2020 emission targets after applying updated GWPs from IPCC AR4

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In IPCC's 2007 Fourth Assessment Report (AR4) the Global Warming Potentials (GWPs) were updated from those in the 1995 Second Assessment Report (SAR). The SAR GWPs are used in the national inventories of UNFCCC Parties and to account for greenhouse gases (GHGs) under the Kyoto Protocol. They are also generally applied for estimating absolute emissions in 2020 for Parties' proposed emission targets under the Copenhagen Accord.

- Applying the updated GWPs from the AR4 for establishing AAUs, rather than from the SAR, improves the estimate of the relative effect of different GHGs on global warming. For example, relative to CO_2 methane emissions have a 19% stronger effect of global warming according to the AR4 GWPs compared to the SAR.
- As new gases since SAR are only present in the AR4 GWP tables, adopting GWPs from the AR4 for all GHGs for the next commitment period ensures consistency and comparability over the complete mix of GHG species.
- The effect of planned policy on the mix of individual GHG emission reductions in individual sectors will likely change during a switch from SAR to AR4 GWPs.
- Even in the most extreme (and unlikely) cases assessed here, the total effect on CO_2-equivalent targets of such a policy is generally limited to ±1% of 1990 emissions during a switch from SAR to AR4 GWPs, for the GHG mix of a typical Party. Hence, compliance risk is limited to at the very most 'overcompliance' or 'undercompliance' by ±1% of 1990 emissions.
- Use of GWPs in energy-economic models needs to be updated to give the appropriate weighting. This will ensure the link is preserved between estimated climate-change impacts and emission (reduction) targets for mitigating impacts.

PREVENT Project supporting SIDS and LDCs climate negotiators

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I. Introduction

In IPCC's 2007 Fourth Assessment Report (AR4) the Global Warming Potentials (GWPs) were updated from those in the 1995 Second Assessment Report (SAR)[1]. The SAR GWPs are used in the national inventories of UNFCCC Parties and to account for greenhouse gases (GHGs) under the Kyoto Protocol[2]. They are also generally applied for estimating absolute emissions in 2020 for Parties' proposed emission targets under the Copenhagen Accord. However, the updated set of GWP values from AR4 is based on new scientific research and continuing to apply GWPs from SAR may lead to errors in estimating the effect of emission targets on global warming. In section II implications of an update of GWPs for 2020 reduction targets are discussed. Section III presents the conclusions based on the analysis in Section IV.

II. Implications of updating GWPs from SAR to AR4 values

It is assumed here that in the future, as at present:

a) Targets are set as a % of base year (e.g. 1990) emissions, base year emissions are the GWP-weighted total of the inventory
b) The same set of GWPs is used to calculate the base year as is used to weight the emissions in a given year and to compare to the GWP-weighted base year emissions. To do otherwise and to change only the GWPs for the commitment period emissions leaving the base year and AAU calculations based on the SAR GWPs would be scientifically inconsistent.

As such, switching the GWPs set used will not change aggregate targets expressed in % of base year. However, the following does change:

a) The GWP weighted emissions of the base year and hence the target year (e.g. the total number of AAUs change). For a typical national GHG emission mix of any Party, the AR4 GWP set increases the total GWP weighted emissions, compared to the SAR.
b) The GWP weighted emission reductions achieved from the target.
c) The relative effect on total GWP weighted emissions of differential policies on different sectors and GHGs. If a Party planned to meet its target for the first commitment period or 2020 through emphasizing methane more than CO_2, and based its planning to meet a relative reduction goal on the SAR GWPs, a switch to AR4 GWPs may require adjustment to the policy.

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[1] See table 2.14 of IPCC AR4 – Forster et al. (2007). "Changes in Atmospheric Constituents and in Radiative Forcing", in Solomon et al. (ed.), *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press. See also errata for this table at http://www.ipcc.ch/publications_and_data/ar4/wg1/en/erratataserrata-errata.html.

[2] Decision 2/CP.3 "Methodological issues related to the Kyoto protocol" para 3 UN Doc. FCCC/CP/1997/7/Add.1 (Kyoto, 1-11 December 1997).

