Understanding the Changes to Global Warming Potential (GWP) Values

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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\(_2\)e) – 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$_2$e in order to compare their climate change impacts.

![The Greenhouse Effect](image)

*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.

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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\textsubscript{2}. GTP values are not currently used in organisational assessments\textsuperscript{3}.

Table 1. 100-year GWP\textsubscript{s} published by IPCC

<table>
<thead>
<tr>
<th>GHG</th>
<th>Second Assessment Report (SAR)\textsuperscript{4}</th>
<th>Fourth Assessment Report (AR4)\textsuperscript{5}</th>
<th>Fifth Assessment Report (AR5)\textsuperscript{6}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>carbon feedback</td>
<td>feedback</td>
<td>without climate-carbon</td>
</tr>
<tr>
<td>CO\textsubscript{2}</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>CH\textsubscript{4}</td>
<td>21</td>
<td>25</td>
<td>(28^b/30)</td>
</tr>
<tr>
<td>N\textsubscript{2}O</td>
<td>310</td>
<td>298</td>
<td>265</td>
</tr>
</tbody>
</table>

\(b\): Methane

\(f\): Fossil methane

Causes of GWP updates

Many factors influence the revision of GWP\textsubscript{s}, 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\textsubscript{2} is the reference gas for GWP\textsubscript{s}, its GWP is by definition always going to be 1. However, changes in the understanding of the global warming impacts of CO\textsubscript{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 CH₄ of the indirect radiative forcing effect of the O₃ created in the troposphere and that of stratospheric H₂O, both induced by a reaction with CH₄ which increased the effect of CH4 by 50% and 15% respectively⁷. This effect, whose value was reevaluated in AR5, was in fact taken into account in AR4, but was not retained in its Summary for Policymakers⁸.

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 N₂O decreased compared to AR4 because of higher abundance of CH₄ and N₂O, which in turn reduced its radiative efficiency⁹.

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 climate¹⁰, 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.

On the other hand, taking into account the feedback 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 CO₂ and another GHG. In AR4, climate-carbon feedbacks were taken into account for CO₂, 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 CO₂ and non-CO₂ gases.

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⁷ ibid
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”\textsuperscript{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\textsubscript{4} will see their emissions increase the most, due to the rise in CH\textsubscript{4}’s GWP value. Activities that generate a lot of CH\textsubscript{4} include the production of natural gas, livestock production and landfilled waste\textsuperscript{13}. As for N\textsubscript{2}O, agriculture (from animal manure and urine and synthetic fertilizer) as well as fossil fuels are its primary sources\textsuperscript{14}.

Take a look at some common U.S. emission factors in the table below to examine how their CO\textsubscript{2}e 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)

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\textsuperscript{12} Ibid


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

<table>
<thead>
<tr>
<th></th>
<th>Electricity grid&lt;sup&gt;15&lt;/sup&gt;</th>
<th>Gasoline passenger cars&lt;sup&gt;16&lt;/sup&gt;</th>
<th>Truck deliveries&lt;sup&gt;17&lt;/sup&gt;</th>
<th>Waste landfilled MSW&lt;sup&gt;18&lt;/sup&gt;</th>
<th>Short haul flight&lt;sup&gt;19&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAR</td>
<td>kgCO&lt;sub&gt;2&lt;/sub&gt;e</td>
<td>0.56178</td>
<td>0.38298</td>
<td>0.29791</td>
<td>0.20</td>
</tr>
<tr>
<td>AR4</td>
<td>kgCO&lt;sub&gt;2&lt;/sub&gt;e</td>
<td>0.56173</td>
<td>0.38301</td>
<td>0.29789</td>
<td>0.24</td>
</tr>
<tr>
<td>AR5 no feedback</td>
<td>kgCO&lt;sub&gt;2&lt;/sub&gt;e</td>
<td>0.56149</td>
<td>0.38294</td>
<td>0.29781</td>
<td>0.27</td>
</tr>
<tr>
<td>AR5 with feedback</td>
<td>kgCO&lt;sub&gt;2&lt;/sub&gt;e</td>
<td>0.56182</td>
<td>0.38316</td>
<td>0.29792</td>
<td>0.33</td>
</tr>
<tr>
<td>% change in CO&lt;sub&gt;2&lt;/sub&gt;e emissions between SAR and AR5 with feedback</td>
<td>-0.05%</td>
<td>-0.01%</td>
<td>-0.03%</td>
<td>33%</td>
<td>-0.13%</td>
</tr>
<tr>
<td>% change in CO&lt;sub&gt;2&lt;/sub&gt;e emissions between AR4 and AR5 with feedback</td>
<td>0.01%</td>
<td>0.05%</td>
<td>0.004%</td>
<td>62%</td>
<td>-0.01%</td>
</tr>
</tbody>
</table>

