Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit

Umwelt Bundes Amt
Für Mensch und Umwelt

Classification of ODS Substitutes on the Basis of Their

Global Warming Potential

The Montreal Protocol on Substances that Deplete the Ozone Layer lays down an international phase-out schedule for ozone depleting substances. Possible substitutes have Global Warming Potentials (GWP) in the range of zero to several thousand. Parties to International Treaties already use terms like „low-GWP“ and „high-GWP“ substitutes*(1)*. However, as of today there is no internationally accepted classification system in place these terms could be based on. The Technology and Economic Assessment Panel of the Montreal Protocol on Substances that Deplete the Ozone Layer as well as Non-Governmental Organizations have made first recommendations. These are either quite academic (complex) and therefore not easily applicable in praxis or allow only a black-and-white decision. To overcome these limitations we suggest a simple, easily applicable and sustainable classification:

GWP < 20 “low-GWP”

20 ≤ GWP ≤ 150 “moderate-GWP”

GWP >150 “high-GWP”

This proposal is presented here as a contribution to the international discussion.

Substitutes and their global warming potential

There are a multitude of substances available today which can replace ozone-depleting substances (ODS). Current substitutes have global warming potentials (GWPs) ranging from zero to several thousand (see Table). GWPs smaller than 20 are attributed mainly to non-halogenated substances (see Figure 1). Important substitutes free of halogens are propane or butane, water, air, ammonia and CO_2. Today, halogen-free substances and technologies exist for nearly all former ODS uses. In some applications and countries, the changeover process is almost complete *(2)*. Substances exhibiting GWPs higher than 20 include, in particular, fluorinated greenhouse gases (perfluorocarbons (PFCs) and hydrofluorocarbons (HFCs) (F-gases), fluorinated ethers and nitrogen trifluoride (NF_3). Some of the above substitutes are flammable, others are toxic or classified as volatile organic compound (VOC).

Substitute	GWP_{100}	Typ
717 (NH_3)	0	-
744 (CO_2)	1	-
600a	< 20	HC
1270	< 20	HC
32	675	HFC
134a	1,430	HFC
152a	124	HFC
227ea	3,220	HFC
245fa	1,030	HFC
365mfc	794	HFC
404 A	3,922	HFC-blend
407 C	1,774	HFC-blend
1234yf	4	HFC
Opteon XP 10	approx. 600	HFC-blend
NF_3	17.200	-

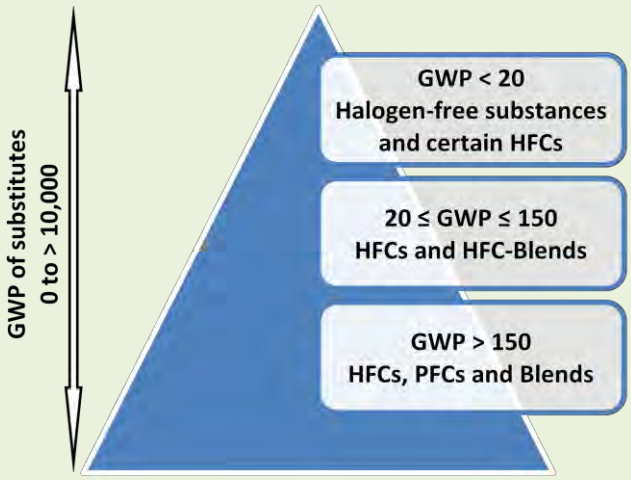

Fig. 1: GWPs of current ODS substitutes

Classification of ODS substitutes on the basis of their global warming potentials

Requirements for definition or classification

We propose a three-tier model based on the requirements sustainability, applicability, understandability and relevance as shown in Figure 2. Given the many and highly diverse applications, a two-tier model would, in our view, excessively limit possible options. On the other hand, a model comprising more than three tiers we regard as being too complex to be practicable.

