NEW

OzonAction

OzonAction Kigali Fact Sheet 19

Phase-down Strategy: Impact of Gas Choices

UN environment

Background:

In Kigali Fact Sheet 6 the development of a national HFC phase-down strategy is discussed. That Fact Sheet gives background information on the "core actions" that can be used to deliver the required cuts in HFC consumption. These actions include:

- Use of lower GWP refrigerants in new equipment
- Leak prevention
- Retrofit of existing equipment with lower GWP alternatives
- Use of reclaimed refrigerant

It was stressed that the most important long-term core action is to use lower GWP alternatives to HFCs in all new equipment. In this Fact Sheet we show how the choice of refrigerant selected in new equipment has a strong influence on the rate of HFC phase-down.

Lifecycle of RAC Equipment:

In most Article 5 countries the consumption of HFCs is dominated by the requirements in the refrigeration and air-conditioning sectors (RAC). An important characteristic of the RAC market is the relatively long life of equipment and the on-going demand for refrigerant for servicing. The consumption of HFCs by RAC equipment consists of:

a) The initial filling of new equipment

b) The top-up of any leaked refrigerant during plant servicing throughout the life of the equipment.

In many Article 5 countries, the majority of RAC equipment is imported. Much of this equipment is imported pre-charged with refrigerant (e.g. car air-conditioning, small room air-conditioners, large chillers). This means that in terms of Montreal Protocol consumption (which does not include ODS and will not include HFCs in pre-charged imports) demand for initial filling is quite low. A large proportion of annual refrigerant consumption is for the RAC service sector[1].

Most RAC equipment has a life in the 15 to 20 year range. Some equipment, such as car air-conditioning, has a shorter life of around 10 years, whilst industrial refrigeration and large air-conditioning water chillers can have a much longer life (in the 25 to 30 year range). This long lifecycle means that there is always a significant "bank" of refrigerant in existing RAC equipment. If there is a switch to a new refrigerant it takes many years before the bank of old refrigerant is replaced – leading to a long period with an on-going service demand for the old refrigerant.

Impact of a switch to high GWP HFCs:

Until recently a lot of new RAC equipment used HCFC refrigerants, in particular, HCFC-22. The HCFC phase-out Management Plans (HPMPs) Plans are in place to phase-out out the production and consumption of HCFCs in developing countries. In many situations in Article 5 countries this is leading to a switch from the use of HCFC-22 (GWP 1810) in new RAC equipment to an HFC with a high GWP. For example, R-410A (GWP 2088) is commonly being used in small air-conditioning systems and R-404A (GWP 3922) in food retail and industrial refrigeration. These are the same choices that were made in non-Article 5 countries during the last 20 years.

However, this results in a rapidly growing installed bank of high GWP HFCs. As discussed above, much of this equipment has a long life cycle and will require on-going top-up over the next 15 to 25 years. This makes it hard to achieve the Kigali Amendment HFC phase-down targets, especially in Article 5 countries that import a lot of pre-charged HFC equipment.

[1] Note, this is not the case for countries that have significant RAC equipment manufacture within the country.

A better strategy – an early switch to lower GWP alternatives:

During the last five years there has been significant development of lower GWP alternatives. Many of these are widely used in non-Article 5 countries in response to national or regional regulations that require reductions in HFC use. Many of these technologies are becoming available in Article 5 countries and the level of availability is rapidly increasing. In a national HFC phase-down plan, each country could consider how the lower GWP technologies can be introduced as early as possible.

Examples of RAC markets with lower GWP alternatives already widely available are shown in Table 1.

Table 1: RAC Markets with Lower GWP Alternatives

Market sector	High GWP HFC in common use (GWP)	Examples of lower GWP alternatives (GWP)
Domestic refrigerators	R-134a (1430)	R-600a (3)
Small split room air-conditioning	R-410A (2088)	R-32 (675)
Water chillers for air-conditioning	R-134a (1430)	R-1234ze (7), R-1233zd (4), R-514A (7)
Food retail systems	R-404A (3922)	R-744 (1), R-448A (1387), R-449A (1397)
Car air-conditioning	R-134a (1430)	R-1234yf (4)

During the development of a phase-down strategy it will be important to:

a) Engage with relevant stakeholders (e.g. RAC equipment importers) to identify the availability of lower GWP products (see Kigali Fact Sheet 8 for information on stakeholder engagement). If certain lower GWP technologies are not yet available it will be important to identify any barriers (e.g. lack of training) and take steps to overcome these barriers (see Kigali Fact Sheet 11 for information on barriers).

b) Do some scenario analysis to identify the potential benefits of an early switch to a lower GWP technology.

