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FINAL REPORT

OPTIONS FOR THE MANAGEMENT SURPLUS OZONE DEPLETING SUBSTANCES IN CANADA

Project: K2218-7-0027

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1.0 SUMMARY

This project was undertaken to develop a discussion paper on options for the management of surplus ozone depleting substances (ODS). Surpluses are expected for specific CFCs and Halons and without implementation plans for safe disposal, it is only a matter of time before all CFCs and Halons would be released to the atmosphere. The study which was called for in the National Action Plan prepared by the Federal Provincial Working Group on Controls Harmonization (ODS) (FPWG) for the Canadian Council of Ministers of the Environment (CCME) focussed on chlorofluorocarbons (CFCs) used as refrigerants and on Halons (bromochloroflurocarbons and bromofluorocarbons) used as fire suppressants. The Auditor General's report also has indicated the need for such a study.

The work was carried out through a consultative process with stakeholders including manufacturers, service representatives, reclaimers and recyclers and federal and provincial representatives and by the review of management procedures and tools used in provincial jurisdictions and other countries. Substantial progress has been made in Canada to reduce the emissions of ODS. This progress has been made through regulatory actions taken by the federal and provincial governments, changes in technology and voluntary actions by industry. With the ban on manufacture and importation of virgin CFCs, these materials have been replaced by alternatives, such as hydrochlorofluorocarbons, hydrofluorocarbons and other materials. The existing inventory of CFCs still in use in existing equipment and standby stocks requires careful management to ensure that emissions from these sources are prevented.

ODS continue to be used as refrigerants in five types of equipment, mobile air conditioning, mobile refrigeration, household appliances, commercial refrigeration and air conditioning and chiller air conditioning. Halons are used in portable and stationary fire extinguishing equipment. The study has developed an overview of the current status of ODS inventories in Canada. A predictive model was developed under this project for this purpose. It was determined that although there is not currently a shortage of supply of CFCs for existing equipment, the expected period of availability ranges widely with some sectors, notably mobile air conditioning facing the most immediate shortages, possibly in mid-1998 while other sectors are less likely to face short term shortages. In some sectors, in fact, CFCs will be around for many years and will need to be disposed of to prevent their eventual release. Because of these sectoral differences, it is necessary to prioritize the efforts to manage the inventories in these sectors.

Halon 1211 and 1301 are both in surplus supply. Halon 1301 is unique and for some applications requires special consideration. This is not the case with Halon 1211. A review of ODS destruction technologies showed that practicable destruction technologies exist. Facilities are in operation for this purpose (in the USA and Germany, for example) although there are no facilities currently in operation in Canada. There are also several promising destruction technologies under development and, in some cases, commercialization. The study also included a review of the regulatory and control activities in selected countries including Australia, Sweden, Germany and the United States. This review provided insight into model Extended Producer Responsibility programs such as that managed by Refrigerant reclaim Australia Ltd. as well as a range of existing and proposed controls on the use of CFCs and Halons.

- The study has identified four strategic options available for the management of ODS. These are:
- The Status Quo, i.e. the continuation of current regulatory controls and activities.
- Restrictions on imports and exports of CFCs and Halons to and from Canada, i.e. extend the current ban on importation of virgin CFCs to include recovered/recycled CFCs and to ban the export of these materials other than for destruction at approved destruction facilities.
- Limit the refilling of all or some categories of equipment with CFCs and Halons, i.e. require conversion of equipment requiring servicing to alternative non-CFC refrigerants.
- Limit the use of CFCs and Halons in all or some categories of equipment, i.e. require conversion of all equipment to alternative refrigerants after a specified date(s), whether the equipment requires servicing or not.

Each of these options has advantages and disadvantages. Each option will have a different impact on the removal of ODS from the inventory and thus on eventual releases to the atmosphere. Each option also presents a different inherent cost. Generally speaking, the above four options are listed in order of increasing effect on lowering emissions and in order of increasing cost. It is recognized that different options may be more appropriate for different sectors. The Halon sector, for example, requires special consideration since for Halon 1301, a completely satisfactory alternative is not currently available for some critical uses. However, acceptable alternatives are available for Halon 1211.

The implementation of the chosen option(s) will require effective management tools. An important conclusion of this project is the need for a strategic objective to be developed by the FPWG and the development of a program to achieve this objective. An Extended Producer Responsibility program should be considered as a route to the strategic objective.

2.0 BACKGROUND

Substantial progress has been made in Canada to reduce the emissions of ozone depleting substances (ODS). This has been accomplished through strong regulatory action taken by federal government and provincial governments, changes in technology, and voluntary actions by industry such as the move to alternatives. An Environmental Code of Practice for Refrigeration and Air Conditioning Systems was issued by Environment Canada in 1996. With the ban on the manufacture and importation of CFCs, they have been effectively replaced for all new applications by HCFCs, HFCs and other chemicals. However it is important to bear in mind that while HCFCs have a lower ozone depletion potential and HFCs are not ODS, they are greenhouse gases. and their emissions are undesirable for that reason. It is also important to recognize that while ODS have been replaced in new applications, a very large inventory still exists in previously manufactured equipment and there is a continuous and ongoing need to prevent or reduce ODS emissions.

The issue of ODS is addressed in Canada by an active government group that meets twice a year, the Federal Provincial Working Group on Controls Harmonization (Ozone Depleting Substances) - FPWG. The FPWG has issued a number of documents on the subject. The most recent document, published in January 1998, specifically calls on Environment Canada, on behalf of the FPWG, to carry out, among others, the following tasks:

- Update ODS, HFC inventory to 1996, to be completed by the end of 1998.[1]
- Development of a Discussion paper on the disposal of surplus CFCs & Halons, to be completed by mid 1998[2]; and
- Development of a Strategic Plan for Disposal of Surplus CFCs and Halons, to be completed by the end of 1999[3].

The Auditor General's 1996/97 preliminary report[4] has pointed out a gap in Environment Canada's plans to develop and implement a plan to manage the stock of surplus CFCs and Halons. As a result, Environment Canada has initiated this work. This report examines the refrigeration and air conditioning sectors, and the fire extinguishing systems sector. Other sectors such as foam manufacturing, solvent cleaning, dry cleaning and aerosols, which previously were significant users of ODS, no longer use CFCs and Halons and are, therefore, not included in this study.

The air conditioning and refrigeration industry is composed of two main sectors: mobile air conditioning, and refrigeration and stationary refrigeration and air conditioning applications. The mobile sector is sub-divided into two subsectors: air conditioning (mainly automobile) and refrigeration (transportation refrigeration). The stationary sector is divided into three sub-sectors: appliances, general commercial, and chiller air conditioning . Each sub-sector has its own particular type of systems, service practices and market distribution-related issues. Each sector and sub-sector is discussed separately in this report.

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[1] From NAP, January 1998: "This task is an extension and expansion of the previous work completed in 1993. The original study was useful in defining the 1993 needs and determining progress regarding the major use of the main ODS such as CFCs, HCFCs, and Halons. The original inventory provided the necessary data for the development of effective direction and suitable programs to reduce emissions and uses. The updated inventory will include HFCs as well as all ODS. It will not only provide information to be used as a base for future programs, but also will be a clear measure of actual progress in reducing use on the various industry sectors over the past three years."

[2] From NAP, January1998: "The availability of alternatives for CFCs and for many HCFCs, coupled with the probability of future use phase out in some industry sectors, may lead to a surplus of CFCs. A similar situation could also occur with Halons. An assessment of this potential problem is required.

[3] From NAP, March 1997: "A strategic plan with a high level of harmonization is essential to the development of a successful program having cooperation of industry. The strategic plan development will include the following major components:

- a clearly defined objective;
- specified dates for achieving important milestones;
- an action plan defining specific actions and responsibilities;
- a plan to monitor progress."

[4] Professor W. (Bill) Leis, Queens University, was on contract to Auditor General's office for this work.

3.0 OBJECTIVES

The objective of this project is to develop a report which is to be used for discussions on the need for and the major considerations and implications in the development of a strategy for the management of surplus CFCs and Halons in Canada. The report is to provide the following information:

- An overview of the current situation with respect to:
  - stocks of CFCs and Halons;
  - conversion to CFC and Halon substitutes and their impact on future stocks;
  - implementation of containment, including recycling and recovery strategies, and their impact on future stocks;
  - effectiveness of current user practices in disposing of surplus ODS stocks;
  - contaminated stocks and their disposition;
  - international activities relevant to the management of surplus stocks as well as the strategies used in other countries
- Analysis and discussion of the potential for future surplus stocks in Canada.
- Discussion of feasible disposal, conversion or other options for Canada, for managing surplus stocks along with barriers and impediments.
- Discussion and analysis of stakeholders views and perspectives on the above, and stakeholder views on the roles and responsibilities for management of surplus stocks.
- Discussion and analysis of feasible and cost effective strategies for the management of surplus ODS stocks, as well as the tools available to governments, that could be considered in Canada.

The discussion paper should include:

- Identification of use quantities and industry sectors.
- Estimates and projections of future surpluses, depending on possible control programs or regulations
- Identification of possible disposal scenarios[5], such as
  - natural phase-out,.
  - conversion to other environmentally acceptable compounds, and
  - destruction (e.g. incineration at Swan Hills, AB or a US location)
- Identification of activities in this area in other countries. Some of the producers of refrigerants, i.e. ICI, DuPont, believe that USA has little interest in taking regulatory action in this area.
- evaluation of possible advantages of the various scenarios[6], [7];
- options for future actions (infrastructure);

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[5] United Nations Environmental Program (UNEP), 1995 ODS Technology Update; Technology And Economic Assessment Panel; ODS Disposal Subcommittee Workshop, May 2-3, 1995, Montreal, Quebec, Canada; Presentation by Bernard Madé, Acting Head, Ozone Protection Programs Section, Environmental Protection Service, Environment Canada, CFC and Halon Stocks in Canada and Future Needs for Disposal.

[6] The cost of recovering CFCs is about $4/kg.

[7] Cost of containment and storage (a safe location such as an abandoned underground mine) is approximately $4.60/kg, see Footnote 1.

- discussion of disposal responsibilities.

The NAP reinforces the need that the discussion paper should include the above items in the discussion paper.

4.0 METHODOLOGY

The options for the management of ODS inventories contained in this report have been developed by:

- discussions with stakeholders by means of meetings with stakeholders in working groups and telephone, e-mail and facsimile communications with stakeholders outside of these meetings. Appendix F of this report provides a list of stakeholders.
- telephone interviews based on written sector specific questionnaires
- the development of a predictive model for each ODS use sector
- the collection of information on the activities in other countries and in Canadian provinces
- the collection of information on Extended Producer Responsibility concepts based on the Office of Economic Cooperation and Development and other countries' activities.
- a review of ODS destruction technologies, both developing and existing based on United Nations Environment Program activities.

4.1 Working Group

Based on the information obtained using the sources listed above, ODS inventory status information and possible management options were developed. These were presented to participating stakeholders at a series of three meetings held in Toronto in the first quarter of 1998. Stakeholders who were unable to attend were sent the information presented and the stakeholders' comments and their input solicited.

The information developed and the options proposed were revised and updated based on the input received at the previous meeting or received directly from participating stakeholders or other sources, e.g. the US EPA.

4.2 Interviews and Questionnaires

Based on the consultants' experience and with guidance provided by stakeholders, telephone interviews were held with sector specific stakeholders and trade associations involved with ODS through regulation, servicing, recovery, recycling and reclamation activities. The information gathered was then used to develop and/or confirm ODS inventory information and management options. The following groups were contacted:

- provincial environmental ministries,
- industry trade associations
- automobile air conditioning service companies
- transport refrigeration service companies,
- chiller manufacturers/service companies

- refrigerant manufacturers,
- independent service companies for appliances and commercial refrigeration
- grocery stores,
- refrigerant reclaim companies.

Information questionnaires were prepared and sent to major groups and representatives. Others were contacted directly and by telephone. All information and notes were then sorted and collected together by industry sector and used in the development of management options and, as applicable, in the predictive model described in Section 4.3

Available statistical data from Environment Canada reports and information from the OECD and UNEP was also reviewed and used in a similar fashion.

4.3 Predictive Model

The data and information described was analyzed and assessed relative to the following perspectives:

- inventories on hand or available for servicing,
- start of general use of alternates in new equipment,
- normal service age of most equipment,
- normal operational leakage rates of equipment,
- market growth rates,
- extent to which recovery and recycling is practiced,
- use of reclaim service companies, quantities reclaimed, and
- availability of standby inventory for servicing.

With the assistance of Environment Canada staff, a predictive model was developed. This model was used to establish ODS inventory information for each of the identified sectors for the period 1993 to 2020. Five analytical models were prepared, one for each of the following sectors:

- Mobile Air Conditioning
- Mobile (Transportation) Refrigeration
- Appliances
- Commercial Refrigeration and Air Conditioning
- Chillers (Building Air Conditioning)

After review of all the information it was found that the same basic standard model could be used by applying different sector specific factors where necessary. A detailed discussion of the model elements and examples are provided in Appendix C . The computer-based model can also be used to modify the assumptions used to develop the inventory information and to evaluate "what-if?" hypotheses.

4.4 Other Countries and Jurisdictions Activities

Information was solicited from countries known to be active in the management, control and regulation of ODS. The responding countries were Australia, the United States, Sweden and Germany.

4.5 Extended Producer Responsibilities

Information was obtained on Extended Producer Responsibilities concepts for possible application in management options. The OECD workshops and the Australian model represented by Refrigerant Reclaim Australia Ltd. were the primary sources of information.

4.6 ODS Destruction Technologies

A brief review of available and developing destruction technologies was carried out. It is apparent that there are several technologies currently approved for the destruction of CFCs and Halons and that there are several technologies in the development or commercialization stage which hold promise as additional destruction methods. There does not appear to be any reason for concern that technologies would not available for the destruction of CFCs.

There is no operating experience in Canada with ODS destruction but there is in the USA. Data received from operators of ODS facilities in that country report destruction costs of $0.46 - $2.00 per kilogram depending on the type of ODS. Liquid materials would be in the low end of the range while pressurized materials such as CFC-12 would be at the upper end of the range. These costs also are not believed to included collection and transportation costs. Some Canadian reclaimers have expressed an interest in operating facilities in Canada and there is no reason to anticipate any significant problems in implementing ODS management options because of a lack of technology or accessible facilities.

5.0 OVERVIEW CURRENT STATUS OF ODS INVENTORIES

5.1 Overall demand and inventories

The 1993, inventory study which was completed for Environment Canada[8] included all CFCs, and some HCFCs. With this base data, and the model incorporating all the essential variables, it has been possible to make reasonable estimates and projections of the market supply and activity. All sectors have reported that with the possible exception of the mobile air conditioning sector, there is currently no shortage of CFCs to meet servicing needs, with sufficient standby inventory to last from 4 to 7 years for CFC-11, up to 4 years for CFC-12 and 4 to 5 years for R502. Refrigerant supply and needs will be discussed in detail for each sector. There are currently one or more alternative refrigerants available as substitutes for each existing CFC, so no negative

[8] Summary Report: National Inventory Of CFC And HCFC Installations In Canada, Environment Canada File KA168-2-7055, prepared by Bovar Environmental Services, Calgary, Alberta in Association with Concord Environmental Corporation, Toronto, Ontario and Roger Buxton Associates, Unionville, Ontario, October 1993

industry impact has been noted. Generally there is a relatively high level of recovery and reclamation being carried out, with some variation depending on the sector. Considerable attention has been paid to containment over the past few years, especially with larger systems. This has reduced leakage losses to the atmosphere and reduced the demand for additional refrigerant.

5.2 Mobile Sector

5.2.1 Mobile Air Conditioning

The mobile air conditioner sector represents the largest inventory of CFCs in Canada. The most recent Environment Canada estimate, published in 1995, reports an inventory of 48,000 tonnes of CFCs, of which 42%, or 20,000 tonnes, is in the mobile A/C sector. Virtually all of this amount was CFC-12. In 1994, original equipment mobile air conditioners were no longer manufactured using CFC-12 but were re-engineered to use R-134a, an HFC refrigerant. Data developed in this project indicates that the inventory at the beginning of 1998 had decreased to approximately 12,000 tonnes or 30% of the total . The mobile air conditioning sector is the largest sector of the five CFC-using sectors studied in this report. It is probable that the available inventory of CFC-12 for this sector will be used up within a very few years, possibly as early as the second half of 1998.

5.2.2 Mobile Refrigeration

Mobile or Transportation Refrigeration systems (sometimes referred to as reefers) represents one of the major uses of refrigerants. This would include dairy product delivery and transportation vehicles, mobile snack wagon vehicles and field canteens, bulk meat transport trailers, fresh soft fruit transport trailers, frozen food transport trailers, fresh fish and sea food transport trailers and delivery vehicles. Refrigeration equipment on passenger trains, as well as refrigeration on ships and planes were not included in the study. The principal CFC refrigerants used are CFC-12 and R502. (HCFC22 is also used to some extent.)

