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Title: Calculations from the New Zealand Hydrofluorocarbon Inventory in relation to the Kigali Amendment 2016 to the Montreal Protocol

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1. Introduction

The Montreal Protocol on Substances that Deplete the Ozone Layer is an international treaty that entered into force in 1989 to protect the ozone layer by phasing out chlorofluorocarbons (CFCs), hydrofluorocarbons (HCFCs) and other substances that are responsible for ozone depletion. Due to its widespread implementation it has been acknowledged as an example of exceptional international co-operation.

On the 15th of October 2016 in Kigali, Rwanda, New Zealand adopted an amendment to the Montreal Protocol to phase down hydrofluorocarbons (HFCs), powerful greenhouse gases used mainly in refrigerants and aerosols (United Nations 2016). Minister for the Environment Dr Nick Smith said New Zealand advocated for an ambitious change to the Montreal Protocol at the Kigali meeting in Kigali: "Once implemented, the agreed phase down will avoid significant global warming of potentially up to 0.5degC, and that is a significant step towards meeting the objectives of the Paris agreement [on climate change, which came into force last November]."

For New Zealand, this will mean an 85% phase down in the consumption of bulk HFCs by 2036. The first step of the phase down will happen in 2019, with a reduction of 10% compared to 2011-2013 levels. Dr Smith said the Ministry for the Environment will work closely with industry in New Zealand to implement the phase down over the next 20 years.

In recent years, CRL Energy has prepared a report each year to investigate the use of HFCs, perfluorocarbons (PFCs), sulphur hexafluoride and other Synthetic Greenhouse Gases[1] in New Zealand and to estimate their annual emissions for inclusion in New Zealand's Annual Greenhouse Gas Inventory Report to the United Nations Framework Convention on Climate Change. For example, the report presented in 2016 involved reviewing the previous data (1990-2013) to check for consistency in methodology and conducting surveys of importers, exporters and users of these substances to calculate 2014 data.

The use of HFCs increased during the 1990s when CFCs and HCFCs began to be phased out under the Montreal Protocol. HFCs possess similar chemical and physical properties to CFCs and HCFCs making them suitable substitutes. Although HFCs are not ozone depleting substances, they are greenhouse gases with 100 year global warming potentials (GWPs) of between 140 to 3800 times that of CO_2 for the most common HFCs[2].

The Intergovernmental Panel on Climate Change (IPCC) provides various methods for calculating emissions and these have undergone some major improvements in the Guidelines for National Greenhouse Gas Inventories (IPCC 2006). According to these guidelines, emissions of HFCs are separated into six source categories (or applications):

- Aerosols;
- Solvents (no such usage identified in New Zealand);
- Foam;
- Refrigeration and air conditioning;
- Fire protection; and
- Other (no such usage identified in New Zealand).

[1] Alongside the Kigali Amendment and other commitments, the New Zealand Government will continue to monitor and control emissions of these Synthetic Greenhouse Gases using the New Zealand Emissions Trading Scheme and other means.
[2] It should be noted that New Zealand's National Inventory Report and the Kigali Amendment calculations use the updated GWPs recommended in the IPCC 2007 Fourth Assessment Report, which also covers a wider range of Synthetic Greenhouse Gases than the IPCC 1996 Second Assessment Report GWPs used in previous reporting for emissions to the end of 2012.

The purpose of this report is to explain how HFC consumption calculations related to the Kigali Amendment are derived from the base data used to calculate inventory emissions and in particular, where there are some important differences.

2. Calculation of HFC Consumption

UNFCCC reporting focuses on manufacturing, installation, operation and eventually disposal emissions associated with all the types of equipment using HFCs. This requires assessment of the quantities of each imported bulk HFC gas (minus any exports) used in manufacturing (usually stored for several years) as opposed to installation and operation (replacing leaked gas emissions).