Carrying out scenario analysis:

Scenario analysis was briefly introduced in Kigali Fact Sheet 6, which included an example which assessed a switch from R-134a to R-1234yf in car air-conditioning. That Fact Sheet also explained the availability of "top-down" data showing national consumption of HCFCs and HFCs and the need to better understand the use of these gases in the various market sectors and sub-sectors.

To carry out good scenario modelling it is necessary to build a "bottom-up" national model of the use of HFCs, together with all relevant alternative fluids including HCFCs and the lower GWP alternatives that can be used in the future. This model should distinguish between the important sub-sectors of the market as these can each have different characteristics. In particular, the historic and future choices for refrigerants can vary significantly between each market sub-sector.

OzonAction has been developing a software tool, *HFC Outlook*, cooperating with Kuwait and Bahrain as a pilot. The tool will provide comprehensive bottom-up modelling for Article 5 countries, which will enable scenario analysis that compares different HFC phase-down strategies.

Figures 1 to 6 provide examples of modelling using this tool for a fictitious Article 5 country.

Figure 1 shows modelling of HCFC consumption (purple line) and HFC consumption (blue line). The modelled data is compared to the annually reported data (purple and blue dots). The bottom-up model is "tuned" to top-down reported data to ensure that the model represents a good starting point for making forecasts.

Figure 1: Historic Modelling

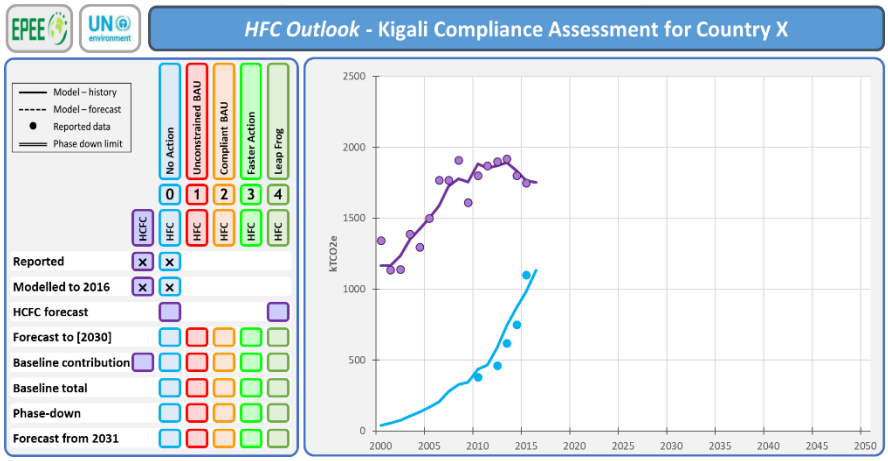
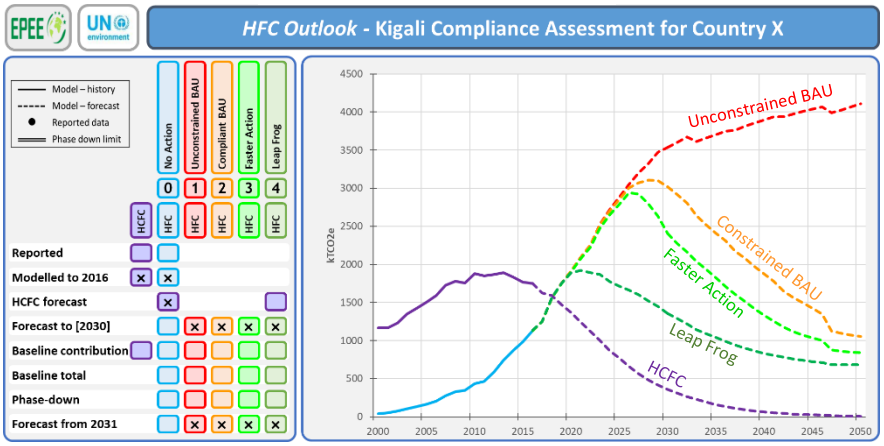


Figure 2 also shows forecasts for future consumption of HCFCs and HFCs.

There is a single HCFC forecast based on the expected changes under the HCFC phase-out programme (purple line).

There are four different HFC forecasts, each based on a different future scenario. The difference between each of these scenarios depends mainly on the choices for use of alternative refrigerants. The four scenarios follow the same path until around 2020. After that date different responses to the Kigali Amendment become apparent.