The project survey indicates that the mobile refrigeration sector is the fourth largest CFC-using sector in this study. The in-use and available inventory was estimated at about 6,300 tonnes at the beginning of 1998. As with the mobile air conditioning sector, the CFC available for servicing could be reduced to zero during 1998.

5.3 Stationary Air Conditioning and Refrigeration

5.3.1 Appliances

The Appliance Sector includes all household plug-in refrigeration and air conditioning equipment except window air conditioners, which do not contain CFCs but HCFC22. Such equipment as refrigerators, freezers, and dehumidifiers are the major users of CFC. With the exception of dehumidifiers which use R500, all other appliances use CFC-12. Based on industry sources, there are approximately 10,000,000 appliances in Canada that use CFC refrigerants. Although the number of CFC-using units is the largest of the five sectors studied, because the quantity of CFC per unit is small, the total CFC inventory in this sector is the smallest, estimated at about 4,700 tonnes at the beginning of 1998. This small charge per unit combined with the low leakage rate and the change to alternative refrigerant with units manufactured after 1995, indicates that the CFC required for servicing will be available up to the year 2020.

5.3.2 Commercial Refrigeration and Air Conditioning Sector

The commercial sector covers a broad range of size and type of equipment, including such units as plug-in case coolers and freezers for small stores, restaurants and bakeries; remote units in large grocery stores served in groups by centrally located compressors; large walk-in freezers and coolers for storage as found in large grocery stores or dairy type take out stores; split air conditioning systems for various types of commercial buildings and restaurants; as well as large direct cooling air conditioning systems. The principal CFCs used are CFC-12 for refrigerated coolers and R502 for medium and low temperature applications such as frozen food display cases and storage freezers. There are several million locations in Canada using such types of systems. Commercial refrigeration and air conditioning sector is the second largest in this study. Inventory at the beginning of 1998 is estimated at approximately 2,000 tonnes. Economic factors as well as well as commitment to reduction of releases to the atmosphere have resulted in an 80% reduction in releases compared to past practices. These factors combined with commercial planning and recovery practices, and the availability of alternatives, has extended the availability of CFCs in this sector. Current inventories are predicted to last until 2008.

5.3.3 Chiller Sector Current Assessment (1993-1998)

The chiller sector involves large air conditioning units which provide cooling to buildings by cooling a medium such as water which is then circulated to the area to be cooled. A relatively small range of equipment types are used for this purpose, basically being divided into low pressure and high pressure units. Approximately 90% of the units are low pressure. Chiller installations are two stage in action, i.e. the chiller cools the storage water which is piped to one or more air cooling units. Industry sources indicate that there are approximately 7000 chillers in Canada based on industry estimates. Chillers have a refrigerant charge varying from 300kg to 1000 kgs. for the majority of equipment; an average charge being in the range of 500kg. Thus chillers are relatively few in number but have large charges, as compared to stationary air conditioning and refrigeration units such as appliances which have very small charges but are virtually ubiquitous. A tight, leak free system is important for chillers.

The chiller sector represents the third largest inventory of CFCs at approximately 7,200 tonnes at the beginning of 1998. As with commercial refrigeration and air conditioning, economic and business planning factors, the sector appears to be in a relatively sound position with respect to the availability of CFCs for maintenance of existing equipment. Inventory availability is predicted until the year 2020. Because of the comparatively small number of units and their large size, the sector appears to be a good candidate for further CFC-reduction initiatives.

5.4 Halons

Halons are halogenated aliphatic hydrocarbons containing bromine and fluorine atoms. They are used in fire extinguishing systems. The two Halons used in Canada in fire extinguishing applications are Halon 1211 (bromochlorodifluoromethane) and Halon 1301 (bromotrifluoromethane). Halon 1211 is generally used is in portable (hand-held and wheeled) fire extinguishers while Halon 1301 is generally used in fixed total flooding systems. Small amount of Halons have also been used as refrigerants (less than 1% of the total).

Halons 1211 and 1301 are used in fire extinguishers because they are effective when used for this purpose and because they do not cause property damage when discharged, an important consideration in sensitive areas such as computer rooms, archives and data storage areas. In addition, humans can survive in the presence of Halon 1301, an important consideration for use in closed areas such as aircraft and armoured fighting vehicles.

6.0 MANAGEMENT ACTIVITIES IN OTHER COUNTRIES

6.1 USA

Activities in the USA are essentially in the form of monitoring supply and demand. The EPA's Vintaging Model is a computer model developed by the EPA for this purpose, provides these estimates.

6.1.1 Supply of CFC-12

The inventory takes in to account:

- Stockpiles at the beginning of 1996
- Amount of R-12 reclaimed from existing a/c and refrigeration equipment
- Illegal imports (acknowledged but not used in calculations)
- Demand
- Number of operating R-12 a/c and refrigeration systems that require replacement of R-12 through leakage and upon servicing

According to this report, the total CFC-12 inventory in USA on January 1, 1997 was ~50 MM lbs. It was held by

• OEMs	30%
• Packagers/reclaimers	25%
• Auto parts chains and distributors	20%
• Stationary/Commercial sector distributors	15%
• Others, including chemical manufacturers	10%

In 1996, prices rose briefly from US$9.50/lb. to US$20/lb.

6.1.2 Demand for CFC-12

- The model was constructed to estimate use and emissions of CFCs, Halons, methyl chloroform, HCFCs, HFCs, and PFCs for more than 40 different end-uses in the USA through 2030;
- The model estimates annual demand for CFC-12 by projecting the total size of the equipment stock in each end use over time, and simulating the use and emissions of R-12 from this equipment each year.

6.1.3 EPA Vintaging Model Key Inputs for CFC-12 Use

US Supply/Demand for CFC-12 (MM lb.)

- Monitoring stocks of CFC-12; Report on CFC-12 supply-demand 1996-2000 available
- Report prepared for EPA by ICF Consulting Group, July 1, 1997 (Update of July 11, 1996 report)
- Demand estimates are taken from EPA's Vintaging Model
- Supply
  - Stockpiles at the beginning of 1996
  - Amount of R-12 reclaimed from existing a/c and refrigeration equipment
  - Illegal imports (acknowledged but not used in calculations)
- Demand
  - Number of operating R-12 a/c and refrigeration systems that require replacement of R-12 through leakage and upon servicing
- Unlike the Bovar report, the EPA inventory does not look at the amount of R-12 in existing a/c and refrigeration equipment. In contrast, the Bovar report did not look at supply/demand.

Industry Sector	Pipeline est. (MM pounds)	Stockpile est. (MM pounds)	Total (million pounds)
Chemical manufacturers	0-5	0	0-5
Packagers/reclaimers	5-10	5	10-15
OEMs	0-5	10-15	10-20
Auto parts chains and distributors	5-10	0-5	5-15
Do-It-Yourselfers	N/A	1-3	1-3
Stationary/Commercial sector distributors	0-5	5	5-10
Wholesale clubs	0-1	0	0-1
Total	10-36	21-33	31-69

Much of the focus of the US monitoring activities have been focussed on CFC-12. The most recent data suggests that CFC-12 will be in shortage this year. It should be noted that some OEM manufacturers believe that inventory estimates of stocks that OEM companies have is too low and supplies over the near term will sufficient to meet demand. One can conclude, however, that supplies will at best be sufficient only for the very short term say 1 – 2 years at best and possibly during 1998 at worst.

The data also indicate that approximately 2/3 of the annual demand is in mobile air conditioning. All of this is assumed to be used in the servicing of older, existing units since conversion to HFC refrigerant was effected in 1994.

The data also indicate that about ¼ of the annual demand is for commercial refrigeration. There is no reason to believe that these data are not generally applicable to Canada, a view which is supported by the Canadian information gathered for this report.

The EPA has offered to run Canadian data through their computer model. This offer should be taken up for three reasons:

- This would take advantage of the effort which has been put into the development of the computer model at minimum cost.
- The data format established for the EPA model would provide an excellent guide to the acquisition of Canadian data.
- The comparability of the two sets of data (USA and Canada) would prove useful for future studies.

6.2 Sweden

Sweden has recently promulgated new regulations for controlling CFCs. These regulations provide that:

- as of January 1, 1998, it will be forbidden to
- refill existing refrigeration and a/c with CFCs;
- fill new refrigeration and a/c units with HCFCs;
- use Halons (with certain exceptions made for critical uses such as military and aviation applications,
- as of January 1, 2000, it will be forbidden to:
- use CFCs as a working medium in existing facilities. Domestic refrigeration is exempted from this ban.
- as of January 1, 2002, it will be forbidden to:
- refill refrigeration and a/c units with HCFCs
- Suppliers are obliged to take back recovered refrigerant at no charge
- CFCs and Halons not reused or exported must be delivered for destruction only, to an authorized body. One Swedish company has been authorized to destroy ODS. The quantities destroyed were:

Year	Quantity Destroyed (Tonnes)	
	CFCs	Halons
1996	163	38
1997	160	56

- Exports of CFCs and Halons are permitted only for the purpose of destruction in another country

6.3 Germany

- Inventory of CFCs in existing equipment was 44,000 tonnes in 1997, including 5,000 tonnes in household refrigeration. Values for Canada are very similar (42,000 tonnes and 4,000 tonnes respectively) which is somewhat surprising considering population differences but probably is a reflection of wider use of air conditioning and refrigeration of all types, mobile residential and commercial.
- Distributors of CFCs and Halons are obligated to accept the return of these substances and "preparations"
- Manufacturers/distributors must maintain record of returned substances and "preparations" (blends?).
- Disposal in not regulated separately but is covered by existing regulations for disposal of hazardous waste.

6.4 Australia

Regulatory jurisdiction in Australia appears to be a state responsibility An example is the New South Wales Ozone Protection Act which was updated December 24, 1997. This Act enables the regulation of the manufacture, sale, distribution, use, emission, re-cycling, storage and disposal of stratospheric ODS and articles that contain those substances. The regulations may make provisions for or with respect to the regulation or prohibition of the manufacture, sale, distribution, conveyance, storage, possession and use of ODS by:

- regulating the design, installation, operation, servicing, maintenance, repair, modification or decommissioning of any controlled article or any plant or equipment used to manufacture such an article
- requiring and regulating the recovery, recycling, disposal and destruction of ODS and controlled articles
- regulating or prohibiting the emission of controlled substances
- payment of compensation, out of money to be provided by Parliament, in connection with the operation of this Act.

Similar regulations are believed to be operative in the other Australian states.

A condition of these regulations is a for of Extended Producer Responsibility (EPR). Industry response has been the creation of a non-profit, group which manages the programs to reduce ODS emissions through recovery, reclamation and destruction of the recovered ODS. The group, Refrigerant Reclaim Australia Ltd. (RRAL) does not own or operate recovery reclamation destruction facilities but acts as a coordinating and monitoring group for these activities. It is financed by a surcharge on the sale of new refrigerants. These funds are used to award a credit for each unit of ODS returned and to finance the destruction of the returned materials. It is relevant to note that the formation of this group is authorized by the government regulations.

There are similarities between the Australian and Canadian situations which make this model of particular interest. These are:

- Both countries cover a large geographical area with very uneven population distributions.
- Both countries previously manufactured CFCs but both countries have ceased the manufacture of these substances.

At the same time, Australia and Canada also present differences of which the following instances are relevant:

- Australia's population is approximately two thirds of that of Canada.
- Australia's climate is significantly warmer than that of Canada.

RRAL estimates that Australia consumed less than 1,500 tonnes of CFCs in 1996. Estimated use of CFCs in Canada is 7,138 tonnes. The reasons for the large difference in CFC usage is not obvious but Australia appears to use a much higher percentage of its refrigerant in the form of R-22, an HCFC.

7.0 STAKEHOLDER VIEWS

The participants at the meetings held on January 13th, February 17th and March 17th, 1998 expressed a number a number of views and provided valuable input into the development of the management options contained in this report. Their participation is gratefully acknowledged. The Management Options and the Conclusions integrate some of these views with those of the consultants.

It should be recognized that the views expressed by the stakeholders at the three meetings covered a broad spectrum of opinions. In general, industry representatives did not favour extending bans on use in existing equipment. Many expressed the view that the status quo, with the possible incorporation of some minor adjustments, was working reasonably well. There was considerable, but by no means unanimous, support for the view that recovery/recycle programs extended the time frame of releases but ultimately all of the CFC inventory would be released to the atmosphere. The extended release was also viewed as a route to reducing the impact of the released ODS on the atmosphere.

There was also considerable support for a ban on all imports including recovered/recycled material. At the same time there was view that a ban on exports would not provide the expected benefits but would simply encourage increased manufacture of virgin material in those areas which are allowed to do so. Some stakeholders, however, were not favourably inclined to allowing exports. A complete compilation of their views and opinions are contained in Appendix E.

8.0 MANAGEMENT OPTIONS FOR CFCS & HALONS

Four management options for ODS have been identified in this study. These options offer increasingly stringent degrees of removal of ODS from the inventory, with generally increasing costs. The four options are:

- Status quo
- Restrict imports/exports to/from Canada
- Limit refilling of all/some categories of equipment
- Limit use in all/some categories of equipment

These options may best be described as "What" options. It is apparent from the information gathered and stakeholder input received that a single option is not necessarily feasible or appropriate for all sectors. Each has its pro's and con's which are discussed below and no option can be unequivocally said to be "best".

8.1 Status Quo

The status quo option incorporates the current restrictions on the importation of virgin CFCs, includes elements of recovery and recycling and is reasonably effective in reducing emissions on an annual basis. It does very little to reduce the amount of CFCs currently in inventories, both in use and standby. It does place a cap on the amount to be released by preventing the growth of the existing inventories, something which would surely occur in its absence. It also results in releases to the atmosphere over a longer period of time, thus providing some reduction in impact on the atmosphere.

The status quo may also be said to enjoy the most industry support, although there is considerable support for a total ban on imports. This is attributable in part to the fact that this option is the lowest cost option for them and in part, because of a certain degree of familiarity and comfort with the existing situation.

The disadvantages of the status quo option are effectively the other side of the advantages coin. The option will result in the ultimate release of all of the current inventory. As there is not a ban on imports of recovered/recycled CFCs, there is a distinct possibility that Canada could become a dumping ground for these materials. There is also a strong feeling that the limits on virgin material imports are being circumvented by unethical operators and much improved control and certification procedures are required if imports are to be allowed to continue. There is also the possibility that as time progresses, increased costs could be incurred because of the need for stocking of multiple refrigerants and alternatives.

Finally current recycling efforts may be undermined by confusion arising from the number of refrigerants and alternatives with the resultant contamination creating material which cannot be recycled. Such material must then be destroyed. Although the destruction of this material is not necessarily a bad thing, it can undermine the program to the point of automatic consignment to destruction rather than recycling, even for uncontaminated material. This could result in a *de facto* implementation of the third management option, "Limit refilling of all/some categories of equipment".

8.2 Restrict Imports and Exports to/from Canada

As noted previously, current regulations ban the importation of virgin CFCs. Importation of recovered/recycled material is, however, allowed. The difficulty entailed in ensuring that the material is actually recovered or recycled CFC is immediately obvious. Further, the exemption for even *bona fide* recovered or recycled CFCs does little to reduce the quantity of CFC released to the atmosphere globally but only to the period of time over which it is released. The benefit of an extended release has already been noted and should not be lightly dismissed. At the same time, this also creates the potential situation where Canada becomes a dumping ground for these CFCs and could face substantial financial costs in the future should a ban on refilling come into effect. This is not an unlikely scenario and if realized would place the costs of collection and destruction on Canada. As Canada does not, at present, have destruction facilities in place, this would require either the construction of such facilities or shipment of the surplus CFC to countries having them. A total ban on imports of CFCs from all sources would place a more effective and lower cap on releases than the status quo. Implementation costs, if any, would be modest and the option also has the benefit of substantial industry support.

By reducing the quantity of CFC available, conversion to alternative refrigerants would be encouraged and opportunities for the abuses reported under the status quo would be essentially removed. The disadvantages of this option are comparatively few. The restrictions may infringe international agreements. This possibility, however, is considered remote since several countries already have such restrictions in place. More important is the fact that although the cap on releases is finite and lower than under the status quo option, essentially all CFCs now in use and stockpiles will eventually be released to the atmosphere.

It is also probable that a total restriction on imports will place a financial penalty on firms currently legitimately trading in CFCs and Halons. There appears to be no way to avoid this, however, in any options other than the status quo. It should be noted that the status quo has already imposed financial costs on other industry stakeholders by banning manufacturer and importation. The burden must therefore be viewed as an inevitable and acceptable consequence. A ban on exports has much less support from industry stakeholders. The view was expressed that exports of recovered material can make a contribution to global inventories as it reduces the need for new material which will ultimately be lost to the atmosphere. This is a valid viewpoint from a Canadian perspective at least, since Canada does not manufacture CFCs and therefore would not be using the process to circumvent restrictions on the use of CFCs. It is a form of recycling across borders.

