Understanding the Changes to Global Warming Potential (GWP) Values

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2nd February 2015

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Introduction

Media coverage of the Intergovernmental Panel on Climate Change (IPCC)'s latest Synthesis Report rightly focused on its unprecedentedly dire warnings about climate change and the actions required to mitigate the worst of its effects, including the recommended phase out of fossil fuels by 2100.[1]

One aspect of the Fifth Assessment Report (AR5) that, though it may not be making any headlines, will impact companies' greenhouse gas (GHG) reporting practices, is the publication of updated Global Warming Potentials (GWPs) values.

GWPs are used to estimate the climate change impacts of various GHG emissions and express them in a single unit – carbon dioxide equivalents (CO_2e) – and are therefore a critical element for reporting companies to take into consideration.

Best practice dictates that the most recent GWP values should be applied in emissions calculations as they reflect the most up to date representation of the global warming effect of GHG emitting activities. However, while some accounting and reporting standards have started requiring the use of AR5 GWPs, various reporting schemes are still lagging behind, and the main voluntary accounting and reporting standards have thus far remained mute on the subject of which set of GWP values in AR5 to apply, leaving it up to companies to determine the path to follow.

Ecometrica remains engaged with several authorities to stay abreast of best practices in this matter. Our GHG accounting software *Our Impacts* will be automatically updated to include the most appropriate GWP values and our analysts will advise our clients on the pros and cons of applying each based on their circumstances. Firms who are conducting their assessments independently will likely need to investigate and evaluate these options themselves, or possibly contract the services of expert consultants.

This paper aims to help companies understand whether or not they should apply AR5 GWPs by presenting a few key facts about GWPs and the reasons behind their update, their impacts on GHG inventories and an overview of their adoption by accounting and reporting standards.

The role of GWPs

Each GHG has a different capacity for capturing and re-radiating outgoing infrared radiation in the atmosphere, thereby contributing to radiative forcing, as illustrated in Figure 1. GWPs therefore act as a kind of 'exchange rate' for GHGs, converting them into CO_2e in order to compare their climate change impacts.

[1] McSweeney, R. and Pearce, R. (2014). "Media round-up: The IPCC's Synthesis Report". The Carbon Brief. http://www.carbonbrief.org/blog/2014/11/media-round-up-the-ipcc-synthesis-report/

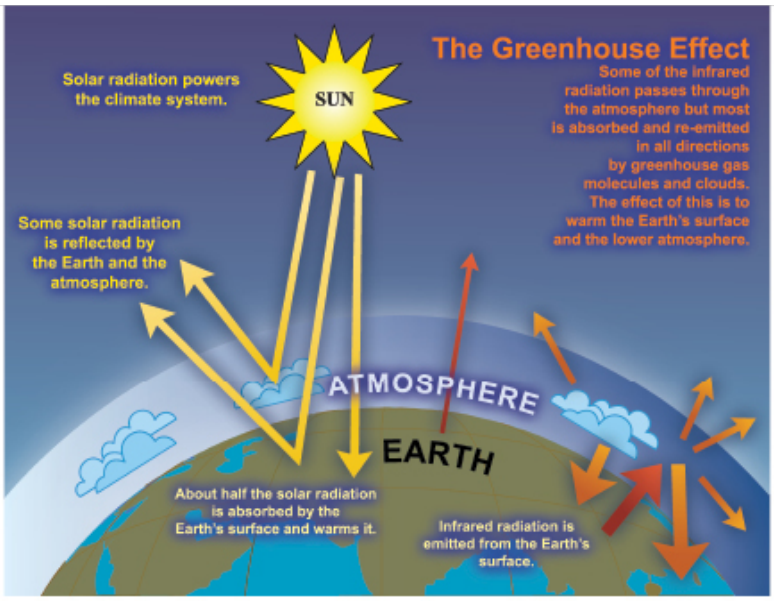

Figure 1. The greenhouse gas effect[2]

Each GHG's radiative forcing effect varies over time, which is why the IPCC has typically published GWPs for 20, 100, and 500-year time frames (100-year GWPs being the most widely adopted in GHG inventories). GHGs with a relatively short lifetime (12.4 years for CH_4, for example) will have a stronger GWP over a shorter time frame, such as 20 years.