In contrast, the Montreal Protocol simply calculates consumption of controlled HFCs as the total bulk gas imports of each HFC minus the total bulk gas exports (United Nations 2016). It does not include gas imported (and exported) in pre-charged or manufactured equipment (such as refrigerators and heat pumps). For the last 17 years, the Recovery Trust has been collecting reclaimed and contaminated refrigerants for export to Australia for analysis and destruction; these are not included in the exported bulk HFCs used in consumption calculations.

a. Imported Bulk Chemical

Information on bulk imported chemical sales of new refrigerant is collated each year from importers and distributors of HFCs. Historical import figures are compiled for each of the four major HFCs and five relatively minor HFCs in separate sheets of the calculation spreadsheet, first as tonnages of HFCs and then as kilotonnes of CO_2 equivalent. A further nine minor HFCs are covered by the Kigali Amendment but none of these has ever been recorded as an import into New Zealand (or as an export).

b. Exported Bulk Chemical

Exports of bulk chemical (particularly to South Pacific island countries) of 2 to 12 tonnes annually were identified for 2004-2014. Where there is information available, this has been compiled alongside the import figures in order to calculate the consumption figures for each HFC in each year (imports minus exports).

c. Total HFC Consumption

The consumption figures for each of the nine individual bulk HFCs consumed in New Zealand are combined in the total consumption sheet on a common basis in terms of their kilotonnes of CO_2 equivalent using the 100 year Global Warming Potential specified in each HFC sheet.

Table 1 - 100 year Global Warming Potentials for the Four Major HFCs

HFC-32	HFC-125	HFC-134a	HFC-143a
675	3500	1430*	4470

* 1 tonne of HFC-134a has the Global Warming atmospheric impact (spread over 100 years) equivalent to 1430 tonnes of carbon dioxide.

The imports, exports and consumption of refrigerant R134a and the refrigerant blends, R404A and R410A are presented in the spreadsheet as a means of illustrating how their historical usage has had an important influence on HFC consumption in general in New Zealand. For accounting purposes, they are included in the total HFC consumption calculation under the four individual HFC components[3].

d. Kigali Amendment Baseline Calculation

The HFC baseline calculation is, in kilotonnes CO_2 equivalent the sum of:

- the HFC component: Annual average of calculated levels of consumption (import – export) of controlled HFCs for the years 2011, 2012 and 2013, plus

- the CFC component: fifteen per cent of 2.8% of the calculated level of consumption (imports minus exports) in 1989 of the controlled CFCs; plus

- the HCFC component: fifteen per cent of the calculated level of consumption (imports minus exports) in 1989 of the controlled substances in Group I of Annex C (HCFCs).

Based on New Zealand's Montreal Protocol information reported on 1989 imports and exports of CFCs and HCFCs, the CFC/HCFC component of the baseline calculation is 153 kilotonnes CO_2 equivalent (about one twelfth) of the total average baseline figure of 1796 kilotonnes CO_2 equivalent for 2011 to 2013.

e. Kigali Amendment Phase Down Steps for New Zealand

The phase down steps from the HFC baseline are:

- (a) 2019 to 2023: 90 per cent of HFC baseline

- (b) 2024 to 2028: 60 per cent

- (c) 2029 to 2033: 30 per cent

- (d) 2034 to 2035: 20 per cent

- (e) 2036 and thereafter: 15 per cent.