At the same time it is seen by some as a process which is virtually impossible to control and therefore will be subject to abuse. The question also presents possible problems politically as it could be seen as an exploitation of the issue outside of our borders. Exports could be seen in a light not dissimilar to the shipping of toxic wastes to other jurisdictions less likely to observe proper disposal techniques.

8.3 Limit Refilling of All/Some Categories of Equipment

This management option would, in essence, ban the topping up or refilling of existing equipment with CFCs. This ban could be selectively applied to individual sectors. Regulatory efforts could be focussed on the sectors which could provide the most effective and efficient reductions. In this way maximum effectiveness and reductions could be achieved with a minimum of disruption and cost. The concept has already been applied to mobile air conditioning in British Columbia and New Brunswick demonstrating the feasibility of the approach.

The ban would encourage and accelerate conversion and with appropriate regulations and procedures would achieve a lower total quantity of releases to the atmosphere. It is also consistent with the Codes of Practice which now state that mobile air conditioning and refrigeration units should not be recharged with CFCs after 2000. The disadvantages to this option include costs, problems of control, disposal and possibly perceptions of fairness.

The ban on refilling option is the second highest of the options identified in this report. The costs will be imposed on the user which can certainly be considered justifiable. There may well, however, be unforeseen and unintended consequences resulting from this option. Limit use in all/some categories of equipment. The user could for example, decide to forego the repair rather than pay the cost of correcting a leaking system. As a result the refrigerant remaining in the system could be allowed to escape rather than recovered. This would likely prove to be a common occurrence in those sectors where the use of the unit is optional, e.g. mobile air conditioning.

The ability to apply the ban by sector could be perceived as being inequitable. It could also prove to be difficult to prevent cross-flow of refrigerant from one sector's stocks to that of another. Assuming a universal ban, as well as the probable increased releases to the atmosphere, a surplus inventory would also created virtually immediately. Existing stockpiles would no longer be required and access to a collection and disposal facility would become a necessity. As such facilities do not currently exist in Canada, they would have to be constructed or foreign facilities located. Given the windows of opportunity for CFC recovery and the likely time period require to obtain the necessary approvals and construct a Canadian facility, it seems likely that shipments to facilities outside of Canada would be necessary for at least the first year or two. It should be recognized that the inconvenience and cost of this disposal procedure is likely to increase the possibility of deliberate venting.

8.4 Limit Use in All/Some Categories of Equipment

The last management option identified for ODS inventories is the banning of their use in some or all equipment, new and existing. This option would result in the greatest decrease in releases to the atmosphere as it would entail the removal and destruction of all CFCs, including those still in service.

Some precedents exist for this option notably option notably the decision of Swedish authorities to implement a similar program. Even there, however, the sheer magnitude of the effort is recognized by the exemption of some equipment, notably household refrigerators from the program. Another example, taken from an entirely different field is the Ontario Hydro conversion of electricity from 50 cycle to 60 cycle, a step which involved the conversion of hundreds of thousands of motors and other electrical equipment.

Despite its maximized reduction of CFCs there are a number of important negative aspects connected with such a program.

- This option is the highest cost option, by far requiring financial resources for the recovery, collection and destruction facilities as well as for the actual conversion effort itself. .
- A phased approach would be required to enable the creation of the necessary procedures and collection and destruction facilities.
- This option would also require a significant period of time for implementation because of the magnitude of the program and the technical resources and skills to implement it would not be available rapid conversion.
- The need for a phased in approach would require decisions to be made as to which sectors would be done first. This would undoubtedly create problems with the perceived fairness of the prioritization.
- The phased in aspect of the program would diminish its effectiveness in reducing ODS releases. It is improbable, for example, that a program of this magnitude could be brought into being in time to prevent large losses in the mobile air conditioning sector where the losses over the next 2 years are estimated at approximately one third of the mobile air conditioning inventory.

9.0 MANAGEMENT OPTION TOOLS

A number of tools for the management of the options described above, have been identified. These are:

- Require industry to establish an Extended Producer Responsibility (EPR) organization for the collection, storage and destruction of ODS.
- Impose a tax/levy on the sale of new refrigerants managed by the organization on the lines of the Australian model. This could be done in conjunction with the establishment of EPR as was done in Australia. (The possibility of counter productive response because of higher costs for new refrigerants and resulting reduced acceptance of conversion to alternative refrigerants should be carefully assessed.)
- The above tools would probably necessitate government regulations requiring the establishment of such an organization and possibly to authorize the levy of such charges.
- Federal/provincial, municipal governments to lead by example, by converting to alternative refrigerants in their own facilities and equipment as quickly as possible. This would also provide useful insight into the problems or ease of such conversions.

10.0 CONCLUSIONS

If not dealt with in an appropriately prompt fashion, the existing in-use and standby ODS inventory will eventually be released to the atmosphere. The consultants have reached the conclusions stated below as routes to prevent the release of ODS inventory:

- Imports of CFCs and Halons, including those from recovered/recycled sources, should be banned.
- Recharging of mobile air conditioning and refrigeration units with CFCs should be banned by the year 2000.
- Recharging with CFCs should be limited in all sectors, possibly with different effective dates.

- Consideration should be given to conserving Halon 1301 for use in critical applications, such as enclosed areas in which humans may be present.
- Consideration should be given to banning export except for destruction at an approved facility.
- Access to a destruction facility is important. Facilities are available outside of Canada (e.g. in the USA) but none are currently operating within our borders.
- The FPWG should be made aware of industry stakeholder allegations of abuses and ineffectiveness of the current process, e.g.
    - CFC collection from scrapped units (mobile A/C and appliances) is erratic,
    - Imports of virgin CFCs under the guise of recovered material are occurring,
    - the controls on imports of blends are ineffective and creating significant problems in the control and recycling of CFCs.
- The FPWG should formulate a strategic objective for the management of surplus ODS in order to prevent the releases of ODS which would otherwise inevitably occur.
- The FPWG should develop and implement a process or procedure to meet this strategic objective..
- A decision to proceed with a management option other than the Status Quo mmust be cognizant of the need to decide on the ultimate fate of the surplus created.

11.0 APPENDIX A: SUPPLY/DEMAND/INVENTORY OF CFCS AND HALONS IN CANADA

11.1 Discussion and Analysis

11.1.1 Mobile Sectors

11.1.1.1 Mobile Air Conditioning

11.1.1.1.1 Current Practices

Current practices in the mobile air conditioning sector vary considerably across the provinces. As a broad generalization, all jurisdictions have programs in place with the following characteristics:

- Venting to the atmosphere is prohibited.
- Capture of residual CFCs is required.
- Recycling of uncontaminated recovered CFCs is required.
- Disposal of contaminated CFCs as a hazardous waste is required.

Some provinces have additional restrictions in place. British Columbia and New Brunswick, for example, ban the refilling of mobile air conditioning units. The Manitoba Ozone Protection Industries Association (MOPIA), which administers the Manitoba regulations, appears to have a very effective recovery program in place, recovering virtually all of the residual refrigerant from vehicle being scrapped. Other jurisdictions appear to have much less effective programs or enforcement in place. It should be noted that even effective programs, such as MOPIA's, are able to recover only about 30% of the theoretical quantity. This is attributed to losses prior to scrappage caused by leaks and accidents.

11.1.1.1.2 Assumptions

For mobile A/C units estimates of losses are approximately 10% per year or about 160% over the life of the vehicle based on the repairs and subsequent losses over the unit's life[9]. This estimate is consistent with US EPA data as reported in section 4.2.1.4. Anecdotal information suggests that this loss could be as high as 300%+ over the life of the vehicle and underscores the large contribution of this sector to emissions of ODS.

Without diminishing the importance of the mobile A/C sector, it must also be noted that since late 1993/early 1994, the use of CFC-12 in mobile A/C has been discontinued by automobile manufacturers with all units using R-134a, an HFC. As no new CFC-containing units are being added to the inventory and with the high rate of loss from existing units, the inventory of CFCs in this sector will diminish more rapidly that in any other sector with the possible exception of the mobile refrigeration sector. This requires a more rapid resolution of CFC problem in this sector

[9] These assumptions are derived from industry statistics from Wards Auto World Yearbooks which estimate a scrappagge rate of approximately 6% per year.

since without such a resolution, it seems probable that the issue will disappear by the year 2010, with all the current inventory having been released to the environment by that time.

Because of the conversion of new mobile air conditioning units to HFCs, the inventory of CFC-12 previously used, is uncertain and its distribution in the chain is very uneven. Automobiles originally equipped with CFC-12 air conditioning units are now out of any warranty period. While some OEM manufacturers still have substantial quantities of CFC-12 on hand, others have essentially none. All in all, it seems that supplies of CFC-12 on hand will be insufficient to meet demand generated by units still in service. This could happen as early as mid-1998 and almost certainly by the year 2000.

The shortfall can be made up by conversion to R-134a or HCFC blends now being offered as replacements. Blends which may contain hydrocarbons are a much greater problem. This is due to their contamination potential for recovered CFC-12 as well as potential safety problems. They are subject to fractionation and thus may present a flammability hazard. Recycling companies have stated that they will not accept material contaminated with these blends for recycling because of safety concerns. Contaminated CFC-12 may therefore result in venting releases since the material is more difficult to dispose of than uncontaminated recovered CFC-12.

It is equally important to note that replacement for CFCs, namely HCFCs and HFCs, may present environmental problems in the future related to their global warming potential. CFCs generally have high ozone depleting potential (ODP) and high global warming potential (GWP). HCFCs have low ODP and GWP while HFCs have very low ODP but GWPs which range from low to very high. R-134a, for example, has a very high GWP.[10] A solution to CFCs, therefore, should also provide a path to the handling of HFCs.

11.1.1.1.3 Estimates of Demands and Inventory Levels

Based on an estimated scrappage of 3,200,000 vehicles for the four year period ending December, 1997, (6% of annual registrations) and an average fully-charged content of 2.5 lbs. of refrigerant, the amount of CFC-12 in the "in-use" inventory has decreased by approximately 3,700 tonnes to 16,300 tonnes since 1993. Data compiled for other sectors indicates that CFC inventories have declined very little (if at all). Assuming stable inventories for these sectors, mobile A/C now represents 34% of the total inventory. This inventory is expected to decline further as the mobile A/C sector inventory decreases at a faster rate than the other sectors.

The demands and usage levels for the mobile air conditioning sector are summarized in Table 1 on the following page. The usage and the surplus cannot be combined since the surplus occurs after the high demand period has passed.

It is assumed that the quantity used in service represents the replacement of CFC lost to the atmosphere through leaks, accidents or venting and therefore is equal to the amount of CFC

[10] Trade-Offs in Refrigerant Selection: Past, Present and Future, James M. Calm and David A. Didion, Refrigerants for the 21st Century paper, ASHRAE/NIST Conference, October 6-7, 1997.

released to the atmosphere. The net total usage of 3,889 tonnes represent the releases to the atmosphere and the 671 tonnes will remain as a surplus.

The table on the following page should not be misconstrued to indicate that sufficient inventory will be available to provide service materials until the year 2007 at which point a surplus will develop. Insufficient numerical inventory data has been generated but the general view of the stakeholders is that sufficient inventories are on hand for only one to three years, with stocks of CFC-12 possibly being used up as early as the end of 1998.

In accordance with the Copenhagen Amendments to the Montreal Protocol. production of CFC-12 ceased on December 31st, 1995. The EPA has developed a computer model, referred to as the EPA Vintaging Model, to monitor the supply and demand of CFC-12. This monitoring is the primary activity relating to CFC-12. A report on the supply and demand of CFC-12 for the period 1996 – 2000 is available.[11] Details of this report are contained in section 5.1. The report states that significant shortages of CFC-12 are probable in 1998 and supports the similar conclusions contained in this report regarding the Canadian scene. The EPA has agreed to operate the model with Canadian data to assist Canada in this area.

Current Estimated Demand – Mobile Air Conditioning Sector

Year	No. of A/C Vehicles* ('000)	Service CFC @0.10 kg/vehicle (Tonnes)	Recovered CFC @ 0.34 kg ea. (Tonnes)	Net CFC Used for Servicing (Tonnes)
1994	14,470	1,480	307	1,173
1995	13,566	1,387	307	1,080
1996	12,662	1,295	307	988
1997	11,758	1,202	307	905
1998	10,854	1,110	307	803
1999	9,950	1,018	307	711
2000	9,046	925	307	618
2001	8142	833	307	526
2002	7,238	740	307	433
2003	6,334	648	307	341
2004	5,430	555	307	248
2005	4,526	463	307	156
2006	3,622	370	307	63
2007	2718	278	307	(29)**
2008	1814	186	307	(121)
2009	910	93	307	(214)
2010	0	0	307	(307)

* Straight line decline 1994 – 2010, 904,000 vehicles per year.
** () = Surplus
Net total usage for the period 1998 to 2010 inclusive = 3,899 tonnes
Cumulative surplus = 671 tonnes

[11] Report prepared for EPA by ICF Consulting Group, July 1, 1997 (Update of July 11, 1996 report) in the form of a memorandum by Heike Mainhardt, Steve Abseck, Jeffrey King and Sandra Phillips to Christine Dibbie.

11.1.1.1.4 Key Sector Issues

By far the most important issue in the mobile air conditioning sector is the clear need for rapid action if the ODS losses to the atmosphere are to be significantly reduced. A management strategy other than the status quo is urgently required to be implemented as the opportunity to act has a very short time frame. At the very least, this strategy should be developed and put into effect by the end of 1999. Any delay beyond this point in time will be ruled by the law of diminishing returns. Given the complexity of implementing such strategies and actions, this may prove to be very difficult. As a consequence, serious consideration should be given to acceptance of this situation, in effect writing off additional efforts in the mobile A/C sector and focussing efforts on sectors which provide more time to act.

11.1.1.2 Mobile Refrigeration

11.1.1.2.1 Current Practices

Because of the need to deliver the product in a chilled or frozen state, delays for maintenance are usually minimized if at all possible. This means that leaks are usually greater on average as some leakages are tolerated in order to deliver the product as soon as possible. This reduces the potential for recovery and recycling. Most reefer units do not have necessary valves for isolating sections of the system for recovery. This leads to increased venting as opposed to recovery. Improved containment rests mostly with the design and manufacturing of equipment. Some improvement could be achieved by installing valves for recovery connections on individual units. More frequent leak checking is also desirable. Recovered material when collected in quantity by the service contractor is usually returned to the wholesaler (for an agreed price), who in turn sends it to the reclaimer.

Because of the relative higher cost of reclaimed R502 and to a lesser degree CFC-12 there has been a tendency in the trucking industry to favour conversion when servicing units. Recovered material is usually collected in recovery containers and returned to a wholesaler when convenient. The service contractor may recycle the material in his shop if he has a recycle unit which can produce a product which meet industry standards. Contaminated material unfit for recycling or reclaim must be disposed of as hazardous waste. There is no sector-wide collection for disposal or destruction of CFCs. All CFC of acceptable quality is considered as useable product to be retained for future service work.

Contaminated stock which can not be wholly or partially reclaimed, must be disposed of as hazardous waste. In each province there are specific regulations relating to hazardous waste. The nature of the contents must be clearly identified; it can only be shipped to a registered disposal site in the province or another province, or possibly to the USA. It can only be transported by a registered hazardous waste carrier. Waste crossing provincial boundaries may also require a permit from the other province.

11.1.1.2.2 Assumptions

Reefer units are similar to smaller commercial equipment but are designed to operate off a truck electrical system. In addition to the operating and maintenance problems of commercial equipment they are subject to road vibration and to air contaminants such as dust, dirt and insects. They generally have higher leakage rates than commercial units and shorter service life. Equipment life is estimated at an average of 12 years, with the resulting replacement rate of 8.3% per year. The market growth rate has been estimated at 1.5% per year. Refer to Appendix A. Table 2, for specific values for a given year.. Leakage rates on equipment are estimated at about 10% per year. Estimated leakage quantities are also shown in Appendix A. Table 2. Estimated conversion rates in each year are shown in the same table. A fairly rapid decline in the number of CFC units is evident.

11.1.1.2.3 Estimates of Demands and Inventory Levels

Based on a previous study, the inventory of CFC in mobile refrigeration was 11,679 tonnes in 1993. In addition to this there was an estimated standby inventory of 6, 000 tonnes, for a total of 17,679 tonnes. Inventories were increased in 1993, 1994, and 1995 in preparation for the elimination of imports of virgin CFCs commencing in 1996.

From Appendix A. Table A-2 and Figure 2, the decline in the use of CFC in operating equipment can be seen, as well as the growth in the use of alternate refrigerants. The impact of market growth in future years can also be seen.

Because of the high replacement rate, and relatively higher leakage rates, it is estimated that at the beginning of the year 2010 there will be 3,727 tonnes of CFC in the working inventory, representing about 35% of that at the beginning of 1998 (10,541tonnes). The standby inventory at the beginning of 1998, (2,416 tonnes) will by then have been used up. By the year 2015, the working inventory of CFC in equipment will be reduced to 2,415 tonnes, representing about 23% of that in 1998. Finally, at the end of the year 2020 there will only be 340 tonnes of CFC still in equipment , or about 3% of that in 1998. At the beginning of 1998 there was a total inventory of 10,541 + 2416 = 12,957 tonnes of CFC in mobile refrigeration sector. At the end of 2020 there remained 340 tonnes. Total emissions for the period will thus be 12,957 - 340 = 12, 617 tonnes of CFC.