The IPCC, the primary authority on climate change science, has updated the GWP values several times over the years, each adjustment the result of advances in scientific understanding (see Table 1 below). In AR5, the GWP values are presented for the first time both with and without climate-carbon feedback. The AR5 report also introduces another emission metric, the concept of Global Temperature change Potential (GTP), which is defined as the change in global mean surface temperature, rather than climate change impact, due to GHG emissions at a certain point in time, relative to CO_2. GTP values are not currently used in organisational assessments[3].

Table 1. 100-year GWPs published by IPCC

GHG	Second Assessment Report (SAR)[4]	Fourth Assessment Report (AR4)[5]	Fifth Assessment Report (AR5)[6]	
			without climate-carbon feedback	with climate-carbon feedback

[2] IPCC (2007). Climate Change 2007: Working Group I: The Physical Science Basis. FAQ 1.3 What is the Greenhouse Effect? http://www.ipcc.ch/publications_and_data/ar4/wg1/en/faq-1-3.html

[3] IPCC (2013). Climate Change 2013: The Physical Science Basis. Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Chapter 8: Anthropogenic and Natural Radiative Forcing.

[4] IPCC (1995). IPCC Second Assessment Report. A Report Of The Intergovernmental Panel On Climate Change. http://www.ipcc.ch/ipccreports/sar/wg_I/ipcc_sar_wg_I_full_report.pdf

[5] IPCC (2007). IPCC Fourth Assessment Report: Climate Change 2007. Working Group I: The Physical Science Basis. http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html

[6] IPCC (2013). Climate Change 2013: The Physical Science Basis. Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Chapter 8: Anthropogenic and Natural Radiative Forcing.

			carbon feedback	feedback
CO_2	1	1	1	1
CH_4	21	25	28[b]/30[f]	34
N_2O	310	298	265	298

b: Methane
f: Fossil methane

Causes of GWP updates

Many factors influence the revision of GWPs, including new estimates of each GHG's lifetime, radiative efficiency and impulse response functions (the development of atmospheric concentration caused by a pulse of emissions).

Because CO_2 is the reference gas for GWPs, its GWP is by definition always going to be 1. However, changes in the understanding of the global warming impacts of CO_2 will result in changes to the GWP of all other GHGs as well.

Changes to the inclusion and strength of indirect effects have also contributed to the revision of GWPs. One instance noted by the IPCC in AR5 is the attribution to CH_4 of the indirect radiative forcing effect of the O_3 created in the troposphere and that of stratospheric H_2O, both induced by a reaction with CH_4 which increased the effect of CH_4 by 50% and 15% respectively[7]. This effect, whose value was re-evaluated in AR5, was in fact taken into account in AR4, but was not retained in its Summary for Policymakers[8].

The GWP of a GHG can also vary over time, affected by changes in concentration of other GHGs. For example, AR5 explains that the GWP of N_2O decreased compared to AR4 because of higher abundance of CH_4 and N_2O, which in turn reduced its radiative efficiency[9].

With or without feedback

The IPCC has also for the first time published two sets of GWP values, one that takes into account climate-carbon feedbacks, which measures the indirect effects of changes in carbon storage due to changes in climate[10], and one that doesn't. But which to use?

Firstly, the GWPs with feedback have a higher level of uncertainty. The more feedbacks are being considered, the more complex and interconnected they become, and the "uncertainty of the magnitude and even direction of feedback increases"[11].

[7] Ibid
[8] Dessus and Laponche (2014). Forçage radiatif et PROG du méthane dans le rapport AR5 du GIEC. Les cahiers de GLOBAL CHANCE (35). http://www.global-chance.org/IMG/pdf/gc35p64-74.pdf
[9] IPCC (2013). Climate Change 2013: The Physical Science Basis. Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Chapter 8: Anthropogenic and Natural Radiative Forcing.
[10] IPCC (2013). Climate Change 2013: The Physical Science Basis. Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Technical Summary.
[11] IPCC (2013). Climate Change 2013: The Physical Science Basis. Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Chapter 8: Anthropogenic and Natural Radiative Forcing.

One the other hand, taking into account the feedbacks is more conservative, as the GWPs are higher and more complete.

