Report of the TEAP XXI/9 Task Force

Lambert Kuijpers

Technical University
Eindhoven, NL

Co-chair Task Force
Co-chair UNEP TEAP

ATMOSPHERE 2010

Brussels
27-28 September 2010

Introduction

- TEAP has published various reports related to conversion from HCFCs
- The XX/8 Task Force report in 2009 already dealt with it and gave estimates for banks and emissions
- The XXI/9 Task Force report on replacements for HCFCs was presented at the OEWG Geneva in June 2010
- This presentation is based on the slides as presented in Geneva in June 2010
- Any comments are very much welcomed

Decision XXI/9 Paragraph 2

To request the Technology and Economic Assessment Panel

(2a) To list all sub-sectors using HCFCs, with concrete examples of technologies where low-GWP alternatives are used, indicating what substances are used, conditions of application, their costs, relative energy efficiency of the applications and, to the extent possible, available markets and percentage share in those markets, to compare these alternatives with other existing technologies, in particular, high-GWP technologies that are in use in the same sectors;

Decision XXI/9 Paragraph 2

(2b) To identify and characterize the implemented measures for ensuring safe application of low-GWP alternative technologies and products as well as barriers to their phase-in, in the different sub-sectors, collecting concrete information from various sources;

Decision XXI/9 Paragraph 2

(2c) To provide a categorization and reorganization of the information previously provided in accordance with decision XX/8 as appropriate, to inform the Parties of the uses for which low- or no-GWP and/or other suitable technologies are or will soon be commercialized, including to the extent possible the predicted amount of high-GWP alternatives to ozone-depleting substances uses that can potentially be replaced.

Process

- The TEAP established a Task Force to update data contained in the XX/8 report and to report on the other issues requested in paragraph 2 of XXI/9
- 12 Chapter Lead Authors and 27 Reviewing Authors participated
- TEAP review (April 2010) was followed by a final Task Force review and agreement by consensus

Kyoto Protocol and GWPs

- The Kyoto Protocol uses GWP values as specified in the Second IPCC Assessment Report (SAR) and has not considered later IPCC revisions of GWP values
- Values are based on a 100 year time horizon
- GWPs of very short lived substances are not addressed in the latest IPCC AR4; important issue is that local effects dominate over global total mixing
- The Kyoto Protocol has never defined “high-GWP” and “low-GWP”; they are comparative in nature

Classification on a GWP Scale

- To scale certain effects normally a factor of 10 is used. One can discriminate between very low, low, intermediate, high, very high GWP etc. by not using 10, but $\sqrt{10}$ as a smaller value, going from 30 to 100 to 300 etc.
- Most HCFCs and HFCs which are applied in dispersive uses have GWPs between 500 and 4000 with a median (weighted average) of somewhat more than 2000. A reduction from an average to a low GWP could be a factor of 10, which would yield a GWP in the order of 300 (this is substantial)

GWP and Radiative Forcing

- Current radiative forcing from ODS (once produced at 1.2 million tonnes/year) is 0.3 W/m^2, whereas the current radiative forcing from CO_2 is about 1.7 W/m^2
- Given production (and emission) values for HFCs in the order of 800 ktonnes, one could define a so-called "low GWP" for a certain steady state radiative forcing
- If "low-GWP" would be comparable in radiative forcing to about 1% of CO_2 and about 5% of the current ODS radiative forcing, one could calculate that substances, emitted annually with the amounts above, need to have a GWP smaller than 300

Classification on a scale

In the report, TEAP proposes the following classification for refrigerant chemicals:

- **Low-GWP: < 300**
  - **GWP < 100** **very low**
  - **GWP < 30** **ultra low**
- **MODERATE GWP: 300-1,000**
- **HIGH GWP: > 1,000**
  - **GWP > 3,000** **very high**
  - **GWP > 10,000** **ultra high**

Toxicity and Flammability

- **High** or **moderate** GWP substances or mixtures may be required when **low** GWP toxic or flammable substances cannot be applied in certain types of products, or under certain circumstances
- New **low** GWP synthetic fluoro-substances are under development
- The future development changes in equipment design will be determining which chemicals can or should be selected (which comes first: chemical or design ?)