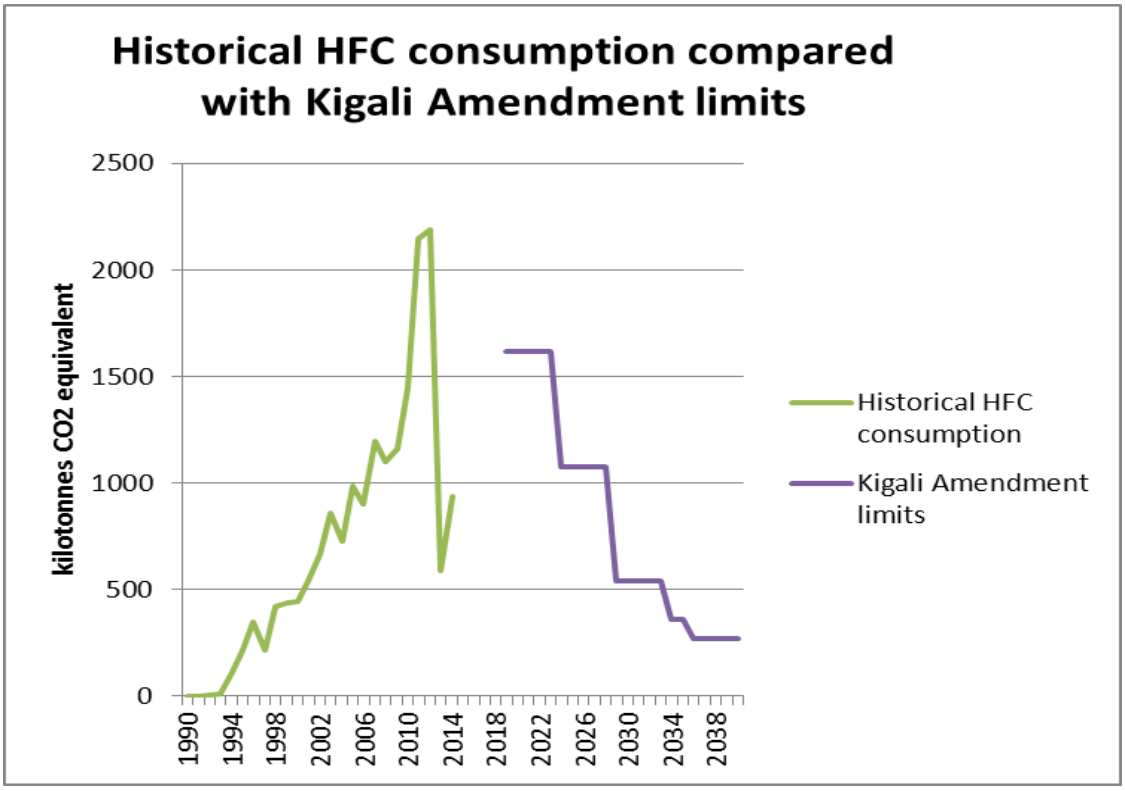
3. Total Consumption Trend for New Zealand

The consumption graph below illustrates the rapid rise of HFC net imports from 1992 to 2010, mainly to service the major stocks that developed in the supermarket, coolstore and dairy farm refrigeration systems but most notably the Mobile Air Conditioning vehicle fleet.

The disrupted trend from 2011 to 2014 is due to stockpiling of imported bulk HFCs before the January 2013 introduction of HFCs into the New Zealand Emissions Trading Scheme. With these ETS reporting and payment obligations signalled to importers well ahead by the

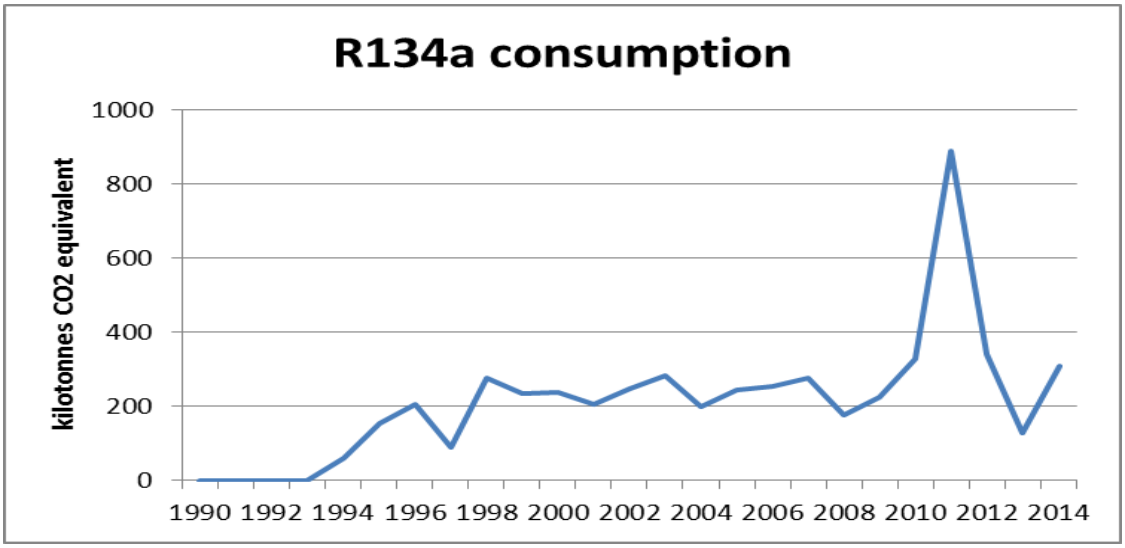
[3] R134a is 100% HFC-134a. R404A is 44% HFC-125, 4% HFC-134a, 52% HFC-143a. R410A is 50% HFC-32, 50% HFC-125.