Since GWPs from AR4 for CH_4, HFCs and PFCs, are higher than those from SAR, the effect of emissions of these GHGs on global warming is stronger than estimated compared to CO_2 emissions using SAR GWPs. Hence, 2020 reduction targets that were established using SAR GWPs need to be re-formulated using GWPs from the AR4. There are two options to be considered here: to use AR4 GWPs only for the new gases proposed and to update as well the old basket of gases with AR4 GWPs.

III. Conclusions

- Applying the updated GWPs from the AR4 for establishing AAUs, rather than from the SAR, improves the estimate of the relative effect of different GHGs on global warming. For example, relative to CO_2 methane emissions have a 19% stronger effect of global warming according to AR4 GWPs compared to the SAR.
- Switching from SAR to AR4 GWPs is a simple operation that ensures the estimate of the effect of future emissions on global warming are up-to-date. Such a switch has minimal effect on relative total GHG targets (expressed as a % change from a base year or period).
- Use of GWPs in energy-economic models need to be updated to give the appropriate weighting. This may not in itself imply a significant change in levels of individual GWP weighted GHG emission in specific years, or in relative changes in emissions from base periods for scenarios that meet specific temperature or concentration goals.
- As new gases since SAR are only present in the AR4 GWP tables, adopting GWPs from the AR4 for all GHGs for the next commitment period ensures consistency and comparability over the complete mix of GHG species.
- AAUs/RMUs/CERs from the first commitment period calculated with SAR GWPs will not be strictly comparable with the those calculated for a later period using AR4 GWPs. The level of inconsistency is however small, and given the uncertainties in calculating GWPs inventories it would be reasonable not to seek to correct units from the first commitment period generated with SAR GWPs.
- The effect of planned policy on the mix of individual GHG emission reductions in individual sectors will likely change during a switch from SAR to AR4 GWPs. This only has an effect in extreme cases, like a fictitious policy that aspired to achieve the complete national emission target by starting with a 50% reduction in methane emissions alone.
- Even in such extreme (and unlikely) cases, the total effect on CO_2-equivalent targets of such a policy is generally limited to ±1% of 1990 emissions during a switch from SAR to AR4 GWPs, for the GHG mix of a typical Party. Hence, compliance risk is limited to at the very most ‘overcompliance‘ or ‘undercompliance‘ by ±1% of 1990 emissions.

IV. Technical Background

This paper only assesses GWPs weighted on a 100-year time horizon. As shown in Table 1 below, GWPs for most greenhouse gases have changed between the SAR and AR4. Generally, they have been adjusted upwards. For methane (CH_4) GWP is a factor of 19% higher in the AR4. Nitrous Oxide (N_2O) is an exception in the sense that its GWP was revised downwards by 4%. The GWPs of Fluorinated-gases (F-gases – HFCs, PFCs and SF_6) generally were increased, with the exception of SF_6. In the AR4 tables of GWPs and their errata, a number of GHGs are included that were not present in the SAR. If for the next commitment period GWPs are applied from the AR4 for all GHGs, this ensures that GWPs of the KP GHG basket (currently expressed using SAR GWPs) are consistent with GWPs of "new" gases that may be included in the GHG basket of the next commitment period.

See Figure 1 for an illustration of calculating base year and 2020 target emissions using SAR and AR4 GWP values. Since for most greenhouse gases AR4 GWPs are higher than SAR GWPs, for many Parties the base year emissions using AR4 GWPs will be higher than when using SAR GWPs (see Table 2). Hence, for equal percentage reductions from base year using AR4 GWPs, the absolute 2020 target emissions level expressed in MtCO2eq will be higher than the SAR-GWPs based level, but the absolute reduction to be achieved will be higher as well (see Table 2 and compare result of Step A with result of Step 1 in Figure 1).

