CANADA'S OZONE LAYER PROTECTION PROGRAM

A SUMMARY

Protocole de
Montréal
Protocol
1987-1997

Canada

Environment Canada Environnement Canada

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PREFACE

1997 is the 10th anniversary of the Montreal Protocol on Substances that Deplete the Ozone Layer. The Montreal Protocol is an international agreement aimed at reversing the damage done to the stratospheric ozone layer that protects the earth from harmful solar ultraviolet radiation. Canada continues to be a leader on ozone protection among the 162 countries that are now signatories of the Montreal Protocol. In celebration of the achievements of the Parties to the Montreal Protocol, Canada is hosting the Ninth Annual Meeting in Montreal in September 1997.

Parties to the Montreal Protocol reached an important milestone on January 1, 1996, with all developed countries eliminating the production and importation of the most damaging ozone-depleting substances (the main ones being CFCs). This success was accomplished through the co-operation and the combined efforts of governments, industry, environmental groups and the scientific community.

However, this achievement does not mean that Canada and the international community can afford to become complacent about ozone depletion. Phase - out of the most damaging ozone-depleting substances is only now beginning in developing countries. Developed countries have already eliminated most ODSs and have begun to adopt reduction and phase-out targets for the remaining ODSs still of concern. Much is still needed in the way of scientific research, development of alternative substances and technologies, technology transfer, and public education. Only then will it be possible for the earth's stratospheric ozone layer to fully recover.

Encouraged by the progress that has been achieved, Canada has renewed its commitment to make ozone protection a top priority. This summary report describes why and how. The report covers the history of our knowledge about ozone depletion, its causes, possible solutions, and what Canada is doing in response to the threat of ozone loss. It explains the disturbing potential consequences of ozone destruction, as well as the challenges Canada and other world countries must face to fully support ozone protection programs.

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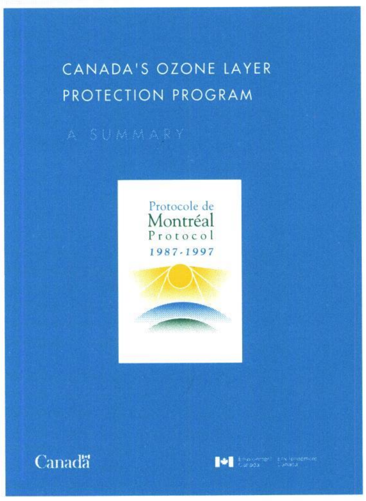

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http://www.ec.gc.ca/ozone

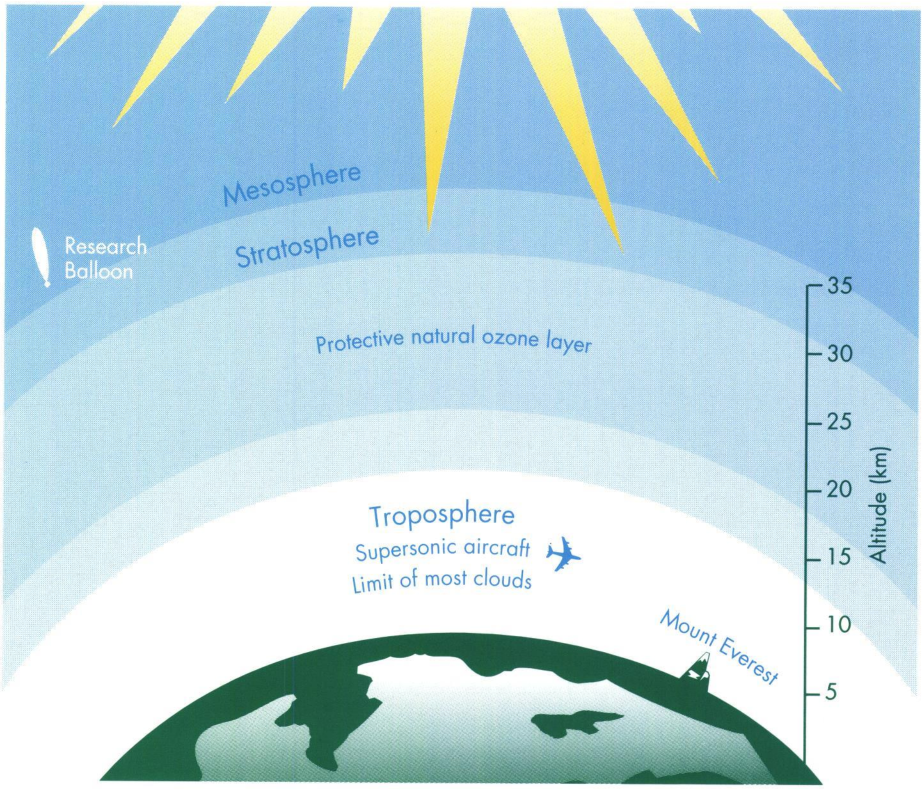
INTRODUCTION

What is the ozone layer?