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<sub>2</sub>O remains the same compared to its AR4 GWP (though reducing slightly compared to its SAR GWP), whereas the GWP for CH<sub>4</sub> 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<sub>2</sub>O.

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<sup>15</sup>EPA (2014). eGrid2013 v.1.0  
However, for most corporate firms operating within the service or manufacturing sectors, the majority of emissions are made up of CO₂, and so the changes in GWP will only cause a marginal impact, as evidenced by the minor percentage changes in CO₂e 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.

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”\(^2\). 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. 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.

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.” Though some commentators urged the EPA to adopt AR5 GWPs, this was ultimately rejected due to concerns that the AR5 GWPs would not be widely applied for many years. Countries reporting to the Kyoto Protocol for example will switch to the AR4 100-year GWPs starting with the 2015 submissions.

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

24 Ibid
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*

<table>
<thead>
<tr>
<th>Denominator unit</th>
<th>Electricity grid(^{26})</th>
<th>Gasoline passenger cars(^{17})</th>
<th>Truck deliveries(^{28})</th>
<th>Waste landfilled MSW(^{29})</th>
<th>Short haul flight(^{30})</th>
</tr>
</thead>
<tbody>
<tr>
<td>kgCO(_2)</td>
<td>0.6</td>
<td>0.4</td>
<td>0.3</td>
<td>-</td>
<td>0.2</td>
</tr>
</tbody>
</table>

\(^{26}\) EPA (2014). eGrid2013 v.1.0


<table>
<thead>
<tr>
<th></th>
<th>kgCH₄</th>
<th>kgN₂O</th>
<th>kgCO₂</th>
<th>kgCH₄</th>
<th>kgN₂O</th>
<th>kgCO₂</th>
<th>kgCO₂e</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAR</td>
<td>0.00001</td>
<td>0.00008</td>
<td>0.6</td>
<td>0.00023</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
</tr>
<tr>
<td>AR4</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00026</td>
<td>0.00043</td>
<td>0.00011</td>
<td>0.00000</td>
<td>0.00000</td>
</tr>
<tr>
<td>AR5</td>
<td>0.00003</td>
<td>0.00000</td>
<td>0.00031</td>
<td>0.00048</td>
<td>0.00010</td>
<td>0.00000</td>
<td>0.00000</td>
</tr>
<tr>
<td>AR5</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00025</td>
<td>0.00059</td>
<td>0.00011</td>
<td>0.00000</td>
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<tr>
<td>kgCO₂e</td>
<td>0.56178</td>
<td>0.38298</td>
<td>0.29791</td>
<td>0.20</td>
<td>0.01504</td>
<td></td>
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</tr>
<tr>
<td>kgCO₂e</td>
<td>0.56173</td>
<td>0.38301</td>
<td>0.29789</td>
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<td>0.15499</td>
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<td></td>
</tr>
<tr>
<td>kgCO₂e</td>
<td>0.56149</td>
<td>0.38294</td>
<td>0.29781</td>
<td>0.27</td>
<td>0.15484</td>
<td></td>
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<tr>
<td>kgCO₂e</td>
<td>0.56182</td>
<td>0.38316</td>
<td>0.29792</td>
<td>0.33</td>
<td>0.15502</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

% change in CO₂e emissions between SAR and AR5 with feedback
-0.05% | -0.01% | -0.03% | 33% | -0.13%
0.01% | 0.05% | 0.004% | 62% | -0.01%

% change in CO₂e emissions between AR4 and AR5 with feedback
-0.04% | -0.02% | -0.03% | 12% | -0.1%
0.02% | 0.04% | 0.01% | 36% | 0.02%