The methodology is also more internally consistent for GWPs with feedback. GWP values are the ratio between the absolute GWP of CO_2 and another GHG. In AR4, climate-carbon feedbacks were taken into account for CO_2, but not for other GHGs, meaning that only the denominator included feedback effects. This is still the case in AR5 for GWPs without feedback, but GWPs with feedback include these effects for both CO_2 and non-CO_2 gases.

Though the IPCC does not explicitly provide an opinion on which set of GWPs should be adopted, it does state that "though the uncertainties range for these metric values [with climate-carbon feedback] is greater… these calculations provide a more consistent methodology"[12].

The impact on companies' stated emissions

How would adopting these new GWPs affect the typical organisational assessment? This of course depends on what types of activities make up the majority of a firm's emissions.

Companies whose operations produce proportionally more CH_4 will see their emissions increase the most, due to the rise in CH_4's GWP value. Activities that generate a lot of CH_4 include the production of natural gas, livestock production and landfilled waste[13]. As for N_2O, agriculture (from animal manure and urine and synthetic fertilizer) as well as fossil fuels are its primary sources[14].

Take a look at some common U.S. emission factors in the table below to examine how their CO_2e value will vary using the GWPs from the SAR, AR4 or AR5 (for a more detailed breakdown of the impacts, see Table 3 in the Annex).

Table 2. Summary of impacts of different GWPs on emission factors for activities which took place in the U.S. in 2014

[12] Ibid

[13] EPA (2014). Overview of Greenhouse Gases: Methane Emissions. http://epa.gov/climatechange/ghgemissions/gases/ch4.html

[14] EPA (2014). Overview of Greenhouse Gases: Nitrous Oxide Emissions. http://www.epa.gov/climatechange/ghgemissions/gases/n2o.html

		Electricity grid[15]	Gasoline passenger cars[16]	Truck deliveries[17]	Waste landfilled MSW[18]	Short haul flight [19]
SAR	**kgCO_2e**	0.56178	0.38298	0.29791	0.20	0.15504
AR4	**kgCO_2e**	0.56173	0.38301	0.29789	0.24	0.15499
AR5 no feedback	**kgCO_2e**	0.56149	0.38294	0.29781	0.27	0.15484
AR5 with feedback	**kgCO_2e**	0.56182	0.38316	0.29792	0.33	0.15502
% change in CO_2e emissions between SAR and	**AR5 with no feedback**	**-0.05%**	**-0.01%**	**-0.03%**	**33%**	**-0.13%**
	AR5 with feedback	**0.01%**	**0.05%**	**0.004%**	**62%**	**-0.01%**
% change in CO_2e emissions between AR4 and	**AR5 with no feedback**	**-0.04%**	**-0.02%**	**-0.03%**	**12 %**	**-0.1%**
	AR5 with feedback	**0.02%**	**0.04%**	**0.01%**	**36%**	**0.02%**

Generally speaking, the AR5 GWPs with feedback will cause a small increase in stated emissions for most organisations. This is because the GWP for N_2O remains the same compared to its AR4 GWP (though reducing slightly compared to its SAR GWP), whereas the GWP for CH_4 increases compared with both its SAR and AR4 GWP. On the other hand, the AR5 GWPs without feedback may cause a decrease in emissions, depending on the emissions of each GHG of course, due to the decline in GWP for N_2O.

However, for most corporate firms operating within the service or manufacturing sectors, the majority of emissions are made up of CO_2, and so the changes in GWP will only cause a marginal impact, as evidenced by the minor percentage changes in CO_2e values. The exception is emission sources like landfilled waste, natural gas production, and livestock activities, which are mostly made up of methane emissions. The more such sources an organization has, the larger the impact will be. In fact, because these sources are now known to have a higher global warming impact, strategic reductions in these areas can also have a greater impact in terms of avoiding emissions.

[15] EPA (2014). eGrid2013 v.1.0

[16] Derived from: EIA (2013). Carbon Dioxide Emissions Coefficients by Fuel. Released February 14, 2013. Online: http://www.eia.gov/environment/emissions/co2_vol_mass.cfm, FHWA (2014). Highway Statistics 2012. US Federal Highway Administration. Washington DC 20590 and EPA (2014). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012. United States Environmental Protection Agency.