The level of emissions by 2020 to be achieved for limiting global warming to below 1.5, or 2°C is derived from scientific assessments such as those that apply climate and energy-economic models. The effect on global warming of emission scenarios in these models does not require the use of GWPs, but is calculated using gas-cycle and radiative forcing sub-models that estimate the effect of a mix of GHG emissions on global warming. GWPs are only applied *a posteriori* to express the derived 'allowed' mix of individual GHG emissions in terms of total GHG targets for the purpose of informing the development of emission reduction policies. Therefore, updating GWPs from the SAR to the AR4 values in both the targets recommended by these models and total emissions in national inventories and AAUs must be applied simultaneously. This in itself does not imply that individual GHG limitations recommended by scientific assessments for, e.g. the year 2020 become more (or less) stringent.

In Figure 2, we illustrate a case where a fictitious Party has implemented an extreme policy under a "SAR GWPs regime" that achieves its proposed reductions by 2020 through reducing CO_2 and N_2O emissions alone; two GHGs with AR4 GWPs close to SAR GWPs. A regime switch from SAR GWPs to AR4 GWPs implies that planned policy turns out to be insufficient ('undercompliance'), because emissions of the other GHGs that have higher GWP in the AR4 compared to the SAR are not addressed sufficiently. Vice versa, if policy is designed to achieve the target by reductions in CH_4 and/or F-gas

emissions as much as possible, a switch from SAR GWPs to AR4 GWPs implies that planned policy achieves more than required ('overcompliance').

In Table 3 we show the effect of updating GWPs for such fictitious extreme planned-policy cases for a selection of Parties' 2020 reduction proposals. In the CH_4/F-gas case, reductions under SAR GWPs are planned by first reducing CH_4 by up to 50% below 1990 if necessary, then F-gases (up to zero if necessary) and only if that still does not add up to the total SAR-GWP reductions required, further reductions are achieved through CO_2. In the N_2O/CO_2 case, all reductions are first aimed at N_2O (up to 50% below 1990 if necessary) and CO_2 in second instance. The resulting emission mix complies with the SAR GWPs targets, but the effective reductions are then calculated using AR4 GWPs and compared to the targets fully based on AR4 GWPs (for both the base year and target year). For Annex-I in aggregate, the effect of updating GWPs in such extreme, fixed policy cases based on SAR GWPs misses the required reduction target after updating using AR4 GWPs ('overcompliance' or 'undercompliance') by generally about ±1% of 1990 emissions (excl. LULUCF). Thus, at the extreme end of potential policies planned under a 'SAR GWPs regime', the effect of an update to AR4 GWPs is to require re-adjustment of reduction targets by at most roughly ±1% of 1990 emissions (excl. LULUCF). New Zealand is an exception in the sense that an adjustment of up to 2% of 1990 emissions would be required, due to the relatively very high contribution of CH_4 and N_2O to total emissions, compared to other Parties.

Table 1. 100-year GWPs from IPCC SAR and AR4, as well as the factor by which GWPs changed from SAR to AR4. Source, see footnote 1.

	SAR	AR4	AR4/SAR
CH4	21	25	1.19
N2O	310	298	0.96
HFC-23	11700	14800	1.26
HFC-32	650	675	1.04
HFC-125	2800	3500	1.25
HFC-134a	1300	1430	1.10
HFC-143a	3800	4470	1.18
HFC-152a	140	124	0.89
HFC-227ea	2900	3220	1.11
HFC-236fa	6300	9810	1.56
HFC-43-10mee	1300	1640	1.26
SF6	23900	22800	0.95
PFC-14	6500	7390	1.14
PFC-116	9200	12200	1.33
PFC-218	7000	8830	1.26
PFC-318	8700	10300	1.18
PFC-3-1-10	7000	8860	1.27
PFC-5-1-14	7400	9300	1.26

