



GWP, CO₂(e) and the Basket of HFCs

Background: Progress towards the HFC phase-down targets under the Kigali Amendment will be measured in **tonnes CO₂ 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 CO₂ equivalent it is necessary to know the **GWP¹** (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 CO₂ over a specific period. CO₂ 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 CO₂. 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 CO₂.

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 CO₂ equivalent?

Tonnes CO₂ equivalent is the GWP-weighted quantity of a gas.

It is often referred to as tonnes CO₂e or simply as tonnes CO₂.

Tonnes CO₂ equivalent is calculated by multiplying the mass of gas (in tonnes) by the GWP (global warming potential) of that gas.

Box 2: Calculating tonnes CO₂ equivalent

For example, the tonnes CO₂ equivalent of 100 kg of HFC 404A is calculated as follows:

$$\text{CO}_2 \text{ equivalent} = \text{mass (in tonnes)} \times \text{GWP}$$

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 CO₂e
= **392.2 tonnes CO₂e**

Measuring HFC phase-down for a “basket” of gases: Using the parameter **tonnes CO₂e** 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 CO₂e and are applied to the total use of the whole basket of HFCs.

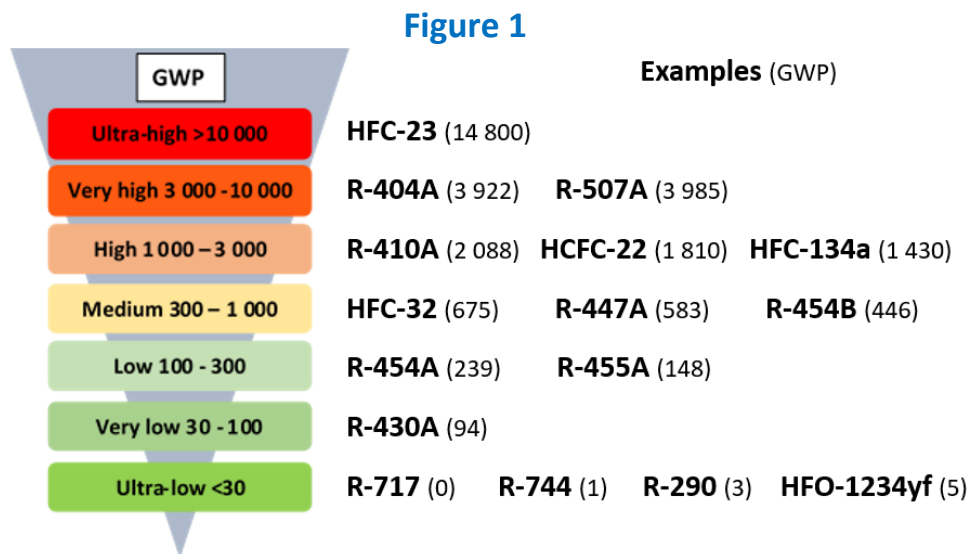
This approach allows each country to plan their phase-down in a way that best suits their local conditions. There are no prescriptive requirements to stop using specific HFC molecules – it is the aggregate target for all HFCs measured in tonnes CO₂e that must be met. This encourages the use of low GWP 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 CO₂e.

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 somewhat arbitrary and not universally accepted, but they help illustrate the mix of fluids that may be used in the future.

The most commonly used HCFCs and HFCs² 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.



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
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	3
	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	13
R-430A	94
R-431A	37
R-432A	2
R-434A	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	1 397
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	1352
R-461A	2103
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	939