11.1.1.2.4 Key Sector Issues

As with the mobile air conditioning sector, standby inventory may be exhausted during 1998. The amount of ODS remaining in use at that time will be approximately 6,000 tonnes, virtually all of which will be released to the atmosphere by the year 2020. This extended release period, as compared to the mobile air conditioning sector is attributable to the longer service life of the units, fewer accidents and lower emission losses through hoses which are exposed to lower temperatures as they are not located under the vehicle hood.

This sector, therefore, is somewhat more amenable to reducing these releases, by implementing management strategies other than the status quo. Because of the large number of units, however, an effective program would require strong regulatory and inspection programs. It is only necessary to consider the difficulties currently encountered with the execution of truck safety programs, to gauge the difficulty of carrying out such programs.

11.1.2 Stationary Sectors

11.1.2.1 Appliances

11.1.2.1.1 Current Practices

The appliance industry does not use recovered or recycled refrigerant when servicing equipment. For warranty work, new CFC-12 is added, for non-warranty work alternate refrigerants and blends are used if CFC-12 is not readily available. There is at least 6 possible choices for use in replacement. Manufacturers may recommend which alternatives are acceptable for their equipment. Conversion takes the unit out of the CFC stream; it allows new refrigerant to be used and conserves the CFC supply for warranty work. In 1996 manufacturers started using an alternate refrigerant for new equipment. However there still remained a large number of units with CFC in the marketing/distribution pipeline. It is expected that these will all be gone sometime in 1999. Conversion of equipment represents about 25 tonnes of refrigerant for 1998. The decline in the amount of CFC in equipment is shown in Figure 2 , Appendix A . The increase of alternate charged equipment can also be seen. It is expected that by the year 2006 volumes of each in operating systems will be equal.

Appliance products are totally factory made and do not require any on-site installation service work. The containment concept is built into the product by design, fabrication and inspection in the plant. Thus field procedures to improve containment are unnecessary. Recovery during servicing eliminates deliberate venting to the atmosphere. Special recovery systems suitable for use with the small quantities in an appliance are available and in use in the market place. However, the level of recovery in actual practice is not felt to be as high as it could be, as explained below.

Recycling involves returning the refrigerant to the operating unit after it has been subject to some on-site cleanup. Most recovery systems have cleanup equipment built in and these are therefore called recycling units as opposed to recovery units. Reuse of field refrigerant is not done in the appliance sector, so recycling is not required or done. Reclamation involves the processing of recovered refrigerant off-site at a process facility. The quality of the reclaimed refrigerant meets or exceeds required industry standards . The only tangible evidence of recovery in the appliance sector is the amount of reclaimed material. Some reclaim was done prior to 1996 due to collection at municipal dump sites, e.g. Montreal, Que. and Burnaby, B.C.

A sizeable increase in reclamation were noted in 1996 and 1997 and it is anticipated that these quantities will increase over the next few years. It is estimated that about 20 tonnes will be recovered from 1993 to the end of 1997. From 1993 to 2015 it is expected that about 162 tonnes or more will be reclaimed. There is a potential for many times this if an efficient collection infrastructure can be organized. This is being studied by the City of Montreal which has a volume of more than 1000 scrapped units a month. Within the Appliance Sector there appears to be a universal opinion at this time that standby inventories of CFC-12 will be required in the future and there is thus no industry disposal plan in effect. See Table A-3.

11.1.2.1.2 Assumptions

Appliances have an average service life of 13 to 15 years. A replacement rate of 7% per year has been used in the Table. Also shown in Table 3 is the market growth rate currently averaged at 1.5% per year. Leakage rates on operating equipment are extremely low, estimated at about 0.2% per year. This is due to the reliability as well as to the small charge in any unit, usually around 4 oz.(112 gm). The refrigerant from these leaks is non-recoverable and goes into the atmosphere. Total leakage into the atmosphere for the period 1993 to the end of 1998 is estimated at approximately 48 tonnes.

11.1.2.1.3 Estimates of Demands and Inventory Levels

At the beginning of 1998 the inventory of CFC in use in operating systems was estimated at 4,249 tonnes, with a standby inventory of an additional 778 tonnes, for a total CFC of 5,027 tonnes. In 1994 and 1995 inventories were increased by marketers, contractors and service companies to ensure there would be adequate supply to meet warranty work needs. (Refer to Appendix A. Table 3). In the appliance sector, equipment is generally under warranty for a period of 5 to 8 years, depending on the appliance and the manufacturer or marketer.

From the reference table, it can be seen that by the beginning of the year 2010 (end of year 2009) there will be a total refrigerant inventory of 2,069 tonnes, including 169 tonnes of standby inventory. The standby inventory is used to replace these losses to keep the equipment running. It is used faster than the operating stock due to leaks, venting and relatively low reclaim rates. By the year 2015 operating stock will have decreased to 1322, with a standby inventory of only 70 tonnes. At the end of the year 2020 there will still be 855 tonnes in operating equipment, with no standby inventory. Working inventory decline is graphically illustrated in Figure 3. This assumes no refrigerant would be available from another sector.

11.1.2.1.4 Key Sector Issues

The appliance sector provides an ideal opportunity to convert an industry sector away from CFC. This is because of such factors as the small quantity of ODS in each unit, the low leakage rate and the long average service life. When equipment is serviced it could be converted in addition to the switch of current production to alternative refrigerants, which has already taken place. At the beginning of 1998 there was 4,249 tonnes of refrigerant in operating systems, in addition to 5,001 tonnes of standby inventory (See Table 3), for a total of 9,250 tonnes. At the end of 2020 there will be a total remaining inventory of 855 tonnes. Projected total atmospheric emissions for the period are thus 8,395 tonnes. The material reclaimed could be used in other sectors. However, a potentially high residual inventory at the year 2020 suggests that an effective, efficient reclaim infrastructure is needed, supported by appropriate disposal strategies and technology.

An important consideration of any strategy for the appliance sector is the wide dispersal of the refrigerant and the small quantities in each unit. Since the leakage rates are so low, a strategy for recovery of the refrigerant at the time of the disposal of the unit would seem to offer a viable opportunity to prevent releases to the atmosphere.

The ability to deal with contaminated stock is also a significant issue. Contaminated refrigerant may be the result of:

- mixing two or more refrigerants, which form an undesirable azeotrope that cannot be separated, or
- contaminating the refrigerant by adding a toxic substance, or
- contaminating the refrigerant by adding a hazardous waste.

Normal impurities which occur in operation such as water, oil, and acidic by-products can be separated. There are only two refrigerants which were used in appliances, CFC-12 and R500. These can be readily separated. However with the advent of replacement blends this might pose a problem because of the many and varied compounds used in the various blends. Potentially, these could form undesirable azeotropes. Toxic and hazardous waste material could not be added to a container without contaminating the recovery equipment and connecting hoses. This is unlikely to occur in the appliance sector. Any such material would have to be disposed of as a hazardous waste and could not be legally shipped to a reclaimer.

11.1.2.2 Commercial Refrigeration and Air Conditioning

11.1.2.2.1 Current Practices

Originally many commercial systems were installed with a minimum of valving, to reduce initial installation cost. Commercial equipment requires regular servicing , at least once every two years, to change filters, oil, dryers, etc. Refrigerant was usually vented to save time and avoid disposal. The refrigerant was often vented in any case to speed up the servicing. In more recent years, recovery and recycling has grown significantly, adequate valving has been added to older systems when they are serviced, and new units are better designed to permit isolation of parts to be removed. Connections have also been added on new units to permit quick recovery of any necessary refrigerant. These changes have improved the containment capability of commercial systems. However these improvements are not universal and further overall improvement is desirable. As seen in Appendix A. Table 4, leakage rates have dropped significantly and should continue to do so.

Deliberate venting into the atmosphere has been one of the principal causes of the high levels of CFCs in the atmosphere. With the advent of recovery/recycle package units and the implementation of regulations, venting has dropped to about 20% or less of previous levels. This permits refrigerant to be recharged back into the same unit following servicing , instead of venting. Refrigerant cost and the commitment of the industry to help solve the ozone depletion problem have been other important factors, as well as the concern of possible material shortages, which in fact was prevented. Continued effort will be required to reduce venting.

Refrigerant recovered from obsolete equipment which is to be sold or used in other units must meet industry quality standards which have been established. Several reclaim companies have established process operations to accomplish this. This provides additional CFC for the market which would otherwise be waste or vented. Current estimates are that from the beginning of 1993 to the end of 1998 there will be approximately 2,740 tonnes reclaimed. (Appendix A. Table 4). During the same period, venting predicted by the computer model, will still result in the release of about 5,350 tonnes.

In 1992 and 1993 most refrigerant producers accepted back recovered refrigerant for reprocessing from wholesalers who were paid an agreed rate. The wholesalers in turn collected refrigerant from the contractors and servicemen and paid an agreed rate. The cost of handling or processing contaminated material was charged back to the original source who provided it to the wholesaler. The recovered material was analyzed by the producer to ensure that all material was acceptable, before batching it together for final processing. Special recovery containers were used in order not to contaminate cylinders for use with virgin product, by putting recovered material in them.

At the present time (1998), most product is sent by the wholesalers or other large companies to a reclaimer, who either reclaims the product for a fee or, pays for the recovered material and sells the reclaimed product to another client. The refrigerant producers mainly advise their clients on where to send it and on other technical and safety details. There is no movement within the Commercial Sector to ship any refrigerant for destruction. It is felt that this material will be needed for future service work. .Residue from reclaimers which contains some CFC is shipped to destruction facilities in the USA.

Because of the larger variety of refrigerants used in the commercial sector, including many types of alternates, there is more potential for contaminated refrigerant. This must be handled as hazardous waste. Disposal usually involves shipping it to a facility in the USA, and a charge per pound is levied based on the quantity and the level of fluorides in the material. There is no facility for handling waste CFC directly in large quantities. CFC waste must be blended with other suitable dilution wastes.

11.1.2.2.2 Assumptions

Some types of commercial equipment operate with high usage rates due to customer practice and the fact that cooler and freezer display cases are poorly insulated on the top display area. High usage leads to more equipment breakdowns, maintenance and servicing, all of which inherently involve losses to the atmosphere. Compressor temperatures are higher than in appliances and compressors rooms are generally quite warm, reducing efficiency. These factors, among others, lead to higher wear, more leaks and more servicing. Average service life of commercial equipment is estimated at 13 years, with an average annual replacement rate of 7.7.%. The current market growth rate has been estimated at 1.5% per year. (See Appendix A-4 .0).

The substitution of alternate refrigerants to replace CFCs (conversion) began in 1993 as CFC prices began to rise and alternate refrigerants became available. Many grocery chains and other multi outlet businesses began strategic planning to ensure an efficient ,financially viable, conversion over a period of a designated number of years. In some cases, various alternatives were used in order to evaluate their performance, operating cost, and associated maintenance.

Estimated conversions are shown in Appendix A. Table 4. Conversion rates vary from year to year and will probably decline in the future as fewer CFC units are in service. However, conversion should be encouraged as standby stock will decline. As shown in Table 2, it is estimated that by the end of 1998, 1,600 tonnes in equipment will be converted. This does not include alternate refrigerants in new equipment. Refer to Table A-2 in the Appendices for yearly details.

11.1.2.2.3 Estimates of Demand and Inventory Levels

At the beginning of 1998 the inventory of CFC in use in operating systems was estimated at 5,957 tonnes, with a standby inventory of an additional 11,372 tonnes for a total CFC of 17,329 tonnes. Prior to 1996, standby inventory was increased significantly to provide for servicing needs after the closure on importation of new CFCs. (Refer to Table 2 in the Appendix 4).

From Table 4 and Figure 4, at the end of 1998 there will be a working inventory of 5,295 tonnes, with an additional standby inventory of about 4,907 tonnes, for a total of about 10,202 tonnes. By the end of 2010 the amount still in equipment will have declined to 2,078 tonnes. The only source of replacement CFC will be reclaimed material. Other needs will have to be met by conversion. By the end of 2015, operating stock will have decreased to 1,407 tonnes of CFC. At the end of 2020, CFC inventory will be reduced to an estimated 953 tonnes. The CFC-containing equipment will represent about 10% of the equipment in service. This means that despite losses to the atmosphere there will still be significant quantities on hand , if no previous new actions are taken.
Industry feedback indicates there is an adequate supply of refrigerant for service work with no shortage reported. Because of cost, R502 is being replaced by alternate refrigerants faster than CFC-12 is. During the period 1993 to end of 1998 emissions due to leaks and venting are estimated to be 1997 and 5,349 tonnes respectively, for a total of 7,346 tonnes.

At the beginning of 1998, there is a working inventory of 5,957 tonnes, plus a standby inventory of 5,628 tonnes , for total of 11,585 tonnes of CFC. At the end of 2020 the estimated inventory will be 953 tonnes. The total emissions to the atmosphere for the period will thus be 9,250 tonnes.

11.1.2.2.4 Key Sector Issues

The commercial sector represents one of the major repositories of CFCs, both currently and in the future, with resulting high emissions, and about 950 tonnes remaining to be managed in the year 2020. The comparatively large window of opportunity and the level of technical and economic skills suggest that this sector may offer the best prospects of effective ODS emissions reductions. The availability of alternative refrigerants combined with the above indicate that strategies to improve recovery/ reclamation rates, as well as conversion rates are prime candidates as feasible, effective management options.

11.1.2.3 Chillers

11.1.2.3.1 Current Practice

Based on a previous study, the inventory of CFC in chillers in 1993 was 3,594 tonnes with essentially no alternates in use. (One or two units had been converted on a test basis prior to that date).This consisted of 3,235 tonnes of CFC11, the principal chiller refrigerant used in low pressure chillers, plus about 359 tonnes of CFC-12 and other minor refrigerants used in high pressure chillers. In addition it is estimated that there was a standby inventory of approximately of 2,000 tonnes, for a total of 5,594 tonnes (Refer to Table 5 in Appendix A).

Current inventory as of the beginning of 1998 as shown in Table 5, is 3,069 tonnes, with standby inventory of 4,862 tonnes[12], for a total of 7,931 tonnes of CFC. Industry feedback indicates that there is an adequate supply of refrigerant for service work in the next 3 to 4 years with no concern for a shortage in the near future. Refrigerant is expected to be readily available providing purge losses, leaks and venting continue to be reduced.

During the period 1993 to the end of 1998, it is estimated that losses due to leakage and venting will amount to 2,425 tonnes and 4,690 tonnes respectively, for a total of 7,115 tonnes. On the positive side, this was also a fairly active period for conversion with an estimated 1,345 tonnes of CFC refrigerant being displaced by an alternative refrigerant. The practice of recovery and reclaim also began to grow with an estimated total of 1,810 tonnes being reclaimed. The reclaim growth can be seen by examining the year to year figures shown in Table 5.

Many large building owners had developed a strategic plan by 1995 to study costs of various phase-out strategies as well as the resources to implement them. With an economic downturn in the rental real estate market, the containment strategy became the favourite one, with intention to operate the equipment for its full service life. As can be seen in Table 3 leakage rates dropped significantly from about 15% in 1993 to about 10% by the end of 1997. Losses (emissions) due to venting also decreased from about 25% in 1993 to an estimated 22% in 1998. The recent broad introduction of high efficiency purge devices could reduce these losses in the future even further than currently estimated in Table 5. The relatively high reclaim rates can be seen by comparing Table 5 data to that in Appendix A. for other sectors. On site recovery and recycling is not shown in the Table, only the net difference which shows as venting. The effect of this is to retard the standby inventory depletion.

Unless there is a tube sheet breakage or a mechanical compressor failure, quality of recovered refrigerant is generally acceptable for reuse in the same equipment or similar equipment by the same owner. Many owners now store standby refrigerant from obsolete equipment on their own premises as opposed to giving it to the contractor. Because it is stored in drums (for low pressure units) leakage losses can go unnoticed through loose drum closures. There is also a problem of

[12] In most sectors, material is usually inventoried by the contractors, wholesalers and producers. In the chiller sector, the building owners have inventoried large quantities. Reclaimers also handle large quantities of CFC-11.

the drums being used as a collector for other organic type wastes. This of course results in a need for reclamation or possibly handling it as a hazardous waste.

Individual lots of unneeded inventory can be disposed of by selling it to a reclaimer for another client who has a need . Reclaimers usually have residuals from the refining process which are shipped to the USA for destruction. At present there is a good supply of refrigerant, but there is no intention in the industry sector to dispose of any standby inventory on a broad basis. Depending on the type and amount of contamination, the material must be shipped as hazardous waste for disposal to a registered disposal company, or it may be sent to a reclaimer. If the contaminant is another refrigerant a portion of the stock can still be reclaimed. Reclaimers usually get a sample for analysis prior to accepting any shipment.