Figure 2: National Forecasts



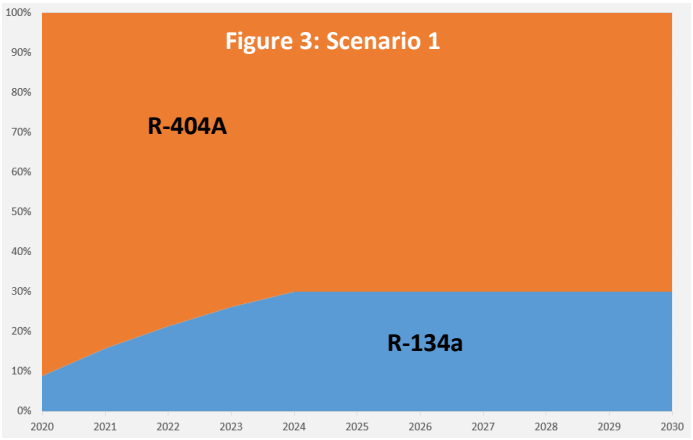
Scenario 1 (red line) is a "non-compliant" business-as-usual scenario, in which high GWP HFCs continue to be used in new equipment. The other scenarios lead to compliance with the Kigali Amendment, although the rate of HFC phase-down is highly dependent on the rate of introduction of lower GWP alternatives.

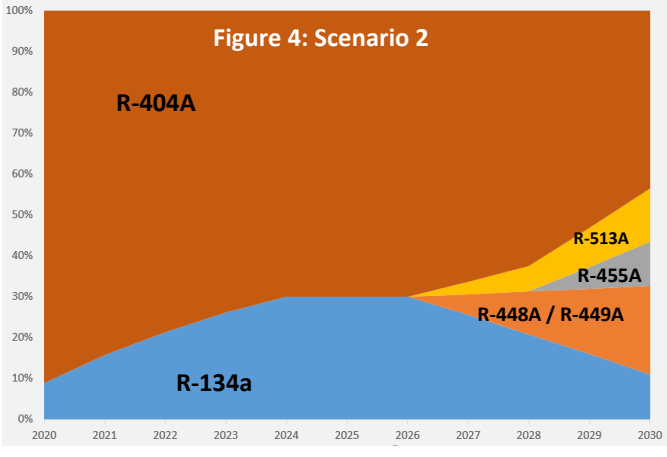
These forecasts are plotted in kTonnes CO_2 and the area under each curve indicates the total amount of CO_2 saved through each phase-down strategy. Table 2 shows the benefits of the 3 compliant scenarios compared to BAU. In the years between 2020 and 2050 the 'leap frog' scenario reduces HFC consumption by almost twice the amount that is achieved by the minimum compliance scenario. This clearly shows the potential benefits of an early switch to lower GWP refrigerants.

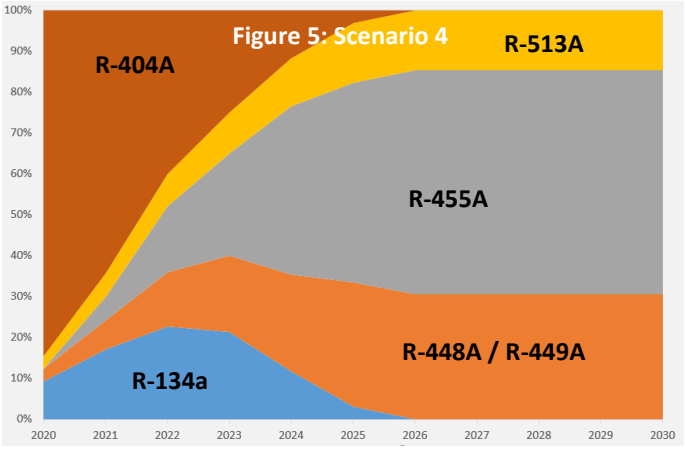
Table 2: Environmental Benefits of HFC Phase-Down, kT CO_2

	Scenario 2: Minimum compliance	Scenario 3: Faster Action	Scenario 4: Leap Frog
Reduction in consumption versus Scenario 1	41 000	53 000	72 000

The modelling in Figure 2 is based on numerous assumptions about the refrigerant choices made in different sectors of the market. The charts in Figures 3 to 5 illustrate the choices for new condensing units used in a selected example sub-sector: chilled food retail, between 2020 and 2030. Under the non-compliant Scenario 1, only high GWP HFCs are used, with R-404A being the dominant choice. Under the minimum compliance Scenario 2, the high GWP refrigerants are used in new equipment until 2026 and then 3 different lower GWP alternatives begin to be introduced. Under Scenario 4, the 'leap frog' scenario, the use of high GWP refrigerants in new equipment ends much more quickly and the lower GWP alternatives are introduced from 2020 onwards.