Government, it was behaviour to be expected on behalf of their customers and this has been confirmed with a few suppliers reporting they were still using up their stockpiles.

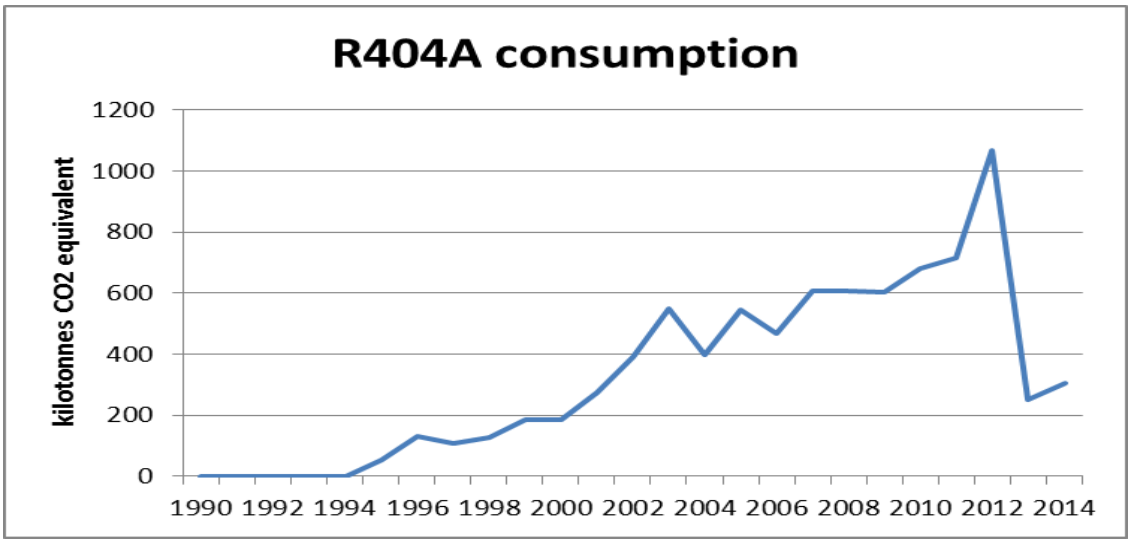


Bulk refrigerant R134a was the first HFC to be imported into New Zealand in 1992 as a major equipment manufacturer began to shift its production of commercial coolers and freezers from HCFC-22 refrigerant to R134a.

This trend accelerated in 1994 when another manufacturer began to use R134a in its major production facility for the manufacture of household refrigerators and freezers. Other factors that year were the first uses of R134a and HFC blend R404A in supermarket and some dairy farm refrigeration systems and in new coolstore installations and to service imported cars installed with R134a in their Mobile Air Conditioning systems.