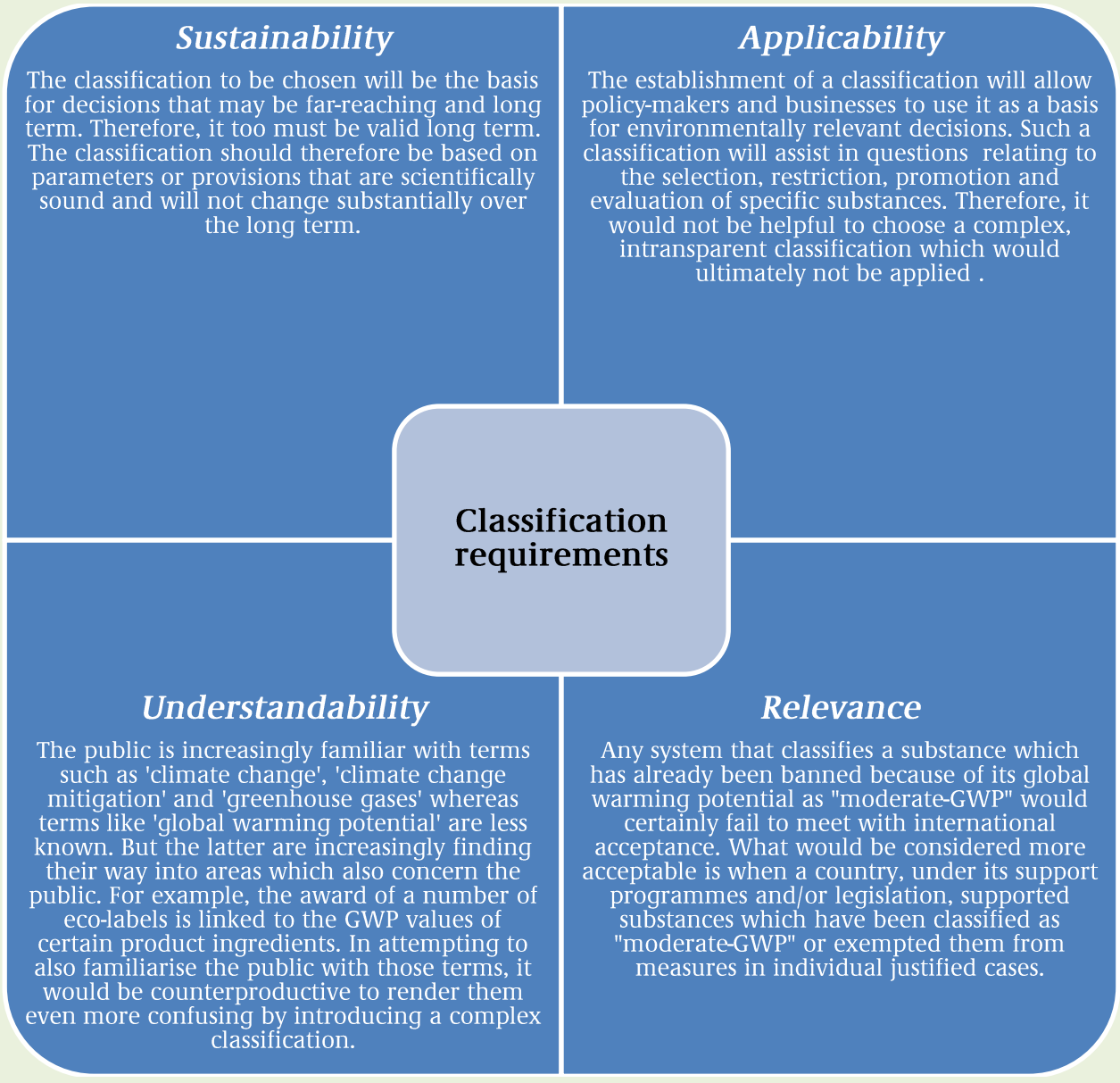

Fig. 2: Requirements for classification of ODS substitutes

Selection of limits

We suggest that limits be defined in accordance with the environmental policy goal pursued and using already existing, established values. Practical examples of the political setting of values exist, one being the 100-year time horizon set for the global warming potential of substances by the Parties to the Framework Convention on Climate Change.

Lower limit 20	A GWP value of 20 has often been applied to differentiate between substances and therefore suggests itself as the lower limit. All non-halogenated ODS substitutes and the new generation of HFC refrigerants may be classified as being below this value. A distinct line should be drawn between these and conventional, halogenated substances. Substances with a GWP below 20 normally have, in their various applications, a negligible impact on the contribution of the overall system to global warming.
Upper limit 150	The second limit should differ significantly from the lower limit, e.g. by a factor of 10. Since 200 is a value not commonly applied, we suggest using a GWP of 150 as the second limit. This value is roughly a factor of 10 higher than 20 and at the same time has been established in EU legislation and already been accepted for the EU. In addition, since it covers at least one HFC, it does not represent a limit that is purely substance-based.

Fig. 3: Reasons for the chosen limits for classification of ODS substitutes

No classification system can function as the sole basis for decisions. Every decision-maker must also consider other aspects such as toxicity, technical suitability, efficiency, flammability, etc.