11.1.2.3.2 Assumptions

Average chiller service life is about thirty years, thus the replacement rate is only 3.3% per year. Systems are normally shut down once per year for maintenance and overhaul. A market growth rate of 1.5% per year has been estimated, consistent with other sectors.

Conversion to alternate refrigerants was well under way in 1993, with the availability of suitable substitutes in commercial quantities and toxicity data available. This can be seen in Table 5, as well as the fact that all new units for replacement or for market growth were now using the alternate refrigerants. The rapidly growing conversion rate was affected by an economic slowdown, and coupled with the high cost of conversion for large units, many of the large building owners began opting for containment strategies as opposed to conversion only. It is estimated that by the beginning of 1998, about 30% to 35% of the units had been converted. This is expected to continue at a 5% or less rate in the future as illustrated in Table 5.

11.1.2.3.3 Estimates of Demand and Inventory Levels

From Table 5 and corresponding figure in Appendix A., the decline in the working inventory in operating equipment can be seen. At the beginning of the year 1999 there will be a working inventory of 2,968 tonnes of CFC, or about 82% of that present in 1998. In addition there will be a standby inventory of 4,371 tonnes for an estimated total of 7,339 tonnes. By the beginning of the year 2010 there will be 2,052 tonnes in operation equipment, or about 65% of that at the beginning of 1999 (2968). This represents a 43% decrease from the year 1993. At this time the standby inventory will be 1,760 tonnes, or about 44% of that at the beginning of 1999.

By the end of the year 2020 there will still be an estimated 1,345 tonnes in operating equipment, representing approximately 45% of the inventory at the start of 1999; this is 37% of the starting inventory in 1993. By this time the standby inventory has declined to only 33 tonnes or about 0.8% of that at the start of 1999. The total combined inventory at the end of 2020 is 1,378 tonnes, equal to 24% of the total at beginning of 1993. The relatively high residual working inventory is due to the low replacement rate of chillers, and the ease at which high boiling refrigerants can be recovered and recycled, plus the strategy of containment rather than conversion. Leakage rates for this period have been estimated at 10%, and venting rates at 20%. While this represents a considerable improvement, these rates could be further reduced by more thorough use of recovery and recycling, and regular maintenance. Objectives to reduce leakage and venting rates to 4% and 20% have been established but no enabling mechanism is yet in place.

At the beginning of 1999 a total inventory (working plus standby) of 7,339 tonnes is estimated; this will be reduced to 1,378 tonnes by the end of 2020. The atmospheric emissions for the period is thus estimated at 5,961 tonnes. The forecast emissions for the whole period, 1993 to the end of 2020, is estimated to be 11,956 tonnes.

11.1.2.3.4 Key Sector Issues

Chillers will be responsible for a large portion of the forecast CFC emissions during the period under study. The long service life, relatively small number of units and the large inventory in each suggests that very effective management strategies could be implemented. The proposed future ban on HCFCs in the year 2020 is a potential detriment to conversion for long life equipment such as chillers. An exemption for chillers, particularly the low pressure types make up about 90% of the units, should be studied to evaluate its pros and cons. (Environment Canada has proposed amendments to this effect under consideration.)

11.1.3 Halons Sector

11.1.3.1 Current Practices

In 1994, Parties to the Montreal Protocol agreed to a complete ban on the production and importation of virgin Halons in industrialized countries. In those cases reviewed, however, some recognition is taken of their unique characteristics and exemptions in use allowed in certain critical applications.

In Canada, the use of Halons is regulated under a wide range of federal, provincial and territorial regulations. All regulations in common no release of ODS and recovery of ODS requirements. Other requirements vary widely and are summarized in Appendix D. Of course it is an unavoidable consequence, that when the Halons are put to use for their intended purpose, they will be released to the atmosphere except for those destroyed in the fire.

The Halon Roundtable is a voluntary forum with representatives from all major sectors of fire prevention and protection in Canada. Members include distributors, installers, manufacturers of fire protection equipment, as well as certification agencies, legislators, environmental groups and users. The Halon Roundtable met on several occasions to develop principles for the management of Halon inventories in Canada. The Environmental Code of Practice for halons, for example, discourages the discharge of Halons during testing and training and refers to the US NFPA for recommended practices.

11.1.3.2 Assumptions

The releases of Halons to the atmosphere are almost entirely attributable to discharge in suppression of fire. Losses may also occur because of accidental discharge or damage to the system but these are very small. Losses because of leakage is very low and virtually negligible.

11.1.3.3 Estimates of Demand and Inventory Levels

11.1.3.3.1 The Halon Bank

There is no specific agreed-upon definition of the Halon bank. In a study done for the Ministry of Environment, Land and Parks in British Colombia in 1997 banked Halon was referred to as the amount stored for refilling. Another definition of the Halon bank is the quantity of Halons that sits in equipment awaiting a potential use (fire, test, training, accidental release, etc.). This definition does not include stored amounts at the service or recycling companies. This amount is generally small compared to the amount in active systems.

One method to estimate the Halon bank includes calculating the difference between the total supply, cumulated over the years of active supply (only by importation in Canada as no Halon production have ever occurred in the country) and the total loss, cumulated over the years of active use.

Reduction of Halon arise from essentially two causes:

- Emissions to the atmosphere as a consequence of their use in fire suppression, and
- Export of recovered material from existing systems.

This methodology provides amount of the total Halon inventory whether in active systems or stored and is the method adopted here. Annual Halons amounts (in systems and stored) in British Columbia were summarizes in one study as follows:

Year	In systems (kg)	Stored (kg)	Total (kg)	% of total based on 1993
1993	15,853	89	158,672	--
1994	146,880	5,116	151,996	96
1995	133,393	4,551	137,944	87
1996	121,927	8,251	130,178	82

As of March 1998, the estimated total amounts of Halons in Canada (Halon bank) are:

Halon 1211	1,370,000 kg
Halon 1301	1,760,000 kg
Total	3,130,000 kg
Amount of total Halon released in 1997	136,000 kg
Rate of conversion to alternatives	8%

A study of the total Halons in Federal facilities was carried out and indicated that they had 12.5% and 16.5% of the total bank of Halon 1211 and 1301 respectively.

11.1.3.2 Exports and Imports

1994 is the year that the Parties to the Montreal Protocol agreed to a complete ban on production and importation of Halons in the industrialized countries. The USA excise tax on Halon 1301 was removed in January 1997, and exports to USA of this Halon were about 114,000 kg. The excise tax on Halon 1211, though it was scheduled to be removed in January this year (1998), is still applicable making exportation of this Halon to the USA a not-viable business.

Exports and imports of Halons in bulk (recovered and reclaimed) in recent years are summarized below:

Total - 1995 – 1997	
Halon 1211 imports	14,000
Halon 1211 export	44,449
Halon 1211 net in/(out)	(30,449)
Halon 1301 import	323,332
Halon 1301 export	1,791,384
Halon 1301 net in/(out)	(1,468,052)
Total net in/(out)	**(1,498,501)**

11.1.3.3 Emissions to the Atmosphere

Emissions to the atmosphere occur during fire protection or by accidental release. This amount is statistically a ratio of present Halon bank, not a fixed percent. The actual amount, therefore, decreases as the Halon bank itself decreases. In one study done in British Columbia, Halon amounts in the year 1997 were as follows:

Location	Amount (kg)	% of Total
Halons in active systems	121,927	84.2
Released to atmosphere	614	0.4
Stored for refilling	8,251	5.7
Decommissioned	14,106	9.7
Total	**144898**	**100**

Percent calculations assume that the Halon amount in active systems did not include the commissioned amount. Percent of total indicate that very small amount (0.4%) of the Halon is emitted to the atmosphere in actual fire fighting and that the decommissioning rate is high (about 10%) which is the main reason of creating a surplus of Halons. The study also mentioned doubling of the stored Halon from 4,551 kg in 1995 to 8,251 kg in 1996.

11.1.3.4 Key Sectoral Issues

Halons are potent ozone depleters of stratospheric ozone. The ozone depletion potential (ODP) describes the efficiency with which a chemical destroys stratospheric ozone. This efficiency depends on the molecular weight, the number and the type of the halogen atoms substituting hydrogen in the molecule, and the atmospheric lifetime of the compound. Halon 1211 and Halon 1301 have 3 to 4 times and 10 to 16 times, respectively, the ozone depleting potential (ODP) of CFC-11[13]. Although the volume of Halons in use is much less than CFCs, their high ozone depletion potential indicates dealing with them should be a priority.

Alternative fire extinguishing materials are available for many applications. Substitution or conversion strategies should be reviewed to speed up the process beyond that effected by the current activities. In view of the unique characteristics of Halon 1301it would appear appropriate to concentrate on Halon 1211, initially at least.

11.2 Supply/Demand/Inventory of CFCs in Canada

The information in the following tables and charts is based on the data generated by the predictive model created during this work. For details of the program itself, refer to Appendix C. Predictive Model.

[13] Ozone-depleting Substances Regulations, 1995 (lower values) and the November 1991 Ozone Scientific Assessment Panel under the United Nations Environment Program (UNEP), (higher values).

Table 1 Material Inventory Update - Mobile Air Conditioning - Tonnes

Start of Year	Initial Inventory			Replacement		Market Growth 1.5%		Scrapped		Losses: Leaks	Losses: Venting	Converted to Alt		Final in Equipt.		Potential Consump	Reclaim	Actual Consump	Standby Inventory	Purchases	Final Standby	Total Available
	CFC	Alt.	Total	CFC	Alt	CFC	Alt.	CFC	Alt	CFC	CFC	CFC	Alt	CFC	Alt	CFC	CFC	CFC	CFC	CFC	CFC	CFC
1993	20475	190	20665	640	607	154	146	1280	12	2559	640	0	0	19989	931	4479	640	3839	1750	4000	2551	22540
1994	19989	931	20919	0	1220	0	293	1249	58	2499	625	0	0	18739	2385	4373	625	3748	2551	4000	3428	22167
1995	18739	2385	21125	0	1238	0	297	1171	149	2342	586	375	349	17193	4120	4287	773	3514	3428	5000	5687	22880
1996	17193	4120	21314	0	1257	0	302	1075	258	2149	537	860	799	15259	6221	4191	967	3224	5687	0	3430	18689
1997	15259	6221	21480	0	1276	0	306	954	389	1907	477	763	710	13543	8124	3719	858	2861	3430	0	1428	14970
1998	13543	8124	21666	0	1295	0	311	846	508	1693	423	677	630	12019	9851	3301	762	2539	1428	0	0	12019
1999	12019	9851	21870	0	1314	0	315	751	616	1502	376	601	559	10667	11424	2930	676	2254	0	0	0	10667
2000	10667	11424	22091	0	1334	0	320	667	714	1333	333	533	496	9467	12860	2600	600	2000	0	0	0	9467
2001	9467	12860	22327	0	1354	0	325	592	804	1183	296	947	880	7928	14616	2544	769	1775	0	0	0	7928
2002	7928	14616	22544	0	1374	0	330	496	913	991	248	793	737	6640	16144	2131	644	1487	0	0	0	6640
2003	6640	16144	22784	0	1395	0	335	415	1009	830	208	664	618	5561	17482	1785	540	1245	0	0	0	5561
2004	5561	17482	23043	0	1416	0	340	348	1093	695	174	556	517	4657	18662	1495	452	1043	0	0	0	4657
2005	4657	18662	23320	0	1437	0	345	291	1166	582	146	466	433	3901	19711	1252	378	873	0	0	0	3901
2006	3901	19711	23612	0	1595	0	350	390	1232	488	122	390	363	3120	20787	1195	390	804	0	0	0	3120
2007	3120	20787	23907	0	1589	0	355	312	1299	390	98	312	290	2496	21723	956	312	644	0	0	0	2496
2008	2496	21723	24219	0	1590	0	361	250	1358	312	78	250	232	1997	22548	765	250	515	0	0	0	1997
2009	1997	22548	24545	0	1595	0	366	200	1409	250	62	200	186	1598	23285	612	200	412	0	0	0	1598
2010	1598	23285	24883	0	1604	0	372	160	1455	200	50	160	149	1278	23954	489	160	330	0	0	0	1278
2011	1278	23954	25232	0	1616	0	377	128	1497	160	40	0	0	1150	24450	328	64	264	0	0	0	1150
2012	1150	24450	25600	0	1635	0	383	115	1528	144	36	0	0	1035	24940	295	58	237	0	0	0	1035

Table 1 Material Inventory Update - Mobile Air Conditioning - Tonnes

						Market Growth				Losses						Potential		Actual	Standby		Final	Total
Start of	Initial Inventory			Replacement		1.5%		Scrapped		Leaks	Venting	Converted to Alt		Final in Equipt.		Consump	Reclaim	Consump	Inventory	Purchases	Standby	Available
Year	CFC	Alt.	Total	CFC	Alt	CFC	Alt.	CFC	Alt	CFC	CFC	CFC	Alt	CFC	Alt	CFC	CFC	CFC	CFC	CFC	CFC	CFC
2013	1035	24940	25975	0	1655	0	389	104	1559	129	32	0	0	932	25424	265	52	214	0	0	0	932
2014	932	25424	26356	0	1676	0	394	93	1589	116	29	0	0	839	25905	239	47	192	0	0	0	839
2015	839	25905	26744	0	1697	0	400	84	1619	105	26	0	0	755	26384	215	42	173	0	0	0	755
2016	755	26384	27138	0	1719	0	406	75	1649	94	24	0	0	679	26860	193	38	156	0	0	0	679
2017	679	26860	27539	0	1742	0	412	68	1679	85	21	0	0	611	27336	174	34	140	0	0	0	611
2018	611	27336	27947	0	1765	0	419	61	1708	76	19	0	0	550	27811	157	31	126	0	0	0	550
2019	550	27811	28361	0	1789	0	425	55	1738	69	17	0	0	495	28287	141	28	113	0	0	0	495
2020	495	28287	28782	0	1814	0	431	50	1768	62	15	0	0	446	28764	127	25	102	0	0	0	446

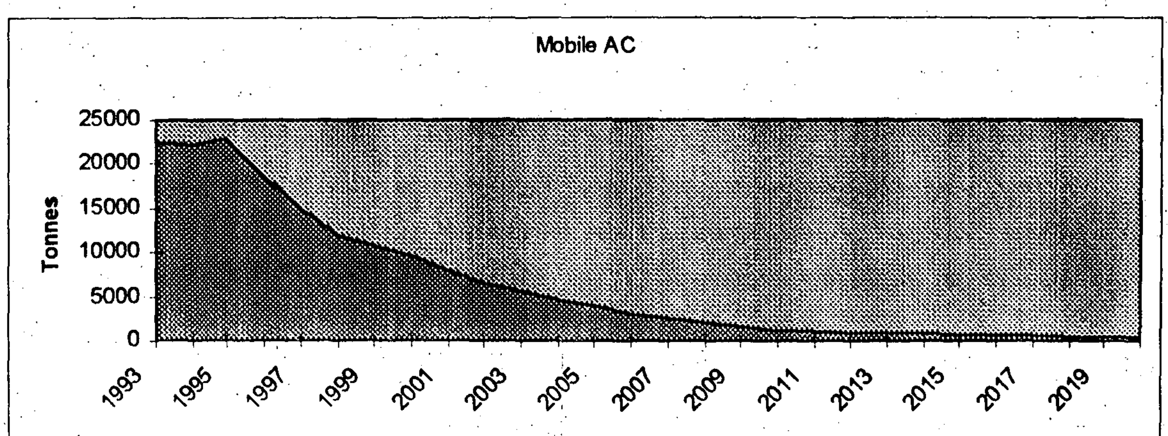


Table 2 Material Inventory Update - Mobile Air Refrigeration - Tonnes

				Replacement		Market Growth				Losses						Potential		Actual	Standby		Final	Total
Start of	Initial Inventory			8.3%		1.5%		Scrapped		Leaks	Venting	Converted to Alt		Final in Equipt.		Consump	Reclaim	Consump	Inventory	Purchases	Standby	Available
Year	CFC	Alt.	Total	CFC	Alt	CFC	Alt.	CFC	Alt	CFC	CFC	CFC	Alt	CFC	Alt	CFC	CFC	CFC	CFC	CFC	CFC	CFC
1993	11679	0	11679	969	0	175	0	969	0	1168	4672	584	543	11270	543	6984	292	6692	6000	6892	6200	17470
1994	11854	0	11854	984	0	178	0	984	0	1185	4742	1185	1102	10847	1102	7089	593	6496	6200	8296	8000	18846
1995	12032	0	12032	899	93	108	67	999	0	1203	4813	2406	2238	9634	2398	7023	1203	5820	8000	6820	9000	18634
1996	12040	160	12200	400	571	54	120	999	13	1204	3612	3010	2799	8485	3850	5270	1445	3825	9000	0	5175	13660
1997	11495	838	12333	0	957	0	173	954	70	1149	3448	3448	3207	7092	5174	4598	1839	2759	5175	0	2416	9508
1998	10541	1898	12439	0	971	0	176	875	158	1054	3162	3689	3431	5977	6476	4216	2108	2108	2416	0	308	6284
1999	9666	2887	12553	0	986	0	178	802	240	967	2900	3866	3596	4997	7647	3866	2320	1547	308	0	0	4997
2000	8864	3811	12675	0	1001	0	181	736	316	886	2659	4432	4122	3696	9114	3545	2305	1241	0	0	0	3696
2001	8128	4676	12804	0	1016	0	184	675	388	650	2438	4877	4535	2577	10411	3089	2008	1081	0	0	0	2577
2002	7453	5487	12941	0	1031	0	186	619	455	596	2236	4472	4159	2363	10863	2832	1841	991	0	0	0	2363
2003	6835	6249	13084	0	1046	0	189	567	519	547	2050	4101	3814	2167	11298	2597	1688	909	0	0	0	2167
2004	6267	6965	13233	0	1062	0	192	520	578	501	1880	4387	4080	1360	12299	2382	1548	834	0	0	0	1360
2005	5747	7641	13388	0	1078	0	195	477	634	460	1724	4023	3741	1247	12655	2184	1420	764	0	0	0	1247
2006	5270	8280	13550	0	1094	0	198	437	687	422	1581	3689	3431	1144	13002	2003	1302	701	0	0	0	1144
2007	4833	8884	13717	0	1110	0	201	401	737	387	1450	3383	3146	1049	13341	1836	1194	643	0	0	0	1049
2008	4432	9458	13890	0	1127	0	204	368	785	355	1330	3102	2885	962	13674	1684	1095	589	0	0	0	962
2009	4064	10004	14068	0	1144	0	207	337	830	325	1219	2845	2646	882	14000	1544	1004	540	0	0	0	882
2010	3727	10524	14251	0	1161	0	210	309	873	298	1118	2609	2426	809	14321	1416	920	496	0	0	0	809
2011	3417	11022	14439	0	1179	0	213	284	915	273	1025	2392	2225	742	14638	1299	844	454	0	0	0	742
2012	3134	11498	14632	0	1196	0	216	260	954	251	940	2194	2040	680	14951	1191	774	417	0	0	0	680