[17] EPA (2008). Climate Leaders. Optional Emissions from Commuting, Business travel and Product Transport. May 2008. U.S. Environmental Protection Agency.

[18] Derived from: IPCC (2006). Revised IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, EPA (2014). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012, and EPA (2014). Solid Waste Management and Greenhouse Gases. Documentation for GHG Emissions and Energy Factors Used in the Waste Reduction Model (WARM). Management Practices and Background - Landfilling. WARM Version 13 June 2014. Available from: http://epa.gov/epawaste/conserve/tools/warm/SWMGHGreport.html

[19] Defra/DECC (2014). UK Government conversion factors for greenhouse gas reporting. Department of Environment Food and Rural Affairs/Department for Energy and Climate Change, London.

For organizations wishing to adopt the new GWP values in their voluntary GHG assessments, it will be important to highlight which emission changes should be solely attributed to modifications in GWPs, compared to variations in activity levels. If a significance threshold is surpassed, it may also be necessary to conduct baseline recalculations in order to maintain comparability and compliance with reporting standards.

Available guidance on adopting the AR5 GWPs

The updates to GWP values published by the IPCC can, and at times do, create confusion and disagreement. Individuals that are new to GHG reporting may not understand the differences between GWPs and may apply them inconsistently. This can artificially cause changes to an assessment's results that have nothing to do with real changes to activities.

In terms of voluntary accounting and reporting best practice, the World Business Council on Sustainable Development/World Resources Institute (WBCSD/WRI)'s GHG Protocol provides the most widely used and respected standard. An amendment to its "Corporate Standard" states that companies "should use GWP values from the most recent Assessment Report, but may choose to use other IPCC Assessment Reports"[20]. However, because this amendment was released in February 2013, several months before the release of the IPCC's AR5, there is no indication of whether the AR5's GWP values with or without feedback effect are considered preferable.

Several other authorities provide signs that point towards an increasingly widespread use of GWP values without feedback. France's Agence de l'Environnement et de la Maîtrise de l'Énergie (ADEME), for example applies the GWPs without feedback in the latest update to its "Base Carbone" tool[21]. The EPA's 2014 U.S. GHG Inventory also notes that AR5 GWP values without feedback have a calculation methodology that is more consistent with those that were used in the AR4 report[22].

In practice, the adoption of new GWP values has been fairly slow and cautious so far, as national and international agencies emphasize year-over-year consistency and coherence between reporting parties' inventories. Organizations conducting their own GHG assessments typically use AR4 GWPs, unless they previously used SAR GWPs and wish for subsequent reports to be comparable.

At the governmental level, use of AR4 GWPs has only become standard practice several years after their original publication. The EPA's GHG Rule started requiring the application of AR4 GWPs, effective as of January 1, 2014, in order "to better characterize the climate impacts of individual GHGs and to ensure continued consistency with other U.S. climate programs"[23]. Though some commentators urged the EPA to adopt AR5 GWPs, this was ultimately rejected due to concerns that the AR5 GWPs would not be

[20] WBCSD/WRI (2013). Required Greenhouse Gases in Inventories: Accounting and Reporting Standard Amendment. http://www.ghgprotocol.org/files/ghgp/NF3-Amendment_052213.pdf

[21] ADEME (2014). Base Carbone : Les gaz. http://bilans-ges.ademe.fr/fr/accueil/contenu/index/page/giec/siGras/0

[22] EPA (2014). U.S. Greenhouse Gas Emissions and Sinks: 1990-2012. Annex 6 Additional Information. http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2014-Annex-6-Additional-Information.pdf

[23] EPA (2013). 2013 Revisions to the Greenhouse Gas Reporting Rule and Final Confidentiality Determinations for New or Substantially Revised Data Elements. 40 CFR Part 98.[EPA-HQ-OAR-2012-0934; FRL-9902-95-OAR] RIN 2060-AR52.

widely applied for many years [24]. Countries reporting to the Kyoto Protocol for example will switch to the AR4 100-year GWPs starting with the 2015 submissions[25].

Eventually, however, it is safe to assume that the adoption of AR5 GWPs will become best practice.