Discussion of alternative proposals

The classification suggested here contrasts with a number of other proposals. For example, a task force set up by TEAP has discussed various variants of a definition and as outcome has proposed the classification shown below, the authors pointing out that the separation between the classes is not a strict one and that revisions over time are needed (2):

GWP < ~30 “very low-GWP” (“ultra-low”)[i]

GWP < ~100 “very low-GWP”

GWP < ~300 “low-GWP”

GWP < ~1,000 “moderate-GWP”

GWP < ~3,000 “high-GWP”

GWP < ~10,000 “very high-GWP”

GWP > ~10,000 “ultra-high-GWP”

SUBSTITUTES

Non-halogenated substances

- hydrocarbons (HCs) like propane (290) or iso-butane (600a)
- ammonia (717)
- CO_2 (744)
- water (718)
- air
- dimethyl ether (DME)
- nitrogen (N_2)

mostly have global warming potentials below 20 and, with the exception of CO_2, are not covered by the Kyoto Protocol. Their production and use is not regulated. Even if they are marketed in large amounts as ODS substitutes, the impact on total greenhouse gas emissions will be small. However, some of these substances are extremely/highly flammable, toxic and/or hazardous to water. Therefore, relevant safety measures must be applied when using them.

Halogenated substances

- perfluorocarbons (PFCs) and hydrofluorocarbons (HFCs)
- fluorinated ethers

usually have global warming potentials higher than 150 and like CO_2 are covered by the Kyoto Protocol, with the exception of fluorinated ethers. The Kyoto Protocol does not, however, regulate their production and use. Since they are suitable ODS substitutes, these substances will see such strong growth in amounts used that in 2050 they will account for about 8 % of total greenhouse gas emissions (business-as-usual scenario). Projections made in cooperation with the producers of these substances arrive at even higher shares (3).

For some time now, a number of producers have been working to develop a new generation of HFCs and are gradually launching them on the market. These are unsaturated HFCs – hydrofluoroolefines (HFOs) – which like non-halogenated substitutes are characterized by a low GWP. These substances are flammable, however.

An evaluation of the proposal on the basis of the requirements shown in Figure 2 reveals that it fails to meet them:

Reasons

The GWP classification proposed by (2)

- is based on the current market situation and not on market-independent scientific criteria. This means that every major change in the market situation would entail the need to adapt the classification. This could make the classification very short-lived.
- comprises many classes, although the last two classes are likely of minor relevance at most. The many classes make the classification difficult to apply and be tailored for use by GHG specialists. Its incentive effect is low.
- does not appropriately reflect the current status of the discussion, because, for example, it would classify substances with GWPs of up to 300 as “low-GWP substances”.
- does not sufficiently delimit either natural substitutes or the new chemical substitutes with GWPs lower than 20.

Another proposal envisages the introduction of a system consisting only of two tiers. It is favoured by most non-governmental organizations. When such a system is evaluated against the above requirements, it is found that it meets them completely. However, by failing to offer a middle way it leaves little choice. Given the highly diverse applications in which HCFCs need to be replaced, we consider a three-tier system more suitable for classifying substitutes.

Outlook

Many of today’s substitutes for ozone-depleting substances (ODSs) are harmful to the climate, like ODSs are. The global warming potential (GWPs) of the substitutes has been used again and again as a criterion for decision-making. However, there is as yet no internationally accepted definition as to which GWPs should be classified as low or moderate and therefore as fully or partially tolerable and which as high and therefore as candidates for regulation. We believe that such a classification is necessary and conclude that numerous aspects need to be considered in establishing it. We also conclude that suitable values for classification need to have an incentive effect. We suggest using values that have already been established. The political setting of values has precedents in other areas. One example is the reference period of 100 years set for substances’ global warming potential. The classification proposed here is capable of assisting policymakers and businesses in making environmentally relevant decisions as regards the replacement of ozone-depleting substances and of having an appropriate incentive effect from the perspective of environmental policy.

References

1. **21st Meeting of the Parties.** Decision XXI/9: Hydrochlorofluorocarbons and environmentally sound alternatives. Port Ghalib, Ägypten : UNEP, 2009.
2. **TEAP.** Report of the Decision XXI/9 Task Force on the assessment of HCFCs and environmentally sound alternatives. Nairobi : UNEP, 2010.
3. **Velders, Guus J. M. et al.** The large contribution of projected HFC emissions to future climate forcing. PNAS Early Edition. Juni 2009.
4. **German Federal Environment Agency.** Avoiding fluorinated greenhouse gases - prospects for phasing out. Dessau-Roßlau : German Federal Environment Agency, 2011.
5. **Barbara Gschrey, Winfried Schwarz.** Projections of global emissions of fluorinated greenhouse gases in 2050. Dessau-Roßlau : German Federal Environment Agency, 2009. Vol. 17/2009, Climate Change. UBA-FBNr: 001318.

Disclaimer
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and Federal Environment Agency (UBA)
Contact:
BMU, IG II 1, igii1[at]bmu.bund.de | www.bmu.de
UBA, III 1.4, III1.4[at]uba.de | www.umweltbundesamt.de
Editorial deadline: July 2011

[i] “Although one could use the term “ultra-low”, it is proposed to also use the term “very low” for substances with GWPs lower than 30. This is done because this range also includes carbon dioxide (although having a GWP of 1) being the largest contributor to human induced global warming”