Table 2 Material Inventory Update - Mobile Air Refrigeration - Tonnes

Start of	Initial Inventory			Replacement 8.3%		Market Growth 1.5%		Scrapped		Losses: Leaks	Losses: Venting	Converted to Alt		Final in Equipt.		Potential Consump	Reclaim	Actual Consump	Standby Inventory	Purchases	Final Standby	Total Available
Year	CFC	Alt.	Total	CFC	Alt	CFC	Alt.	CFC	Alt	CFC	CFC	CFC	Alt	CFC	Alt	CFC	CFC	CFC	CFC	CFC	CFC	CFC
2013	2874	11956	14830	0	1214	0	219	239	992	230	862	2011	1871	624	15261	1092	710	382	0	0	0	624
2014	2635	12398	15033	0	1232	0	223	219	1029	211	791	1845	1715	572	15568	1001	651	350	0	0	0	572
2015	2416	12824	15240	0	1251	0	226	201	1064	193	725	1691	1573	524	15874	918	597	321	0	0	0	524
2016	2216	13236	15452	0	1270	0	229	184	1099	177	665	1551	1442	481	16178	842	547	295	0	0	0	481
2017	2032	13637	15669	0	1289	0	233	169	1132	163	610	1422	1323	441	16481	772	502	270	0	0	0	441
2018	1863	14027	15890	0	1308	0	236	155	1164	149	559	1304	1213	404	16784	708	460	248	0	0	0	404
2019	1709	14407	16115	0	1328	0	240	142	1196	137	513	1196	1112	371	17087	649	422	227	0	0	0	371
2020	1567	14779	16345	0	1348	0	244	130	1227	125	470	1097	1020	340	17390	595	387	208	0	0	0	340

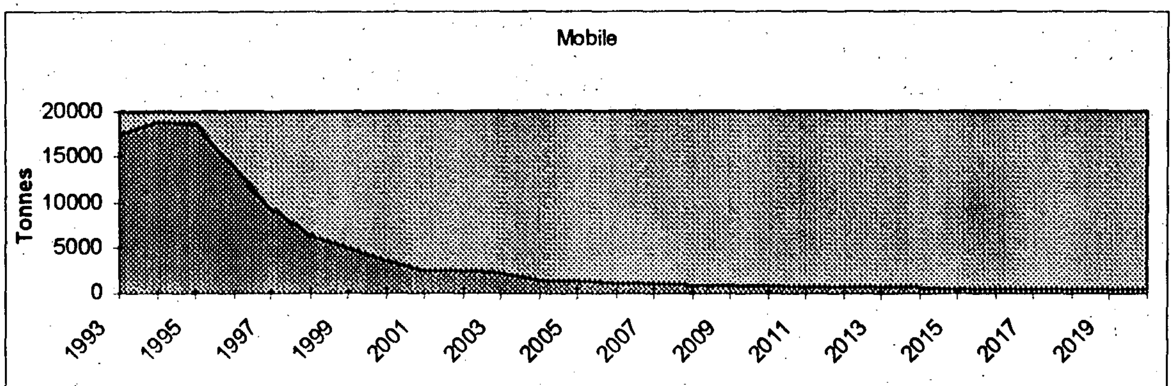


Table 3 **Material Inventory Update - Appliances - Tonnes**

Start of	Initial Inventory			Replacement		Market Growth		Scrapped		Losses		Converted to Alt		Final in Equipt.		Potential		Actual	Standby		Final	Total
				7.0%		1.5%				Leaks	Venting					Consump	Reclaim	Consump	Inventory	Purchases	Standby	Available
Year	CFC	Alt.	Total	CFC	Alt	CFC	Alt.	CFC	Alt	CFC	CFC	CFC	Alt	CFC	Alt	CFC	CFC	CFC	CFC	CFC	CFC	CFC
1993	4062	0	4062	284	0	61	0	284	0	8	49	24	23	4099	23	402	0	402	400	452	450	4548
1994	4123	0	4123	289	0	62	0	289	0	8	49	25	23	4160	23	408	1	408	450	958	1000	5160
1995	4185	0	4185	278	14	60	3	293	0	8	50	25	23	4205	40	397	2	394	1000	894	1500	5705
1996	4230	17	4246	268	28	57	6	296	0	8	51	25	24	4232	74	383	4	379	1500	0	1121	5353
1997	4257	50	4307	238	55	51	12	298	0	9	51	26	24	4223	141	349	6	343	1121	0	778	5001
1998	4249	117	4366	178	111	38	24	297	0	8	51	25	24	4143	275	276	7	269	778	0	509	4652
1999	4168	252	4420	58	217	13	47	292	0	8	46	23	21	3924	537	125	9	116	509	0	393	4317
2000	3947	515	4462	0	293	0	55	276	36	8	43	22	20	3649	883	51	10	41	393	0	352	4001
2001	3671	827	4498	0	297	0	51	257	58	7	40	20	19	3394	1194	48	12	36	352	0	316	3710
2002	3414	1117	4531	0	300	0	48	239	78	7	34	17	16	3158	1481	41	14	27	316	0	289	3447
2003	3175	1387	4562	0	304	0	44	222	97	6	32	16	15	2937	1750	38	16	22	289	0	266	3203
2004	2953	1638	4591	0	307	0	41	207	115	6	30	15	14	2731	2000	35	18	17	266	0	249	2980
2005	2746	1872	4618	0	310	0	38	192	131	5	27	14	13	2540	2233	33	18	15	249	0	234	2774
2006	2554	2089	4642	0	312	0	36	179	146	5	26	13	12	2362	2449	31	18	13	234	0	222	2584
2007	2375	2291	4666	0	315	0	33	166	160	5	24	12	11	2197	2650	28	15	14	222	0	208	2405
2008	2209	2478	4687	0	317	0	31	155	173	4	22	11	10	2043	2837	27	9	18	208	0	190	2233
2009	2054	2653	4707	0	319	0	29	144	186	4	21	10	10	1900	3011	25	3	21	190	0	169	2069
2010	1910	2815	4726	0	321	0	27	134	197	4	19	10	9	1767	3172	23	1	22	169	0	147	1914
2011	1777	2966	4743	0	323	0	25	124	208	4	18	9	8	1643	3323	21	0	21	147	0	125	1769
2012	1652	3107	4759	0	325	0	23	116	217	3	17	8	8	1528	3463	20	0	20	125	0	105	1634

Table 3 **Material Inventory Update - Appliances - Tonnes**

Start of	Initial Inventory			Replacement		Market Growth		Scrapped		Losses		Converted to Alt		Final in Equipt.		Potential		Actual	Standby		Final	Total
				7.0%		1.5%				Leaks	Venting					Consump	Reclaim	Consump	Inventory	Purchases	Standby	Available
Year	CFC	Alt.	Total	CFC	Alt	CFC	Alt.	CFC	Alt	CFC	CFC	CFC	Alt	CFC	Alt	CFC	CFC	CFC	CFC	CFC	CFC	CFC
2013	1537	3237	4774	0	327	0	21	108	227	3	15	8	7	1421	3593	18	0	18	105	0	87	1508
2014	1429	3359	4788	0	328	0	20	100	235	3	14	7	7	1322	3714	17	0	17	87	0	70	1392
2015	1329	3472	4801	0	330	0	19	93	243	3	13	7	6	1229	3826	16	0	16	70	0	54	1283
2016	1236	3577	4813	0	331	0	17	87	250	2	12	6	6	1143	3931	15	0	15	54	0	39	1182
2017	1149	3675	4824	0	332	0	16	80	257	2	11	6	5	1063	4028	14	0	14	39	0	25	1089
2018	1069	3765	4834	0	333	0	15	75	264	2	11	5	5	989	4118	13	0	13	25	0	12	1001
2019	994	3850	4844	0	334	0	14	70	269	2	10	5	5	920	4203	12	0	12	12	0	1	920
2020	925	3929	4853	0	335	0	13	65	275	2	9	5	4	855	4281	11	0	11	1	0	0	855

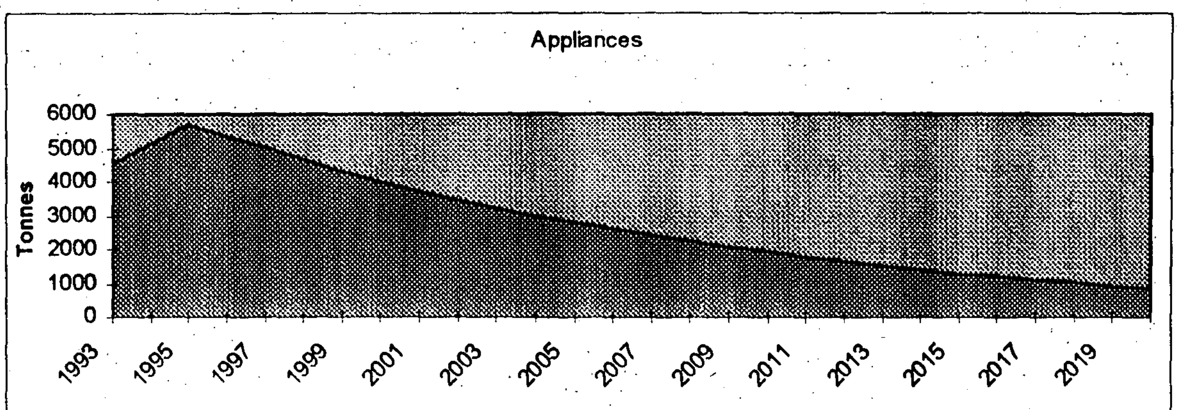


Table 4 **Material Inventory Update - Commercial - Tonnes**

				Replacement		Market Growth				Losses						Potential		Actual	Standby		Final	Total
Start of	Initial Inventory			7.5%		1.5%		Scrapped		Leaks	Venting	Converted to Alt		Final in Equipt.		Consump	Reclaim	Consump	Inventory	Purchases	Standby	Available
Year	CFC	Alt.	Total	CFC	Alt	CFC	Alt.	CFC	Alt	CFC	CFC	CFC	Alt	CFC	Alt	CFC	CFC	CFC	CFC	CFC	CFC	CFC
1993	7060	0	7060	503	25	101	5	530	0	353	1765	177	164	6958	194	2648	530	2118	2500	2218	2600	9558
1994	7134	30	7164	482	52	96	10	535	2	357	1427	357	332	6820	424	2319	571	1748	2600	4148	5000	11820
1995	7177	90	7267	269	257	54	51	538	7	359	718	287	267	6675	665	1615	431	1184	5000	3684	7500	14174
1996	6962	391	7353	0	515	0	249	522	29	348	696	348	324	6091	1479	1566	557	1009	7500	0	6491	12582
1997	6440	1126	7565	0	534	0	107	483	84	322	386	213	198	5744	1964	1191	328	863	6491	0	5628	11372
1998	5957	1682	7638	0	542	0	108	447	126	238	357	214	199	5295	2531	1042	322	721	5628	0	4907	10202
1999	5510	2205	7715	0	550	0	110	413	165	220	275	165	154	4931	3019	909	248	661	4907	0	4246	9177
2000	5097	2700	7796	0	558	0	112	382	202	204	255	166	154	4549	3523	841	229	612	4246	0	3634	8183
2001	4714	3167	7881	0	566	0	113	354	237	189	236	153	142	4208	3989	778	212	566	3634	0	3068	7276
2002	4361	3609	7969	0	575	0	115	327	271	174	218	153	142	3881	4440	720	196	523	3068	0	2545	6426
2003	4034	4028	8062	0	583	0	117	303	302	161	202	141	131	3590	4859	666	182	484	2545	0	2061	5651
2004	3731	4426	8157	0	592	0	118	280	332	149	187	131	121	3321	5258	616	168	448	2061	0	1613	4934
2005	3451	4805	8256	0	601	0	120	259	360	138	138	110	103	3082	5629	535	124	411	1613	0	1203	4285
2006	3192	5165	8358	0	610	0	122	239	387	128	128	102	95	2851	5993	495	115	380	1203	0	823	3674
2007	2953	5510	8463	0	619	0	124	221	413	118	118	94	88	2637	6341	458	106	351	823	0	471	3108
2008	2732	5840	8572	0	629	0	126	205	438	109	109	98	91	2428	6686	423	98	325	471	0	146	2575
2009	2527	6156	8683	0	638	0	128	190	462	101	101	91	85	2246	7006	392	91	301	146	0	0	2246
2010	2337	6460	8797	0	648	0	130	175	485	93	93	84	78	2078	7315	362	84	278	0	0	0	2078
2011	2162	6753	8915	0	657	0	131	162	506	86	86	78	72	1922	7614	335	78	257	0	0	0	1922
2012	2000	7035	9035	0	667	0	133	150	528	80	80	72	67	1778	7902	310	72	238	0	0	0	1778

Table 4 Material Inventory Update - Commercial - Tonnes

				Replacement		Market Growth				Losses						Potential		Actual	Standby		Final	Total
Start of	Initial Inventory			7.5%		1.5%		Scrapped		Leaks	Venting	Converted to Alt		Final In Equipt.		Consump	Reclaim	Consump	Inventory	Purchases	Standby	Available
Year	CFC	Alt.	Total	CFC	Alt	CFC	Alt.	CFC	Alt	CFC	CFC	CFC	Alt	CFC	Alt	CFC	CFC	CFC	CFC	CFC	CFC	CFC
2013	1850	7308	9158	0	677	0	135	139	548	74	74	67	62	1644	8182	287	67	220	0	0	0	1644
2014	1711	7572	9283	0	687	0	137	128	568	68	68	62	57	1521	8454	265	62	204	0	0	0	1521
2015	1583	7829	9412	0	698	0	140	119	587	63	63	57	53	1407	8719	245	57	188	0	0	0	1407
2016	1464	8079	9543	0	708	0	142	110	606	59	59	53	49	1302	8978	227	53	174	0	0	0	1302
2017	1354	8323	9677	0	719	0	144	102	624	54	54	49	45	1204	9230	210	49	161	0	0	0	1204
2018	1253	8561	9813	0	729	0	146	94	642	50	50	45	42	1114	9478	194	45	149	0	0	0	1114
2019	1159	8794	9953	0	740	0	148	87	660	46	46	42	39	1030	9721	180	42	138	0	0	0	1030
2020	1072	9023	10095	0	751	0	150	80	677	43	43	39	36	953	9961	166	39	128	0	0	0	953