Methods and Metrics

- Ultimate choice of technology to phase out HCFCs will be based on ozone depletion and on climate, health, safety, affordability and availability aspects (XIX/6)
- Choosing the lowest suitable GWP substance will not always be the best selection (energy use in manufacturing and during operation is also important)
- Life-Cycle Climate Performance (LCCP) is the most comprehensive method for comparing candidates
- LCCP models need more development to be transparent and adaptable to local ambient conditions

Domestic refrigerators and freezers

- About 63% of new refrigerators employ **HFC-134a**
- About 36% employ **hydrocarbons**, mainly **HC-600a (isobutane)**
- It is predicted that, within 10 years, under a business-as-usual, at least 75% of all new production will apply **hydrocarbons**; required changes in standards are underway and regulations could ease transition
- No identified technology can compete for cost or efficiency with conventional vapour compression technology for mass production

Commercial Refrigeration

- Commercial refrigeration includes three different categories of systems: stand-alone equipment, condensing units, and supermarket centralised systems
- Solutions to replace **HCFC-22** depend on the specific applications in each category
- The majority of stand-alone equipment is currently based on **HFC-134a** technology; the energy efficiency of **HCs** is comparable and some conversion is ongoing (with regional differences)

Commercial Refrigeration (2)

- Condensing units have as the dominant **HCFC-22** replacements **HFC-134a** and **R-404A;** it is a cost driven market; **HCs, ammonia and carbon dioxide** have been tested and are installed in a number of supermarkets
- Centralised systems are increasingly using **indirect systems**; the **HCFC-22** replacements are **R-404A, HFC-134a**, **ammonia, HCs, carbon dioxide** and (maybe) **low-GWP HFCs** blended with **HFC-32**
- Important current trend consists of cascading systems with **HFC-134a** in the high temperature and **carbon dioxide** in the low temperature loop

Transport refrigeration

- Majority of equipment utilises **high-GWP HFCs**
- **HCFC-22** is used mainly in aging vessels and road transport in developing countries
- Development of systems with **low-GWP chemicals** is underway but faces technical challenges because of robustness, low weight, corrosion resistance and safety requirements
- The most promising **low-GWP substances** are **hydrocarbons** and **carbon dioxide**

Large Size Refrigeration

- **Ammonia** has been used as THE refrigerant for a long time, with significant regional variations
- In applications where the toxicity of **ammonia** is unacceptable, **carbon dioxide** has been an alternative
- **HCFC-22** “drop-ins” have not been commercialised
- **High-GWP HFCs** are not widely used in large size refrigeration systems; if adopted then they have been used in low charge systems
- It is unlikely that the **low-GWP HFCs** developed for other applications will be used in this sector

Unitary AC

- Nearly all air cooled AC used **HCFC-22** before 2000, and the transition is complete or well underway in developed countries
- In developed countries, **high-GWP HFCs** have been the dominant replacements, with **R-410A** the most widely used (with **R-407C** in certain regions); **hydrocarbons** are applied in low charge applications
- In developing countries, short term replacements will be **R-407C** and **R-410A**, with **hydrocarbons** for lower charge applications

Unitary AC

- **HFC-32** is a lower GWP alternative for **HCFC-22** than **R-410 A** (one third of their GWPs)
- As experience with flammability increases, **HFC-32** is likely to become the future **HCFC-22** substitute, rather than **R-410A**
- Usage of **hydrocarbons** is expected to increase; use will increase with charge minimisation
- **Low-GWP HFCs** might become replacements; however, lower vapour density will impact equipment dimensions and costs and works counter-productive
- **Carbon dioxide** will increase in use (lower ambient)

Chillers

- Centrifugals employ **HFC-134a** and **HCFC-123** (very low GWP); at this time it is not known whether low-GWP options (such as **low-GWP HFCs, e.g. HFC-1234yf**) will be found suitable for chillers
- **Ammonia** chillers are more common in the smaller sizes with different compressor types; there are **HCs** in a limited number of chiller applications; safety concerns are largely overcome in certain regions
- **Carbon dioxide** is a good alternative for chillers that also produce hot water

Chillers (2)

- **Hydrocarbons** are used in a limited number of small air-cooled chiller installations in Europe. Safety issues are of concern particularly for indoor chiller installations
- In regions where companies, governments, and the public support hydrocarbon solutions, safety concerns have been largely overcome by engineering, technician training, and changes in regulations
- **Water (R-718)** has been applied in a few cases

Mobile Air Conditioning

- **HCFCs** are mainly applied in bus and train AC; the alternatives are **HFC-134a** and **carbon dioxide**
- The replacement of **HFC-134a** in passenger cars will proceed
- The original **HFC-134a** replacement options with GWP<150 are **carbon dioxide** and **HFC-152a**; the most important current alternative is **HFC-1234yf**
- All options have comparable energy efficiency
- The emerging global car manufacturers' **apparent choice** is **HFC-1234yf**

Conclusions

- TEAP proposes a classification of GWPs as **high >1000**, **moderate 300 – 1000** and **low < 300** with subclasses such as **very low < 100**
- Each sector/sub-sector has a variety of low or moderate GWP alternatives available or under development
- Some sectors/sub-sectors may also have Not-In-Kind alternatives that are not Global Warming Substances
- One may wish to select alternatives with the lowest Climate Impact based upon life cycle analyses, such as LCCP and **not** based solely on GWP (energy use or other life cycle emissions may contribute significantly)

Report of the TEAP XXI/9 Task Force

Thank you !