available, were

used. To assess the impact on global average temperature increase, we used MAGICC with an emissions pathway post-2050 in between the representative concentration pathways (RCP) 4.5 and (RCP) 6 scenarios from the IPCC's Fifth Assessment Report as this was interpreted as representing the best available trajectory compatible with IEA's INDC Scenario.

[e] See <http://globalchange.mit.edu/research/publications/other/special/2015Outlook>; MIT Joint Program's 2015 Energy and Climate Outlook estimates the impacts of the INDCs that were submitted by mid-August of 2015. The INDCs specify actions through 2030. While recognizing that further policy measures are needed to stabilize atmospheric GHG concentrations, the MIT Outlook assumes that the INDCs are extended through 2100 but not deepened further. For other regions, it represents Copenhagen–Cancun commitments throughout the study.

[f] See <https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/geco2015-global-energy-and-climate-outlook-road-paris-assessment-low-emission-levels-under>; Note 1: GWP from SAR, emissions reported here exclude LULUCF sinks; Note 2: The 2C scenario relies on policies implemented from 2015; Note 3: Cut-off date for analysis 13/10/2015; Scenarios were created using the POLES-JRC model, derived and updated from the GECO2015 study. Population (UN 2015) and GDP (IMF April 2015 for short term, OECD 2013 for long term) were key assumptions; emissions are from energy balances, UNFCCC, EDGAR, FAO and national sources; simulation start date was 2014. The INDC scenarios compile contributions of 120 parties as of October 13 2015 across the model's 66 regions. They assume the full implementation of unconditional or both unconditional and conditional INDCs. Beyond 2030, climate policies, differentiated across countries, continue so as to maintain the decrease of emissions intensity of GDP achieved in 2020-2030.

[*]Only unconditional efforts