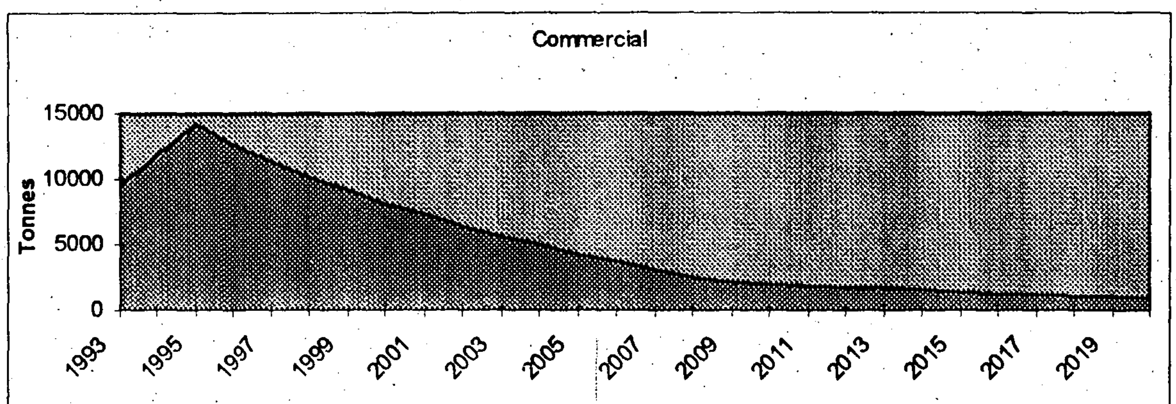
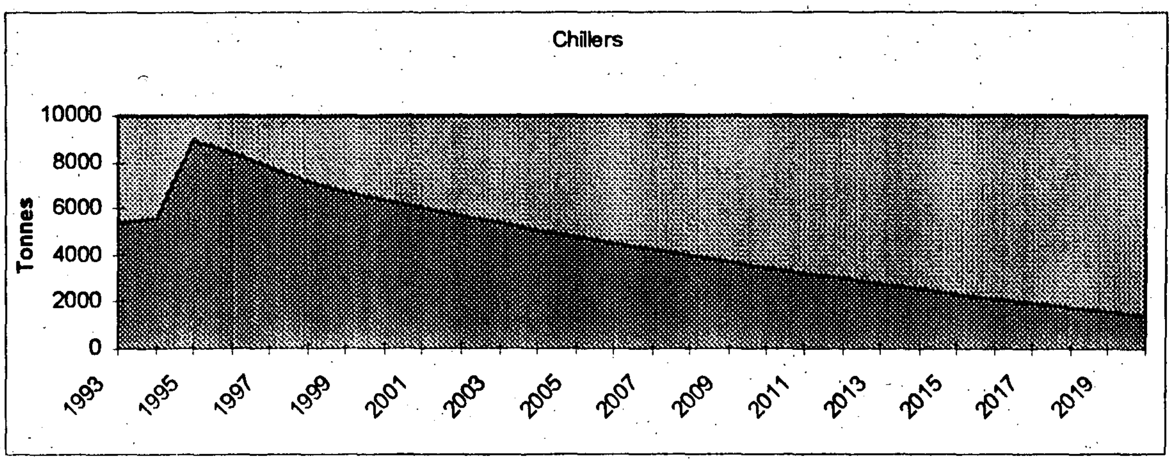


Table 5 Material Inventory Update - Chillers - Tonnes

Start of Year	Initial Inventory			Replacement 3.3%		Market Growth 1.5%		Scrapped		Losses: Leaks	Losses: Venting	Converted to Alt		Final in Equipt.		Potential Consump	Reclaim	Actual Consump	Standby Inventory	Purchases	Final Standby	Total Available
	CFC	Alt.	Total	CFC	Alt	CFC	Alt.	CFC	Alt	CFC	CFC	CFC	Alt	CFC	Alt	CFC	CFC	CFC	CFC	CFC	CFC	CFC
1993	3594	0	3594	24	88	11	40	119	0	539	899	180	167	3330	295	1472	0	1472	2000	1572	2100	5430
1994	3510	128	3638	0	108	0	49	116	0	526	877	351	326	3043	611	1404	140	1264	2100	1664	2500	5543
1995	3394	285	3679	0	104	0	47	112	0	407	849	339	316	2943	752	1256	251	1005	2500	4504	6000	8942
1996	3282	437	3719	0	101	0	46	108	14	328	722	164	153	3010	736	1050	420	630	6000	0	5370	8379
1997	3174	569	3742	0	97	0	44	105	19	317	698	159	148	2910	858	1016	508	508	5370	0	4862	7772
1998	3069	692	3761	0	94	0	43	101	23	307	675	153	143	2814	971	982	491	491	4862	0	4371	7185
1999	2968	806	3773	0	91	0	41	98	27	297	653	148	138	2721	1076	950	570	380	4371	0	3991	6712
2000	2870	912	3781	0	88	0	40	95	30	287	574	143	133	2632	1173	861	603	258	3991	0	3733	6364
2001	2775	1010	3785	0	85	0	39	92	33	278	555	139	129	2545	1263	833	583	250	3733	0	3483	6028
2002	2684	1100	3784	0	82	0	37	89	36	268	537	134	125	2461	1345	805	564	242	3483	0	3241	5702
2003	2595	1184	3779	0	80	0	36	86	39	259	519	130	121	2380	1420	778	545	234	3241	0	3008	5387
2004	2509	1260	3770	0	77	0	35	83	42	251	502	125	117	2301	1489	753	527	226	3008	0	2782	5083
2005	2427	1331	3757	0	74	0	34	80	44	243	485	121	113	2225	1552	728	510	218	2782	0	2563	4789
2006	2346	1395	3742	0	72	0	33	77	46	235	469	117	109	2152	1609	704	493	211	2563	0	2352	4504
2007	2269	1454	3723	0	70	0	32	75	48	227	454	113	106	2081	1661	681	476	204	2352	0	2148	4229
2008	2194	1507	3701	0	67	0	31	72	50	219	439	110	102	2012	1707	658	461	197	2148	0	1951	3963
2009	2122	1556	3677	0	65	0	30	70	51	212	424	106	99	1946	1749	637	446	191	1951	0	1760	3705
2010	2052	1599	3651	0	63	0	29	68	53	205	410	103	95	1881	1786	616	431	185	1760	0	1575	3456
2011	1984	1638	3622	0	61	0	28	65	54	198	397	99	92	1819	1819	595	417	179	1575	0	1396	3216
2012	1919	1672	3591	0	59	0	27	63	55	192	384	96	89	1759	1847	576	403	173	1396	0	1224	2983

Table 5 Material Inventory Update - Chillers - Tonnes

				Replacement		Market Growth				Losses						Potential		Actual	Standby		Final	Total
Start of	Initial Inventory			3.3%		1.5%		Scrapped		Leaks	Venting	Converted to Alt		Final in Equipt.		Consump	Reclaim	Consump	Inventory	Purchases	Standby	Available
Year	CFC	Alt.	Total	CFC	Alt	CFC	Alt.	CFC	Alt	CFC	CFC	CFC	Alt	CFC	Alt	CFC	CFC	CFC	CFC	CFC	CFC	CFC
2013	1855	1703	3558	0	57	0	26	61	56	186	371	93	86	1701	1872	557	390	167	1224	0	1057	2758
2014	1794	1729	3523	0	55	0	25	59	57	179	359	90	83	1645	1893	538	377	161	1057	0	895	2540
2015	1735	1752	3487	0	53	0	24	57	58	173	347	87	81	1591	1910	520	364	156	895	0	739	2330
2016	1678	1772	3450	0	51	0	23	55	58	168	336	84	78	1538	1925	503	352	151	739	0	588	2127
2017	1622	1788	3411	0	50	0	23	54	59	162	324	81	75	1488	1936	487	341	146	588	0	442	1930
2018	1569	1802	3370	0	48	0	22	52	59	157	314	78	73	1438	1945	471	329	141	442	0	301	1740
2019	1517	1812	3329	0	47	0	21	50	60	152	303	76	71	1391	1951	455	319	137	301	0	165	1556
2020	1467	1820	3287	0	45	0	20	48	60	147	293	73	68	1345	1954	440	308	132	165	0	33	1378



11.3 Demand for CFCs and Halons in Canada

Environment Canada data on CFC uses in Canada covers a 12 year period, from 1983 to 1994. Total CFC use and use in various broad categories, air conditioning and refrigeration, foam, solvent, and miscellaneous is in the following tables.

CFC Uses in Canada, 1983-1994

Year	Total (tonnes)	A/C and	Foam	Solvent	Miscellaneous
1983	16380	34%	42%	7%	17%
1984	17830	34%	36%	11%	17%
1985	19490	35%	39%	11%	15%
1986	19450	33%	43%	9%	15%
1987	20780	33%	44%	9%	14%
1988	20300	35%	43%	11%	11%
1989	17400	43%	39%	12%	6%
1990	13000	51%	32%	13%	4%
1991	9600	51%	35%	9%	5%
1992	8400	59%	29%	7%	5%
1993	7500	60%	29%	5%	6%
1994	5320	71%	18%	4%	7%

Air conditioning and refrigerations uses in Canada, 1986-1994

Year	Total (tonnes)	Mobile a/c	Mobile a/c new	Commercial	Domestic a/c	Domestic a/c
1986	6500	10%	31%	55%	3%	1%
1987	6800	12%	31%	53%	3%	1%
1988	7000	19%	31%	46%	3%	1%
1989	7700	24%	25%	47%	2%	2%
1990	6200	25%	28%	44%	2%	1%
1991	5200	21%	31%	45%	1%	2%
1992	4900	28%	32%	38%	1%	1%
1993	4500	42%	18%	38%	1%	1%
1994	3820	64%	0%	35%	1%	1%

Foam Uses in Canada, 1986-1994					
Year	**Total (tonnes)**	**Flexible Foam (%)**	**Rigid Insulation Refrigeration (%)**	**Rigid Packaging (%)**	**Rigid Insulation Other Uses (%)**
1986	8,200	15	0	25	60
1987	9,200	16	0	20	64
1988	8,900	13	12	13	62
1989	6,700	14	16	1	69
1990	4,550	12	19	0	69
1991	3,000	6	24	0	70
1992	2,500	2	21	0	77
1993	2,200	1	22	0	77
1994	960	0	53	0	47

Solvent Uses in Canada, 1986-1994						
Year	**Total (tonnes)**	**Electronic Cleaning (%)**	**General Cleaning (%)**	**Metal Cleaning (%)**	**Dry Cleaning (%)**	**Laboratory Solvent (%)**
1986	1,800	79	0	20	1	0
1987	1,900	79	0	20	1	0
1988	2,200	74	5	17	4	0
1989	2,100	68	9	20	3	0
1990	1,500	67	10	18	5	0
1991	900	55	7	28	10	0
1992	600	53	17	23	7	0
1993	370	21	14	35	13	17
1994	190	29	7	8	17	39

Miscellaneous Uses in Canada, 1986-1994				
Year	**Total (tonnes)**	**Aerosol (%)**	**Leak Testing (%)**	**Sterilization (%)**
1986	2,950	76	4	20
1987	2,880	76	6	18
1988	2,200	73	5	22
1989	900	35	10	55
1990	750	25	12	63
1991	500	24	11	65
1992	400	25	9	66
1993	430	39	3	58
1994	350	33	1	66

Halon Uses in Canada, 1986-1991						
Year	**Total (tonnes)**	**New Fire Extinguishers (%)**	**Service Fire Extinguishers (%)**	**Refrigeration (%)**	**New Total Flooding Systems (%)**	**Service Total Flooding Systems (%)**
1986	470	41	10	0	39	10
1987	770	57	12	1	25	6
1988	720	58	11	1	22	9
1989	335	47	13	1	24	16
1990	260	41	15	1	26	18
1991	220	53	17	1	8	22

11.4 Inventory of CFCs and Halons in Canada

The most recent Environment Canada estimate was published in 1995. It is estimated that there are 48,000 tonnes of CFCs and 3,000 tonnes of Halons in service in Canada. These stocks are found in 6 categories of equipment, see figure below.

Figure 1: Canada's 1993 Inventory of CFCs and Halons by Sector

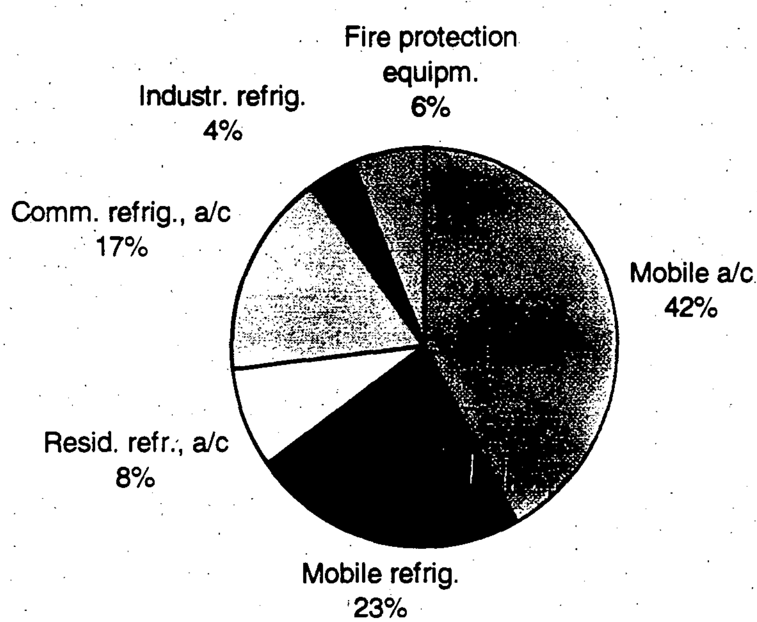
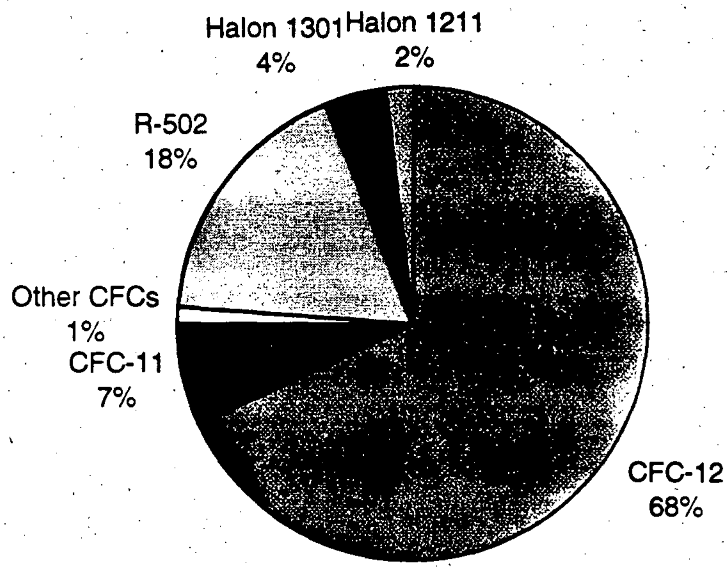


Figure 2 shows the various substances that are currently in the inventory. CFC-12 accounts for more than 2/3 of all ODS in Canada's inventory.

Figure 2: Canada's 1993 Inventory of CFCs and Halons by Substance



12.0 APPENDIX B: ABBREVIATIONS AND DEFINITIONS

12.1 Abbreviations

A/C	Air conditioning
ACRWA	Air Conditioning and Refrigeration Wholesalers Association
CAMA	Canadian Appliance Manufacturers Association
CCME	Canadian Council of Ministers of the Environment
CCPA	Canadian Chemical Producers Association
CEASA	Canadian Electronic & Appliance Service Association
CFC	Chlorofluorocarbon
CFC-11	Trichlorofluoromethane
CFC-12	Dichlorodifluoromethane
CFC-115	Chloropentafluoroethane
CMCSA	Canadian Manufactures of Chemical Specialties Association
CVMA	Canadian Vehicle Manufacturers Association
FPWG	Federal Provincial Working Group on Controls Harmonization
Halon 1211	Bromochlorodifluoromethane
Halon 1301	Bromotrifluoromethane
HCFC	Hydrochlorofluorocarbon
HCFC-22	Chlorodifluromethane
HFC	Hydrofluorocarbon
HRAI	Heating, Refrigerating and Air Conditioning Institute of Canada
NAICC	National Air Issues Coordinating Committee, a CCME committee
NAP	National Action Plan for Recovery, Recycling and Reclamation of hlorofluorocarbons
NFPA	National Fire Protection Association
ODS	Ozone depleting substance
R -	Refrigerant
R-134a	Hydrofluorocarbon refrigerant
R-502	Refrigerant blend, an azeotropic blend of HCFC-22 and CFC-115
RACCA	Refrigeration and Air Conditioning Contractors Association
UNEP	United Nations Environmental Program

12.2 Definitions

Chlorofluorocarbon (CFC) - A very stable chemical compound containing chlorine, fluorine and carbon atoms. Chlorofluorocarbons decompose in the stratosphere and release chlorine which destroys ozone.

Halon - A compound containing bromine, chlorine, fluorine, and carbon in its structure. Halons have high ozone depletion potential.