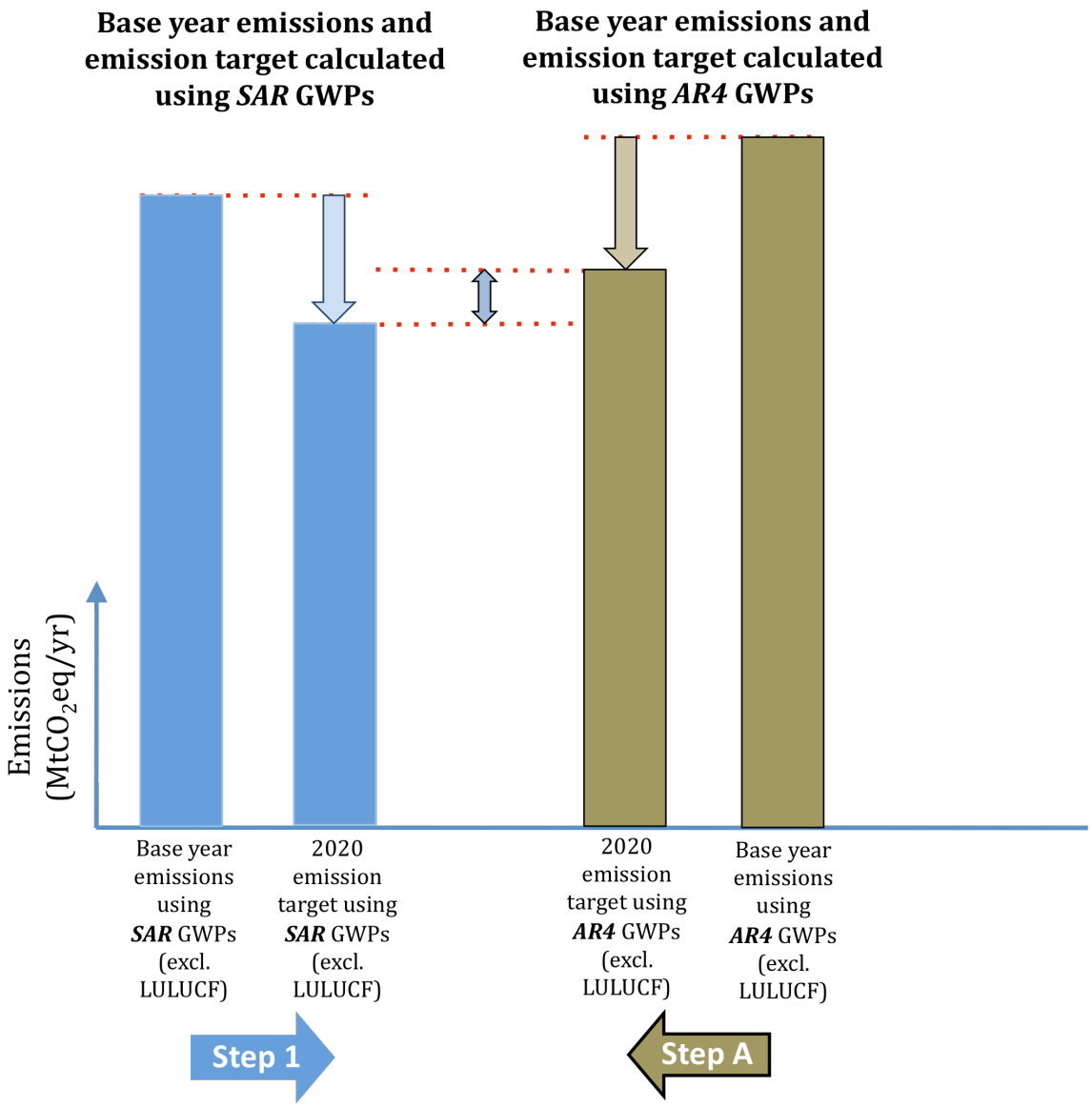

Figure 1. Illustration of calculating base year and target emissions using SAR or AR4 GWPs. In Step 1 target emissions are calculated from the aggregate emissions in the base year using SAR GWPs, in Step A GWPs from the AR4 are applied throughout.

Table 2. Comparison of base year and target emissions, as well as target reductions below base year in MtCO2e for both SAR GWPs and AR4 GWPs. All emissions exclude LULUCF.