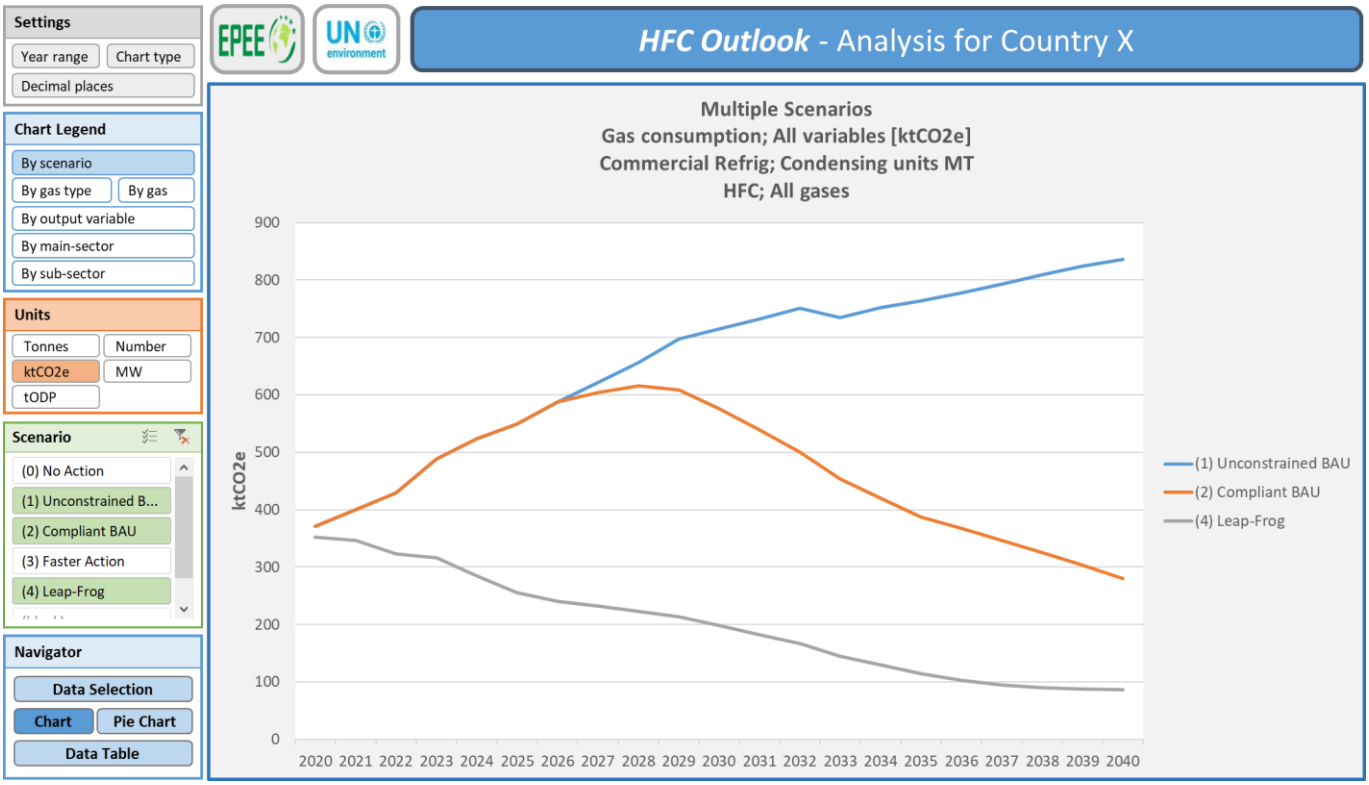




Using the refrigerant selections illustrated in Figures 3 to 5, the scenario modelling tool can estimate the future HFC consumption for each scenario, as illustrated in Figure 6. For this market sub-sector (condensing units for chilled food) there are currently no ultra-low GWP alternatives. However, there are good medium GWP options already in the market. R-448A and R-449A have virtually the same performance characteristics as R-404A, but have a GWP of around 1400 compared to 3922. Moving from HCFC-22 to R-404A for the next 10 years will not support an HFC phase-down initiative. In Figure 6, the non-compliant Scenario 1 and the minimum compliance Scenario 2 both create significant HFC consumption well into the 2030s.

By switching away from high GWP HFCs in the early 2020s (as in the leap frog Scenario 4), HFC consumption in this market sector falls much more quickly and makes compliance with the Kigali Amendment targets much easier in this example.

Figure 6: HFC Consumption Forecasts for a Small Market Sub-Sector



Stimulating Early Action:

The analysis illustrated in Figures 1 to 6 gives an insight into the power of scenario analysis and the importance of encouraging early uptake of lower GWP alternatives. The design of a national HFC phase-down strategy needs to include an evaluation of the availability of lower GWP technologies. A pro-active approach may be required to stimulate a move to these new technologies. Without good stakeholder engagement and encouragement, it is likely that high GWP HFCs will remain the popular choice for several more years. This can be avoided if the benefits of early action can be communicated to the industry and if the barriers to change can be identified and overcome.