Hydrochlorofluoro-carbon (HCFC)	-	A chemical compound containing hydrogen, chlorine, fluorine and carbon atoms. HCFCs are much less stable than CFCs, but small quantities can reach the stratosphere and release chlorine. They are considered acceptable substitutes for CFCs for a transitional period but because of their low ODP, HCFC production and importation will be phased out by year 2030.
Hydrofluorocarbon (HFC)	-	A chemical compound containing only hydrogen, fluorine and carbon atoms. Since no chlorine is present, these compounds have no ozone-depletion potential and are ideal replacements for chlorofluorocarbons.
Ozone depletion potential (ODP)	-	The rated effect of a compound on the ozone layer compared to CFC-11. Which is assigned a value of 1.0. Official ODP values are assigned in the Montreal Protocol and are updated by UNEP.
Ozone depleting substance (ODS)	-	A chemical compound that is sufficiently stable to reach the stratosphere and capable of reacting with stratospheric ozone, either directly or through release of a chemical element that reacts after the compound decomposes.

13.0 APPENDIX C: PREDICTIVE MODEL

The following algorithms were used in the predictive model.

The Initial Inventory (InI) in any subsequent year = initial inventory of the previous year less the amount scrapped (SCR), plus any market growth using CFC, (MG)plus any replacement using CFC (REP).

The same applies to the Initial Inventory of Alternates (ALT) in any subsequent year.
e.g. In I (year X) = InI (Year X-1) -SCR (Year X-1) + REP (Year X-1) + MG (Year X-1)
(F-1)

It is important to be sure that only CFC is added to CFC, and the same for ALT.

The same equation is used for ALT.
(F-2)

The Total Initial Inventory (InIT) is the sum of CFC and ALT in the same year.
e.g. InIT (Year X) = InI CFC (Year X) + InI ALT (Year X)
(F-3)

The amount of refrigerant scrapped each year (SCR) is the inverse of the average equipment service life, (AESL) , to express this as a % it is multiplies by 100.
e.g. SCR = 1 / AESL
(F-4)
%SCR = (1 / AESL) x 100
(F-5)

The amount of Replacement Refrigerant (REP) is determined as follows: Each year the material removed in scrapped (SCR) is replaced by new units containing either CFC or ALT. The Replacement Factor (FR) for each refrigerant determines how much will be replaced by CFC and how much by ALT.

Initially in 1993, in most cases replace was all by CFC, but each year the % CFC decreases and the amount of ALT replacement increases.

In addition when ALT is used as the replacement, an additional factor for weight (FW) must also be used as the weight of ALT is less than the weight of CFC. After a few years, starting in 1993, ALT units begin to replace some of the CFC units and then replacement of ALT units directly with ALT on a kg per kg basis, is also in process.
e.g. REP (CFC) = SCR (CFC) x FR (CFC)
(F-6)
REP (ALT) = SCR (CFC) x FR (ALT) x FW + SRC (ALT)
(F-7)

Note: FW = 0.93 for all applications
(F-8)
Leaks and Leakage Losses

Equipment leaks are mainly due to loose connections caused by vibration. Other causes include corrosion, mechanical wear where tubing is rubbing on something, operators standing or walking on equipment or piping, and failure to tighten or solder joints properly after servicing. In chiller systems significant additional losses occur when the purge system operates. As equipment is better or more frequently serviced and leaks are repaired, leak losses tend to decline. This has been the recent experience.

Leakage Losses (LL) have been estimated for each year of each sector., with values generally in the range of 5% to 10% of the inventory in equipment for a given sector.

Venting and Venting Losses

Venting losses (VL) were originally relatively high in all sectors except appliances, ranging in the area of 25 % to 40% working inventory. By 1998 venting levels had significantly decreased in all areas, with appliance sector remaining essentially constant at about 1%.. Forecast venting rates are as follows:

- § appliances 1%,
- § commercial 4%,
- § chillers 20%,
- § mobile 30%.

Standby Inventory

The Standby Inventory (SBI) was estimated for each sector as of the beginning of 1993.

Thereafter the Standby Inventory at the beginning of any year X, is equal to the Final Standby Inventory (FSBI) in theprevious year.
e.g. SBI (year X) = FSBI (year X-1)
(F-9)

Purchases

Purchases of CFCs (P) are estimated numbers based on provided information.
Final Standby Inventory (FSBI) n any year is the Initial Standby Inventory plus purchases, minus Actual Consumption (AC).
e.g. FSBI = SBI + P - AC
(F-10)
Total Available CFC

The Total Available CFC (TA) is the Final Inventory in Equipment (FIE) plus the Final Standby Inventory.

e.g. TA = FIE + FSBI
(F-11)

Actual Consumption of CFC

The Actual Consumption (AC) of CFC is equal to the Potential Consumption (PC0 minus the amount of Reclaim (RC).

e.g. = PC -RC
(F-12)

Reclaim

The amount of reclaim has been based on information and actual data provided. Actual reclaim rates have then been estimated for each sector for each year.

Potential Consumption of CFC

The Potential Consumption of CFC is the amount scrapped in obsolete equipment (SCR) plus the amount for market growth (MG) plus the amount vented (VL) plus the Leakage Losses (VL).

e.g. PC = SCR + MG + LL + VL
(F-13)

14.0 APPENDIX D HALON REGULATIONS

14.1 Federal regulations

In order to implement the Canadian program to protect the ozone layer, Environment Canada published three sets of regulations under the Canadian Environmental protection Act (CEPA).

These are:

- Ozone-depleting Substances regulation No. 1 (CFCs)
- Ozone-depleting Substances Regulations No. 2 (Halons)
- Ozone-depleting Substances Regulation No.3 (Products)

The two last sets of regulations are relevant to Halons. They were proposed in the Canada Gazette, Part I on November 18, 1989. Several amendments to the regulation r published in the Canada gazette on latter dates. These regulations prohibit production of Halons in Canada. (Halons have never been produced in Canada.) Also they prohibit importation of Halons at levels exceeding that of 1988, effective in January 1992. The last regulation prohibits the sale of portable fire extinguishers containing Halons or CFCs for new uses with certain exemptions. In addition it mandates that servicing, repairing or re-charging operations use recovered or recycled Halons.

14.2 The Environmental Code of Practice on Halons

Under the same Federal Act (CEPA) two environmental codes of practice have been developed. One of these codes deals with CFCs while the other deals with Halons, and is known as the Environmental Code of Practice on Halons. This Code provides directions to Halon owners and users on managing Halon stocks in a manner to reduce, and eventually eliminate Halon emissions to the atmosphere.

These directions cover training, safety, record keeping, inspection, testing, maintenance, decommissioning and other relevant aspects. They also contain a section on hazard/risk analysis, which outlines a methodology of assessing a fire protection installation so that an informed decision on conversion from Halons can be made.

14.3 Provincial Regulations

Fire protection is a provincial jurisdiction. Every province has a "Fire Protection Act". Most Canadian provinces have now implemented mandatory recovery and recycling of ODS including Halons. Certain provincial legislation prohibit the use of portable fire extinguishers containing Halons, while others require specific labeling of such equipment.

Nova Scotia enacted regulations on February 15, 1991 to prohibit the manufacture, importation and sale of hand-held fire extinguishers containing any Halons with some exempted applications. Quebec enacted similar ban on sale of hand-held fire extinguishers effective on and after January

1, 1992 and a ban on sale or distribution of Halons effective on and after January 1, 1995 with the exception of recycled or recovered Halons.
In Ontario, control of the application and use of ozone-depleting substances is governed by part V-A of the Environmental Protection Act, which was amended June 20, 1989. These regulations impact aerosols, foams, and spent refrigerants.

In Alberta any discharge of Halon other than during fire conditions must be reported the Alberta Environment and there are fines for such releases.

The following table is a review of different Provincial/territorial requirements for ODS in general and Halons in particular.

Province	Alta	BC	Man	NB	Nfld	NWT	NS	Ont	PEI	Que	Sas	Yuk
No release of ODS	x	x	x	x	x	x	x	x	x	x	x	x
Mandatory reporting of ODS release	x		x	x	x	x			x			x
No new FPE containing ODS				x	x		x	x	x			
Mandatory ODS recovery	x	x	x	x	x	x	x	x	x	x	x	x
No sale of protable halon FPE	x	x	x	x		x	x			x	x	
Certification to serve FPE	x		x	x	x		x	x	x		x	x
No leak testing with ODS		x	x	x			x		x	x	x	x
No ODS topping of leaking FPE		x	x	x			x					x
No non-refillable containers		x		x	x		x		x			x
Mandatory labelling FPE			x	x				x	x		x	
Mandatory plan to manage and eliminate halons		x	x		x	x						x

14.4 The Federal Provincial Working Group

As seen from the above, differences exist in provincial regulations due to different approaches and priorities. The Federal Provincial Working Group (FPWG) on control harmonization (Ozone-depleting Substances: ODS) was established in 1989. The main focus of the group has been to facilitate the introduction of harmonized regulations to reduce emissions of ODS. The working group lead by Environment Canada prepared the National Action Plan (NAP) for the recovery, recycling, and reclamation of CFCs.

15.0 APPENDIX E: STAKEHOLDERS' VIEWS AND COMMENTS

The following comments have been combined where appropriate and condensed from the discussions at the meetings.

15.1 January 13th, 1998 meeting

Their was general agreement that there is not a surplus of CFCs except for some specialized refrigerants such as R-500 and R-502. At the same time supply and demand vary greatly from sector to sector. Virgin CFC-12 is still available but is insufficient for future needs.
There was also a belief that CFC-11 will remain in use for a long time in the HVAC sector because of conversion costs.

The recycling of CFCs was initially seen as a temporary measure, acting as an interim step between the ban on imports and manufacture and the elimination of their use.
The automobile manufacturers switched to HFC in mobile A/C units in late 1993 or early 1994, coincident with the 1994 model year change. Conversion of existing units has been very slow and lower than forecast.

15.2 March 17th, 1998 meeting

Ineffective controls on refrigerant blends are creating confusion resulting in contaminated refrigerant. As recycling cannot be done with recovered contaminated material, venting to the atmosphere is a frequent consequence. The question was raised as to how realistic it was to expect to recover CFCs from small mobile and residential air conditioners and refrigerators which contain, when fully charged, between 3 to 40 ounces of refrigerant. Also there is not much chance of recovering R-12 which is rapidly being lost to the atmosphere.

For these reason, it was suggested that the focus be on R-11 and R-502 used in large industrial units. These offer opportunities for containment and treatment. Time is a problem. While bans were not generally supported, the British Columbia and New Brunswick bans on "topping up" mobile air conditioners with CFC-12, might be appropriate for other provinces. Such a ban could create a temporary surplus of CFC-12 which could be used in other sectoras. Ultimately, however, destruction of existing inventories of CFCs will have to be addressed.

A user ban on existing units would require collection/destruction which is not in place. Bans on ODS lead to black market activities. They do not solve the problem but simply move it to another area. Globally they do not solve the environmental problem. Export of recovered/recycled or surplus inventory are a bad idea as management and control are very difficult to effect. Currently, there is uncertainty about what happens to recovered ODS.

The user determines conversion and is driven by economics. As long as users can use ODS there will be a market for them and they will be used. Canada has a system equivalent ot the Australian RRA but lacks an "overseeing" group.

15.3 February 17th, 1998 meeting

1998 may be a watershed year for CFC-12 supply in the mobile air conditioning sector. Shortages could occur as soon as this summer. It is believed that only OEM manufacturers have significant stockpiles, retained for servicing their earlier models equipped with CFC-12. This comment was subsequently to be only partly correct. OEM manufacturers stocks ranged from substantial to nil. Some manufacturers had made no provision for aftermarket service at all. All-in-all, stocks of CFC-12 appear to be headed for an early rather than delayed shortage. Some suppliers have a shortage of CFC-12 now. The shortage has been exacerbated by a significant movement of recovered CFC-12 to the United States because of the price differential.

The study should be very careful about economic assumptions, conversion costs, for example, are much higher than originally estimated. The shortage of CFC-12 combined with these high conversion costs has resulted in an increase in the use of blends which are being promoted as "drop-in" replacements. Except for British Columbia, the use of these blends appears to be unregulated. They have the potential to contaminate recovered stocks of CFC-12 which the recyclers will not treat. This creates pressures to vent this contaminated material as there is no mechanism for disposal. Undoubtedly, venting of contaminated material does occur.
After the ban on manufacture and importation of CFCs, a huge demand was created in the automotive aftermarket (10 to 20% went into the stationary sector). There are some concerns that the imports of CFC-12 described as recovered CFC-12 is actually virgin material.

15.4 March 17th, 1998 meeting

Currently regulations are driving the recovery of CFCs but the recovery would be more effective if the economics were better. The Australian model (RRA) could adversely affect conversion to alternatives, the levy increasing the cost of the alternative refrigerant making the conversion less attractive economically. In some regions, mobile air conditioning refrigerant recovery is essentially uncontrolled. As this sector has a short time frame for effective action, it is doubtful that governments can act sufficiently quickly to achieve significant results. It would be better, therefore, to concentrate on sectors which can realistically be controlled under our system. Stationary refrigeration and air conditioning would appear to be obvious candidates. These sectors, however, appear to be already under control so the question arises whether this should be done at all.

Bans on the use of CFCs are not favoured as these are deemed to be not feasible. There are simply not enough resources to act quickly on the millions of units involved. A phased ban on use is also deem to be not feasible. Even a reasonable time spread would still involve large numbers of units and the losses during this period will render the program ineffective.

Bans on the import of any CFC, virgin or recovered, are favoured. Bans on exports are a political problem. Exports should be allowed as this does not create waste and does not add to the global stockpile since Canada does not manufacture CFCs and the material is already in existence. Further the export could actually reduce CFCs releases since it could replace material which would otherwise be manufactured and thus added to the global inventory. Methyl bromide should not be overlooked in considering ODS. Performance stands are being worked on and SAE standards issued. Recyclers believe that they are being viewed too negatively. They are active in other areas such as storage and disposal. Canada should move quickly to establish a destruction facility and recyclers are interested in participating in this activity. It should also be recognized that the market will change in 5 years because of the disappearance of the mobile air conditioning sector contribution to CFC inventories and releases.

16.0 APPENDIX F: REFERENCES

1. Ozone Depleting Substances Products Regulations, Department of the Environment, Department of National Health and Welfare, Extract from Canada Gazette, Part II, December 27, 1995
2. Ozone Depleting Substances Regulations, Department of the Environment, Department of National Health and Welfare, Extract from Canada Gazette, Part II, December 27, 1995
3. 1994 Report Of The Solvents, Coatings And Adhesives Technical Options Committee For The 1995 Assessment Of The Montreal Protocol On The Substances That Deplete The Ozone Layer, Pursuant To Article 6 Of The Montreal Protocol; Decision IV/13 (1993) By The Parties To The Montreal Protocol
4. 1994 Report Of The Flexible and Rigid Foams Technical Options Committee For The 1995 Assessment Of The Montreal Protocol On The Substances That Deplete The Ozone Layer
5. 1994 Report Of The Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee For The 1995 Assessment Of The Montreal Protocol On The Substances That Deplete The Ozone Layer
6. The Montreal Protocol On The Substances That Deplete The Ozone Layer, Technology and Economic Assessment panel, April 1997 Report, Volume 1
7. Environmental Code of Practice for Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems, Environmental Protection Service, Environment Canada, Report EPS 1/RA/2, March 1996
8. National Action Plan for the Environmental Control of Ozone-Depleting Substances and their Halocarbon Alternatives, CCME Draft Report, March 1997, Prepared by the Federal Provincial Working Group on Controls Harmonization (ODS)
9. NAICC (National Air Issues Coordinating Committee) Meeting, Federal-Provincial Working Group on Controls Harmonization (Ozone Depleting Substances), Victoria, BC, February 3-4, 1997
10. Strengthening Canada's Ozone Layer Protection Program; Recommendations to Strengthen Canada's Ozone layer Protection Program, Federal-Provincial Working Group on Controls Harmonization (Ozone Depleting Substances), May 1995.
11. Summary Report: National Inventory Of CFC And HCFC Installations In Canada, Environment Canada File KA168-2-7055, prepared by Bovar Environmental Services, Calgary, Alberta in Association with Concord Environmental Corporation, Toronto, Ontario and Roger Buxton Associates, Unionville, Ontario, October 1993
12. Summary Report: A National Inventory of CFC and HCFC Installations in Canada, Prepared by Craig Morgan, Chemical Industries Division, Industrial Sectors Branch, Environmental Protection Service, Environment Canada, February 1995.
13. Facsimile: UNEP – Halon Surplus and Deficit, by A. Coppin, Halon Resources Inc. to Jean Carbonneau, Environment Canada, January 29th, 1998.
14. A Summary of the 1996 Report on the Management Plans for Industries/Agencies that Use Fire Fighting Equipment Containing Halon in British Columbia, Prepared by Mary C. Gallinger for British Columbia Ministry of Environment, Lands and Parks, Air Resources Branch.

15. Socio-Economic Assessment of a Ban on the Use of Existing Products and Equipment Containing CFCs or Halons, Project Report, prepared for Bernard Madé and Chantal Chalifoux, Environment Canada, by ARC, May 1997.

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