				Base year expressed as MtCO2e SAR GWPs	Base year expressed as MtCO2e AR4 GWPs	Targets expressed as GtCO2e in 2020 SAR GWPs		Targets expressed as GtCO2e in 2020 GWPs AR4		Reductions in MtCO2e SAR GWPs		Reductions in MtCO2e AR4 GWPs	
	low reduction target relative to base year	***high reduction target relative to base year***	***base year***	***emissions in base year SAR-GWPs (MtCO2e)***	***emissions in base year AR4-GWPs (MtCO2e)***	***low-reduction emission target (MtCO2e)***	***high-reduction emission target (MtCO2e)***	***low-reduction emission target (MtCO2e)***	***high-reduction emission target (MtCO2e)***	***low-reduction emission target (MtCO2e)***	***high-reduction emission target (MtCO2e)***	***low-reduction emission target (MtCO2e)***	***high-reduction emission target (MtCO2e)***
Australia	5%	25%	2000	494.9	516.5	470.1	371.1	490.7	387.4	24.7	123.7	25.8	129.1
Canada	17%	17%	2005	731.0	749.8	606.7	606.7	622.4	622.4	124.3	124.3	127.5	127.5
Switzerland	20%	30%	1990	52.7	53.4	42.2	36.9	42.7	37.4	10.5	15.8	10.7	16.0
EU27	20%	30%	1990	5,562.9	5,664.0	4,450.3	3,894.0	4,531.2	3,964.8	1,112.6	1,668.9	1,132.8	1,699.2
Japan	25%	25%	1990	1,269.7	1,283.0	952.2	952.2	962.3	962.3	317.4	317.4	320.8	320.8
Norway	30%	40%	1990	49.7	51.1	34.8	29.8	35.8	30.7	14.9	19.9	15.3	20.5
New Zealand	10%	20%	1990	61.9	66.4	55.7	49.5	59.7	53.1	6.2	12.4	6.6	13.3
Russian Federation	15%	25%	1990	3,319.3	3,423.1	2,821.4	2,489.5	2,909.6	2,567.3	497.9	829.8	513.5	855.8
USA	17%	17%	2005	7,082.2	7,193.4	5,878.2	5,878.2	5,970.5	5,970.5	1,204.0	1,204.0	1,222.9	1,222.9
Annex I	12%	18%	1990	18,661.8	19,074.4	16,422.4	15,302.7	16,785.5	15,641.0	2,239.4	3,359.1	2,288.9	3,433.4