Our planet's only natural sun screen, the ozone layer is located high in the earth's atmosphere. This layer of gas acts as an invisible filter which protects all life forms from over-exposure to the sun's harmful ultraviolet (UV) rays.

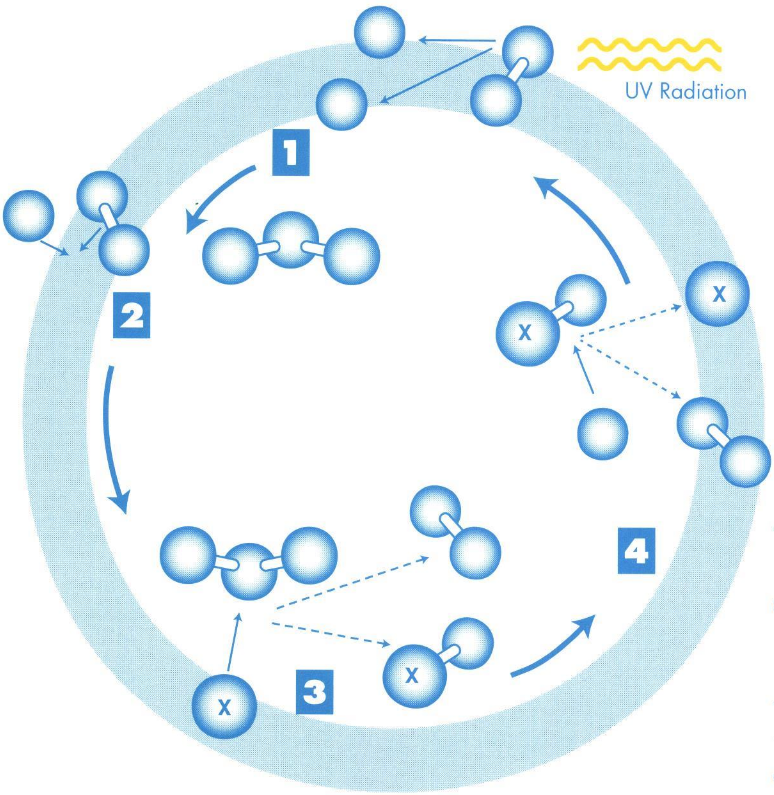
Ozone is a chemical cousin to the oxygen that we need to breathe: regular oxygen is a two-atom oxygen molecule (O_2), and ozone is made up of three oxygen atoms (O_3). An important physical property of ozone is that it absorbs UV radiation very effectively, protecting the earth from most of these damaging rays.

Ninety per cent of all ozone is concentrated in the stratosphere, between 15 and 35 km above the surface of the earth, with a peak concentration at 25 km.



The ozone molecules in the upper atmosphere are spread so thinly that if they were compressed to pure ozone at ground level, they would create a band only 3 mm thick, about the thickness of three dimes.

Ultraviolet radiation itself, plays a primary role in the formation of ozone. In the upper atmosphere, UV radiation causes oxygen molecules to break up, and create free oxygen atoms that attach themselves to intact oxygen molecules to form ozone. The total amount of ozone in the atmosphere is a balance between the rate at which it is produced by sunlight and the rate at which it is destroyed in photochemical reactions with other gases. Once formed in the stratosphere, the concentration and distribution of ozone has a significant effect on the atmosphere's temperature and the movement of air currents around the world. Because photochemical reactions and transport processes vary with season and latitude, ozone concentrations are not uniform



The natural cycle of ozone production and destruction in the stratosphere

1. *O_2 is split into 2 atoms.*
2. *Oxygen atoms attach themselves to oxygen molecules to form ozone.*
3. *Trace substance X destroys ozone, releasing an oxygen molecule.*
4. *Trace substance X released to destroy more ozone molecules.*

throughout the year or from one part of the globe to another. Generally, the ozone layer is thinner over the equator than over the poles.

At the beginning of the 1980s, scientists identified some disturbing and unnatural changes happening in the ozone layer.

What is ozone depletion?

"Ozone depletion" is the term commonly used to describe the diminishing of the earth's protective stratospheric ozone layer. To a great extent, it is the result of human activity.

