*OzonAction Kigali Fact Sheet 3*

# GWP, $CO_2$(e) and the Basket of HFCs

**Background:** Progress towards the HFC phase-down targets under the Kigali Amendment will be measured in **tonnes $CO_2$ equivalent**. It is very important that policy makers and industry stakeholders understand how this parameter is calculated and the way that it enables a flexible approach to HFC phase-down to be adopted by each country. To calculate tonnes $CO_2$ equivalent it is necessary to know the **GWP**[1] (global warming potential) of each relevant gas.

## What is GWP?

Global warming potential (GWP) is a measure of the relative global warming effects of different gases. The GWP indicates the amount of heat trapped by 1 tonne of a gas relative to the amount of heat trapped by 1 tonne of $CO_2$ over a specific period. $CO_2$ was chosen by the Intergovernmental Panel on Climate Change (IPCC) as the reference gas and its GWP is defined as 1. Most HCFCs and HFCs have GWPs that are thousands of times higher than the GWP of $CO_2$. For example, HFC-134a has a GWP of 1 430. This means that the emission of 1 tonne of HFC-134a will create the same contribution to global warming as the emission of 1 430 tonnes of $CO_2$.

## Why are there different GWP values for the same gas?

Different publications do not always quote the same GWP values for a particular gas. There are two main reasons for this:

a) GWPs can be defined to measure impact over different timescales, e.g. 20 years, 100 years or 500 years. This results in different GWP values for each of these timescales.

b) There is some uncertainty about the best GWP value to assign to each gas. A key source of GWP data are the IPCC Assessment Reports. GWP values published by the IPCC have been updated several times over the last 20 years.

## GWPs used under the Kigali Amendment:

Under the Kigali Amendment a standard set of GWP values has been agreed for reporting consumption and production of HFCs. The GWPs of HCFCs and HFCs are listed in Annex C and Annex F of the Montreal Protocol and are based on the 100-year GWPs in the IPCC 4th Assessment Report.

Some HCFCs and HFCs are used as pure fluids e.g. HFC-134a in various RAC applications. However, many of the most commonly used HFCs are blends of two or more separate HFC molecules. The GWP of a blend is the weighted average of the GWPs of the blend components. See Box 1 for an example calculation of a blend GWP.

**Box 1: Calculating the GWP of a Blend**

A widely-used blend is R-404A. It consists of:

52% HFC-143a + 44% HFC-125 + 4% HFC-134a

GWPs: HFC-143a: 4470 HFC-125: 3500 HFC-134a: 1430

**Blend GWP** = 52% * 4470 + 44% * 3500 + 4% * 1430

**= 3922**

| Group | Fluid | Montreal Protocol Standard GWP Value |
|---|---|---|
| HFCs | HFC-134a | 1 430 |
| | HFC-227ea | 3 220 |
| HFC blends | R-404A | 3 922 |
| | R-410A | 2 088 |
| HCFCs | HCFC-22 | 1 810 |
| | HCFC-141b | 725 |

The GWPs of HCFCs are of importance because they form part of a country's baseline consumption (see Kigali Fact Sheet 5 for details on baselines).

The table shows the GWP values that should be used for some of the most common HFCs and HCFCs. A table at the end of this Fact Sheet includes a comprehensive list of GWP values for all relevant molecules and blends.

[1] See Kigali Fact Sheet 14 for a glossary of all acronyms used

## What is tonnes $CO_2$ equivalent?

Tonnes $CO_2$ equivalent is the GWP-weighted quantity of a gas.

It is often referred to as tonnes $CO_2e$ or simply as tonnes $CO_2$.

Tonnes $CO_2$ equivalent is calculated by multiplying the mass of gas (in tonnes) by the GWP (global warming potential) of that gas.