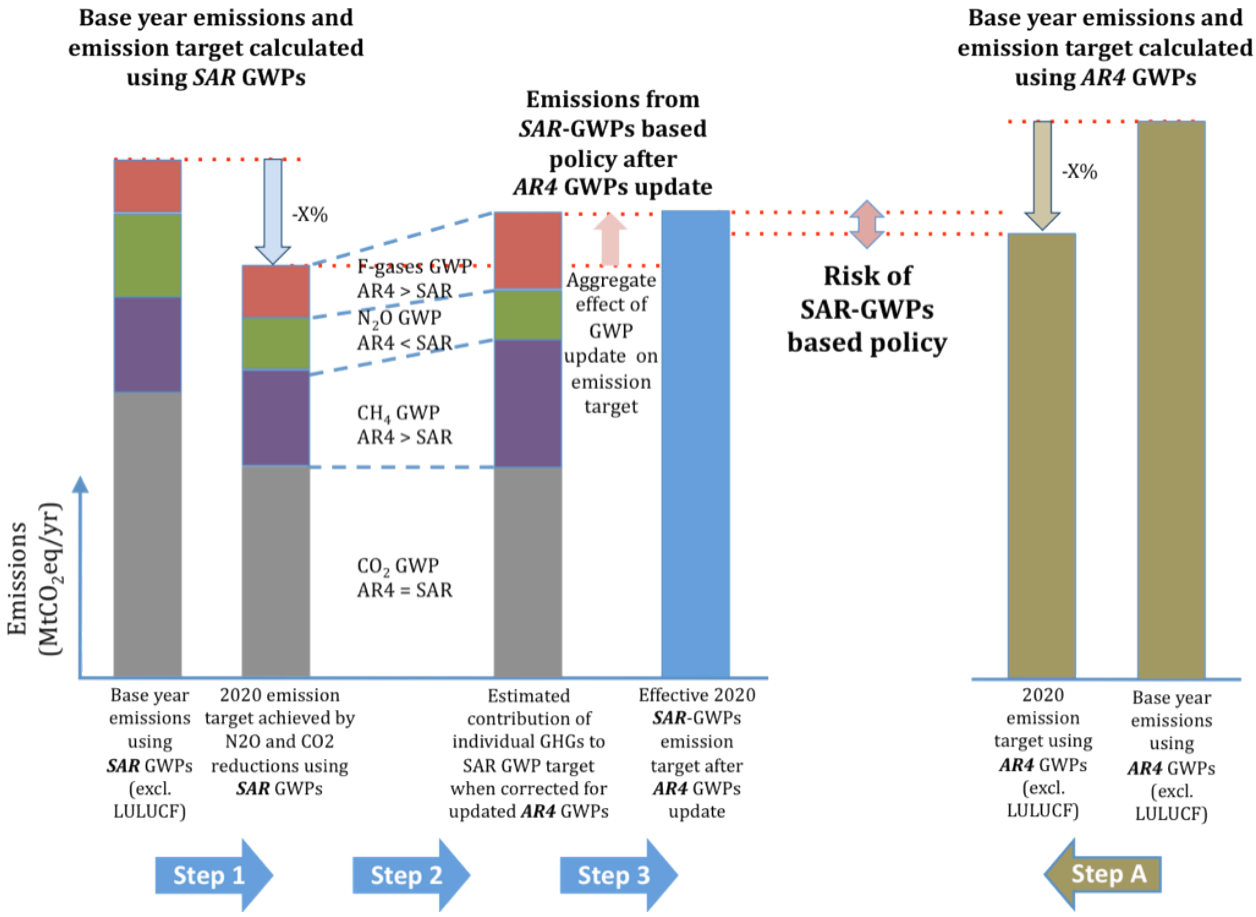

Figure 2. Illustration of the potential implications of a switch from SAR GWPs to AR4 GWPs for fictitious policy planned under the current SAR-GWPs 'regime'. In Step 1 reductions are achieved by reducing only N_2O and CO_2. However, emissions of other GHGs (F-gases and CH_4), which were not reduced, become relatively more important when AR4 GWPs are applied to the same emission levels for each GHG (Step 2). The aggregate AR4-GWPs emissions resulting from SAR-GWPs based policy (Step 3) will be higher than allowed according to the AR4-GWPs emission target calculated from AR4-GWPs based emissions in the base year (Step A).

Table 3. Required adjustment of emission reductions to achieve AR4 reductions for extreme policy cases planned and fixed under a 'SAR GWPs regime'. Examples are given for 'high-reduction' targets only, based on current reduction proposals of the selected Parties.

	Reductions below 1990 in MtCO2e SAR GWPs	Reductions below 1990 in MtCO2e AR4 GWPs	Effective reductions planned under SAR GWPs after AR4-GWPs update		Effective 'SAR reductions' after AR4 update relative to required AR4 reductions 'overcompliance' (+) or 'undercompliance' (-)	
			CH4/F-gas case	N2O/CO2 case	CH4/F-gas case	N2O/CO2 case
	(MtCO2e)	***(MtCO2e)***	***(MtCO2e)***	***(MtCO2e)***	***(% of 1990 emissions excl. LULUCF)***	***(% of 1990 emissions excl. LULUCF)***
Australia	45.1	50.7	53.7	44.7	0.7%	-1.4%
Canada	-14.9	-16.8	-17.7	-14.3	-0.2%	0.4%
Switzerland	15.8	16.0	16.3	15.7	0.4%	-0.5%
EU27	1,668.9	1,699.2	1,733.3	1,659.0	0.6%	-0.7%
Japan	317.4	320.8	328.9	316.8	0.6%	-0.3%
Norway	19.9	20.5	21.1	19.8	1.2%	-1.3%
New Zealand	12.4	13.3	14.7	12.2	2.2%	-1.7%
Russian Federation	829.8	855.8	888.1	825.5	0.9%	-0.9%
USA	206.3	230.7	245.5	200.2	0.2%	-0.5%
Annex I	3,359.1	3,433.4	3,607.6	3,335.2	0.9%	-0.5%