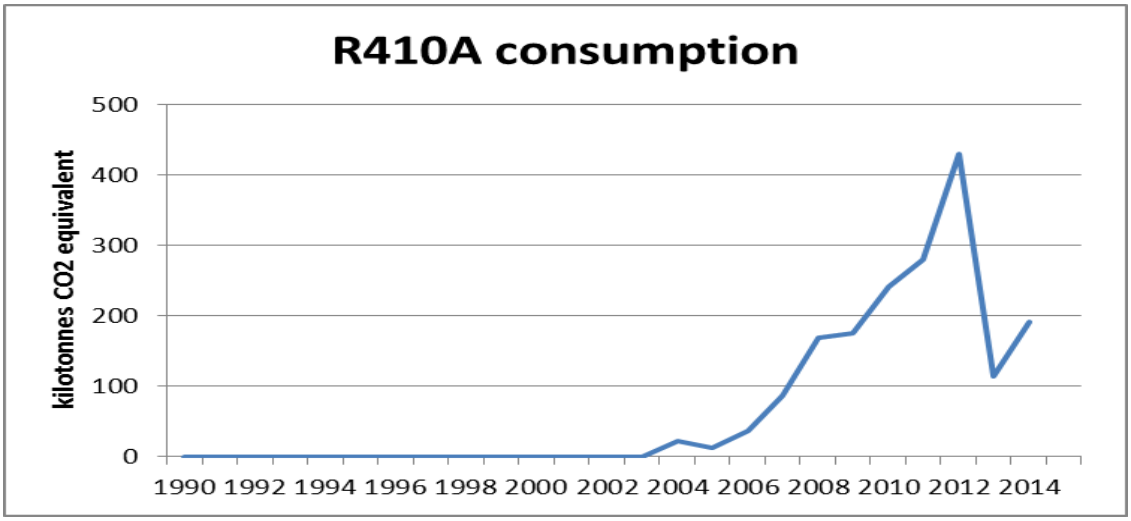


The R404A consumption chart illustrates that the supply of this refrigerant blend had a steady rise from its first import in 1994 and will soon undergoing a slow decline as supermarkets in particular are shifting to some lower GWP alternatives.



Refrigerated Transport (ships, containers, rail units and trucks) and the Stationary Air Conditioning sectors were the slowest to shift to HFC refrigerants because HCFC-22 was well suited to those purposes. Imports of some HFC blends to service some large commercial Air Conditioning and chiller units commenced in 1995, steadily increasing until around 2005 when imports household air conditioners and heat pumps shifted sharply towards models using the R410A HFC refrigerant blend. The major New Zealand manufacturer of commercial and industrial Air Conditioning and chiller equipment shifted its production from HCFC-22 to R410A in 2007, resulting in major imports of its bulk HFC components, HFC-32 and HFC-125. At least three quarters of these gases would then be re-exported in their equipment, but this is not evident from the simplified HFC consumption calculation.

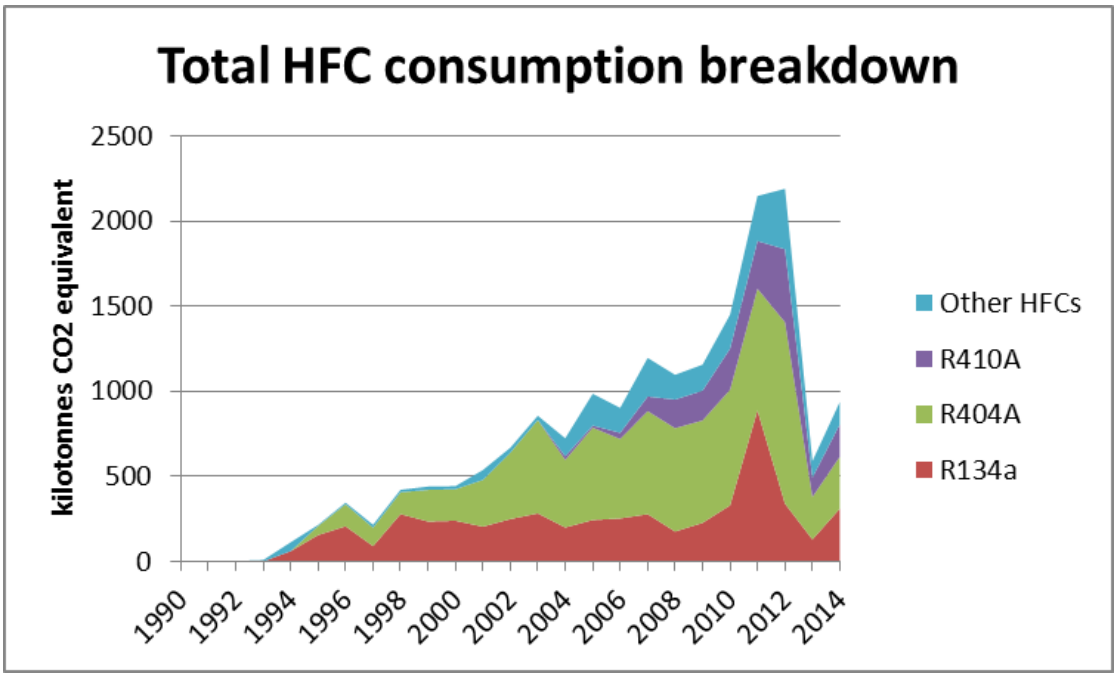
The chart of R410A consumption demonstrates that its use continues to rise rapidly (after a later start than for some other HFC refrigerant blends) so Stationary Air Conditioning (in 2014 holding 3020 kilotonnes CO_2-equivalent in heat pumps mainly) is the largest sector, higher even than the very large 2530 kilotonnes CO_2-equivalent MAC HFC-134a held in the vehicle fleet).