**Box 2: Calculating tonnes $CO_2$ equivalent**

For example, the tonnes $CO_2$ equivalent of 100 kg of HFC 404A is calculated as follows:

**$CO_2$ equivalent = mass (in tonnes) x GWP**

Mass = 100/1 000 = 0.1 tonnes

GWP of R-404A = 3 922

Hence 100 kg R-404A is 0.1 x 3 922 tonnes $CO_2e$

**= 392.2 tonnes $CO_2e$**

## Measuring HFC phase-down for a "basket" of gases:

Using the parameter **tonnes $CO_2e$** to measure progress towards HFC phase-down makes it possible to use a single set of phase-down targets that apply to the whole basket of HFCs. The basket of controlled HFCs are listed in Annex F of the Montreal Protocol, together with standard GWP values. Production and consumption targets are set in tonnes $CO_2e$ and are applied to the total use of the whole basket of HFCs.

This approach allows each country to plan their phase-down in a way that best suits their local conditions. There are no prescriptive requirements to stop using specific HFC molecules – it is the aggregate target for all HFCs measured in tonnes $CO_2e$ that must be met. This encourages the use of low GWP alternatives but allows continuing use of small quantities of high GWP gases in markets where there is no cost-effective alternative.

The baseline for the HFC phase-down calculations is based on a combination of both HFC and HCFC consumption (see Kigali Fact Sheet 5 for details). The baseline amount is also treated as a basket of gases, with the GWP values for HCFCs used to calculate their tonnes $CO_2e$.

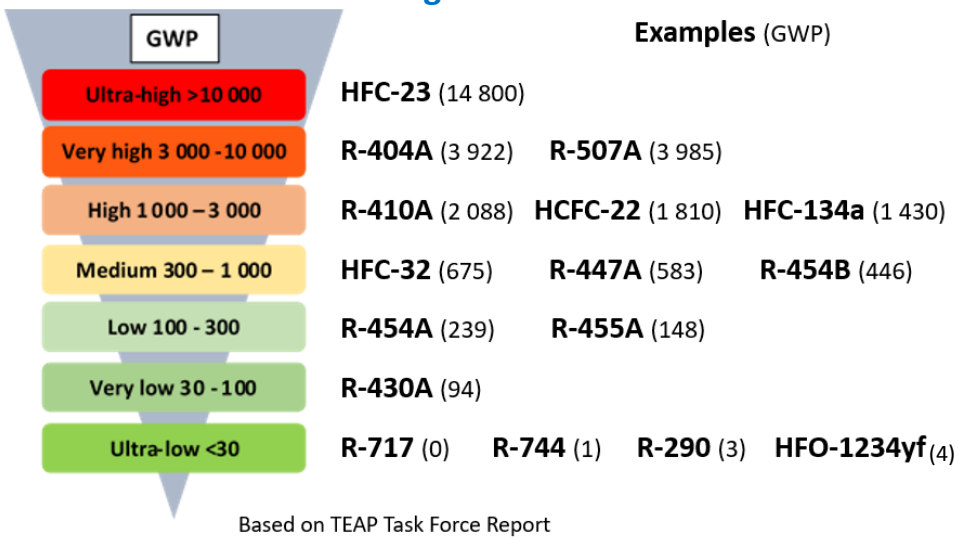
## The spectrum of GWP:

Figure 1 illustrates the spectrum of GWP for HFCs, HCFCs and not-in-kind (NIK) fluids, using GWP-bands specified by the Montreal Protocol Technology and Economic Assessment Panel. The bands are not universally accepted/adopted, but they help illustrate the mix of fluids that may be used in the future.

The most commonly used HCFCs and HFCs[2] have GWPs in the range 1 400 to 4 000. The weighted average GWP of these HCFCs and HFCs is around 2 000.

To achieve an 80% to 85% cut in HFC use via the Kigali Amendment it will be necessary to be using HFCs with an average GWP around 200 to 300. As shown in the figure, there are various "ultra-low" GWP options with GWPs well below 30. It is likely that in the future there will be significant use of ultra-low GWP gases, together with some use of medium GWP gases and limited use of high GWP gases where no other technical alternatives can be used. See Kigali Fact Sheet 4 for details about low GWP options.