Ecometrica always keeps abreast with the best practice standards and developments in the GHG accounting and reporting world, and our experts have been contributing to the development of various reporting and accounting standards, from our Nobel Prize winning Chairman Richard Tipper's work with the IPCC to our GHG team's contributions to the GHG Protocol, PAS 2050 and ISO 14064. We are committed to bringing this expertise to our clients through our products and services and to the general corporate community through our series of white papers.

Ecometrica's greenhouse gas accounting and reporting tool *Our Impacts* currently makes it simple to select the appropriate set of GWPs. We will be closely tracking industry guidance on the adoption of AR5 GWPs, particularly regarding whether the GWPs with or without feedback should be selected, in order to inform their use on our platform. In the meantime, we will continue to offer a tool that guarantees the highest levels of accuracy and clarity for our clients.

Annex

Table 3. Detailed impacts of different GWPs on emission factors for activities which took place in the U.S. in 2014

	Electricity grid[26]	**Gasoline passenger cars[27]**	**Truck deliveries[28]**	**Waste landfilled MSW[29]**	**Short haul flight [30]**
Denominator unit	kWh	mile	short ton-mile	pound	pass-km
$kgCO_2$	0.6	0.4	0.3	-	0.2

[24] Ibid
[25] IPCC (2014). Frequently Asked Questions. http://www.ipcc-nggip.iges.or.jp/faq/faq.html
[26] EPA (2014). eGrid2013 v.1.0
[27] Derived from: EIA (2013). Carbon Dioxide Emissions Coefficients by Fuel. Released February 14, 2013. Online: http://www.eia.gov/environment/emissions/co2_vol_mass.cfm, FHWA (2014). Highway Statistics 2012. US Federal Highway Administration. Washington DC 20590 and EPA (2014). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012. United States Environmental Protection Agency.
[28] EPA (2008). Climate Leaders. Optional Emissions from Commuting, Business travel and Product Transport. May 2008. U.S. Environmental Protection Agency.
[29] Derived from: IPCC (2006). Revised IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, EPA (2014). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012, and EPA (2014). Solid Waste Management and Greenhouse Gases. Documentation for GHG Emissions and Energy Factors Used in the Waste Reduction Model (WARM). Management Practices and Background - Landfilling. WARM Version 13 June 2014. Available from: http://epa.gov/epawaste/conserve/tools/warm/SWMGHGreport.html
[30] Defra/DECC (2014). UK Government conversion factors for greenhouse gas reporting. Department of Environment Food and Rural Affairs/Department for Energy and Climate Change, London.

	$kgCH_4$	0.00001	0.00002	0.000004	0.01	0.000003
	kgN_2O	0.000008	0.000004	0.000003	-	0.000005
SAR	$kgCO_2$	0.6	0.4	0.3	-	0.2
	$kgCH_4$	0.00023	0.00036	0.00007	0.20	0.00006
	kgN_2O	0.0026	0.0011	0.00084	-	0.0015
	$kgCO_2e$	**0.56178**	**0.38298**	**0.29791**	**0.20**	**0.15504**
AR4	$kgCO_2$	0.6	0.4	0.3	-	0.2
	$kgCH_4$	0.00028	0.00043	0.00009	0.24	0.00007
	kgN_2O	0.0025	0.0011	0.00080	-	0.0015
	$kgCO_2e$	**0.56173**	**0.38301**	**0.29789**	**0.24**	**0.15499**
AR5 No feedback	$kgCO_2$	0.6	0.4	0.3	-	0.2
	$kgCH_4$	0.00031	0.00048	0.0001	0.27	0.00008
	kgN_2O	0.0022	0.0010	0.00072	-	0.0013
	$kgCO_2e$	**0.56149**	**0.38294**	**0.29781**	**0.27**	**0.15484**
AR5 With feedback	$kgCO_2$	0.6	0.4	0.3	-	0.2
	$kgCH_4$	0.00037	0.00059	0.001	0.33	0.0001
	kgN_2O	0.0025	0.0011	0.00080	-	0.0015
	$kgCO_2e$	**0.56182**	**0.38316**	**0.29792**	**0.33**	**0.15502**
% change in CO_2e emissions between SAR and	**AR5 with no feedback**	**-0.05%**	**-0.01%**	**-0.03%**	**33%**	**-0.13%**
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