The first imports of bulk HFC-227ea for fire protection equipment was in 1994 while the first use of imported HFC-134a for New Zealand manufacture of insecticide aerosol cans was in

1996. Some experimental HFC-134a was used in the foamblowing sector from 2000 to 2003 but the main blends of HFC-227ea, HFC-245fa and HFC-365mfc for this purpose were not first imported until 2004.

The following chart demonstrates how the consumption of refrigerants R134a, R404A and R410A have been the major influences on HFC consumption in New Zealand while other HFCs have had a relatively minor influence.



For the purpose of assessing the impact of an 85% phase down of bulk HFCs by 2036, predicting a future trend for HFC consumption based on historical trends would be very difficult (that is, highly uncertain) because of several factors:

- The rapid rise in bulk HFC imports in 2011 and 2012 followed by a major decline in 2013 (with a continuing impact in 2014) was due partly to stockpiling related to the introduction of HFCs to the ETS in January 2013. At what point did the supply trend returned to a normal pattern? (or when will that happen?)

- After the final phase of Montreal Protocol restrictions meant that HCFC-22 (in particular) could no longer be imported into New Zealand after 2014, large scale HCFC equipment is still being phased out. The phase out rate is influenced by the availability and price of remaining HCFC-22 stocks compared with the price of alternative refrigerants that do not require major equipment re-design.

- All such technology price comparisons will be heavily influenced by the phasing out of the transitional ETS pricing by 2019 and the impacts on market prices for ETS units required to be surrendered when HFCs are imported.

- Alongside the continuing shift from HCFC-22 to HFC and other refrigerants (including ammonia and hydrocarbons) in large scale refrigerating and Air Conditioning equipment, it is difficult to estimate what is the general growth in the refrigeration industry. Would it be reasonable to assume it is in line with general economic growth?

4. Completeness and Uncertainty Assessment

The companies contacted in relation to their bulk HFC imports are estimated to account for more than 98% of the bulk chemical imported to New Zealand. In inventory assessment terms, this is considered a high level of "completeness", although there is always the possibility that one or two minor suppliers might not come to the attention of the inventory compiler. Consulting with industry experts is consequently an important part of the inventory compilation process.

There is less assurance of completeness for bulk exported HFCs because the quantities are much smaller and so there is less incentive for suppliers to report their quantities accurately: sometimes they are reported down to the kilogram level, while sometimes they are reported as simply "less than 1 tonne".

CRL Energy assesses the uncertainty for the four individual imported bulk gas HFCs as ±10% for a 95% confidence interval from 1990 to 2010 and ±5% for 2011 to 2014. From 1990 to 2014, ±10% is appropriate for the much smaller export quantities.

5. GLOSSARY

CFCs	Chlorofluorocarbons
ETS	Emissions Trading Scheme (New Zealand)
GHG	Greenhouse Gases
GWP	Global Warming Potential
HCFCs	Hydrochlorofluorocarbons
HFCs	Hydrofluorocarbons
IPCC	Intergovernmental Panel on Climate Change
PFCs	Perfluorocarbons
SGGs	Synthetic Greenhouse Gases

6. REFERENCES

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