**Figure 1**




Based on TEAP Task Force Report

[2] HFC-134a, R-410A, R-404A and HCFC-22 represent about 90% of global HFC and HCFC consumption

## Table of GWP Values:

The tables below provides a detailed list of the GWPs* of various fluids that are impacted by the Kigali Amendment. Colour coding based on Figure 1.

| Group | Fluid | GWP |
|---|---|---|
| HFCs | HFC-23 | 14 800 |
| | HFC-32 | 675 |
| | HFC-41 | 92 |
| | HFC-125 | 3 500 |
| | HFC-134 | 1 100 |
| | HFC-134a | 1 430 |
| | HFC-143 | 353 |
| | HFC-143a | 4 470 |
| | HFC-152a | 124 |
| | HFC-227ea | 3 220 |
| | HFC-236cb | 1 340 |
| | HFC-236ea | 1 370 |
| | HFC-236fa | 9 810 |
| | HFC-245fa | 1 030 |
| | HFC-365mfc | 794 |
| | HFC-4310mee | 1 640 |
| HCFCs | HCFC-22 | 1 810 |
| | HCFC-123 | 77 |
| | HCFC-124 | 609 |
| | HCFC-141b | 725 |
| | HCFC-142b | 2 310 |
| CFCs | CFC-11 | 4 750 |
| | CFC-12 | 10 900 |
| | CFC-113 | 6 130 |
| | CFC-114 | 10 000 |
| | CFC-115 | 7 370 |
| HFOs | HFO-1234yf | 4 |
| | HFO-1234ze | 7 |
| | HFO-1233zd | 4 |
| | HFO1336mzz | 9 |
| Other | Ammonia | 0 |
| | $CO_2$ | 1 |
| | Propane | 3 |
| | Iso-butane | 3 |
| | Pentane | 5 |
| | Propylene | 2 |

| Blend | GWP |
|---|---|
| R-401A | 1 182 |
| R-401B | 1 288 |
| R-402B | 2 416 |
| R-403A | 3 124 |
| R-403B | 4 457 |
| R-404A | 3 922 |
| R-407A | 2 107 |
| R-407C | 1 774 |
| R-407F | 1 825 |
| R-408A | 3 152 |
| R-409A | 1 585 |
| R-409B | 1 560 |
| R-410A | 2 088 |
| R-411A | 1 597 |
| R-412A | 2 826 |
| R-413A | 2 053 |
| R-415A | 1 507 |
| R-415B | 546 |
| R-416A | 1 084 |
| R-417A | 2 346 |
| R-418A | 1 741 |
| R-419A | 2 967 |
| R-420A | 1 536 |
| R-421A | 2 631 |
| R-421B | 3 190 |
| R-422A | 3 143 |
| R-422B | 2 526 |
| R-422C | 3 085 |
| R-422D | 2 729 |
| R-423A | 2 280 |
| R-424A | 2 440 |
| R-425A | 1 505 |
| R-426A | 1 508 |
| R-427A | 2 138 |
| R-428A | 3 607 |
| R-429A | 14 |
| R-430A | 95 |
| R-431A | 38 |
| R-432A | 2 |
| R-433A | 3 |
| R-433B | 3 |
| R-433C | 3 |
| R-434A | 3 245 |
| R-435A | 26 |

| Blend | GWP |
|---|---|
| R-436A | 3 |
| R-436B | 3 |
| R-437A | 1 805 |
| R-438A | 2 265 |
| R-439A | 1 983 |
| R-440A | 144 |
| R-441A | 3 |
| R-442A | 1 888 |
| R-444A | 93 |
| R-444B | 296 |
| R-445A | 135 |
| R-446A | 461 |
| R-447A | 583 |
| R-448A | 1 387 |
| R-449A | 1 410 |
| R-449B | 1 412 |
| R-450A | 605 |
| R-451A | 149 |
| R-451B | 164 |
| R-452A | 2 140 |
| R-452B | 698 |
| R-453A | 1 765 |
| R-454A | 239 |
| R-454B | 466 |
| R-454C | 148 |
| R-455A | 148 |
| R-456A | 687 |
| R-457A | 139 |
| R-458A | 1650 |
| R-459A | 460 |
| R-459B | 145 |
| R-460A | 2103 |
| R-461A | 2767 |
| R-502 | 4 657 |
| R-507A | 3 985 |
| R-508A | 13 214 |
| R-508B | 13 396 |
| R-510A | 1 |
| R-511A | 9 |
| R-512A | 189 |
| R-513A | 631 |
| R-513B | 596 |
| R-514A | 7 |
| R-515A | 393 |