The leading cause of ozone depletion has proven to be chlorofluorocarbons (commonly called CFCs), a family of human-made chemicals which, until recently, were commonly used in air conditioners, refrigerators, foams, solvents and other products. CFCs are very stable chemicals that do not break down in the lower atmosphere. When released, they drift up into the stratosphere where they are broken down by ultraviolet radiation. This releases the chlorine that destroys ozone. A single atom of chlorine can destroy 100,000 or more molecules of ozone. Ozone depletion only stops when the chlorine randomly reacts with another molecule to form a long-lived, stable substance. At that point it is no longer free to react with ozone.

Ozone-depleting substances containing chlorine include: chlorofluorocarbons (CFCs), carbon tetrachloride, methyl chloroform, and hydrochloro-fluorocarbons (HCFCs), all of which are human-made.

Halons, methyl bromide, and hydrobromo-fluorocarbons (HBFCs) are ozone-depleting substances that contain bromine, which is also destructive to ozone.

There is now a large concentration of CFCs and other ozone-destroying chemicals in the atmosphere, and some of them have life spans of 25 to 400 years. Almost all of the CFCs and halons ever released are still in the atmosphere and will continue to destroy ozone for many years to come. It is expected that the concentrations of chlorine and bromine in the stratosphere will continue to increase, reach a peak near the year 2000, and then slowly diminish. The fact that levels are expected to begin diminishing is a direct result of the phase-outs called for in the Montreal Protocol. Maximum ozone loss is expected to occur around the turn of the century.

Mounting evidence of a problem in the ozone layer

Ozone depletion was first hypothesized in 1974 by Doctors Mario Molina and F. Sherwood Rowland, two American scientists who were concerned about the impact of CFCs on the ozone layer. Their hypothesis about ozone depletion was first met with a great deal of skepticism. Over the following two decades, however, scientific discovery not only proved their hypothesis correct, it prompted almost every country in the world to action. In 1995, their contribution to solving a global environmental problem that could have catastrophic consequences was acknowledged with the award of the Nobel Prize in Chemistry to Rowland, Molina and a third ozone researcher, Paul Crutzen from the Netherlands.

The first real evidence of ozone depletion was reported in 1985 by the British Antarctic Survey team, which had been measuring the ozone layer over the South Pole for 18 years. Here they found a dramatic thinning in the ozone layer which developed every year from September to November. They determined that this "hole" first began forming in the mid-1970s. Since then, ozone concentrations in this area have grown steadily thinner, with depletions of up to 60 per cent occurring in recent years.

Why is ozone depletion most severe over the Earth's Poles?

While industrial chemicals are the primary cause of ozone depletion, the extreme cold and weather conditions of arctic winters contribute to its depletion. As the temperatures drop, ice clouds form in the upper atmosphere. These clouds provide a "spot" for a combination of chemicals and sunlight to react with CFCs, releasing the chlorine to attack ozone.

Atmospheric temperatures in the Arctic are not as cold as those in the Antarctic, so fewer ice clouds are formed. The Arctic atmosphere also exhibits more unstable circulation than the Antarctic. It is believed that these naturally occurring variations in climate account for the fact that levels of ozone depletion are lower in the northern hemisphere than they are in the southern hemisphere.

Smaller decreases in stratospheric ozone have also been observed in mid-latitude regions of the world. In early 1993, record low seasonal values were recorded over much of Canada. Total ozone concentrations fell by approximately 15 % of the pre-1980 average, and at some altitudes of the lower stratosphere a 30% decrease was observed. These record low concentrations appeared to be linked to aerosols injected into the atmosphere by the eruption of Mount Pinatubo in June of 1991. By 1994, ozone amounts over Canada had recovered to pre-Pinatubo levels, but still remained below the long-term averages recorded prior to 1980.[1]

[1] A State of the Environment Report - Understanding Atmospheric Change, A Survey of the Background Science and Implications of Climate Change and Ozone Depletion, Second Edition 1995, Henry Hengeveld, Atmospheric Environment Service, Environment Canada - July 1995

SOME COMMON QUESTIONS

What is the ozone hole?

Over the South Pole, a dramatic thinning of the ozone layer occurs from September to November each year. Although the thinning is quite severe — up to 60 per cent depletion in recent years — it is not actually a "hole" through the entire layer. This area of low concentrations in ozone or "hole" has been growing steadily and its edges now reach beyond the Antarctic continent to the tip of South America. Similar but less dramatic thinning of the ozone layer occurs over the North Pole each year as well.

Does ozone depletion cause global warming?

Ozone depletion and global warming are both mainly caused by changes in the atmosphere due to human activities. Global warming is due to the build-up of heat-trapping gases in the atmosphere and is not caused by ozone depletion. Some chemicals which deplete ozone, such as CFCs and halons, also trap heat in the atmosphere and contribute to global warming. However, ozone depletion actually causes cooling in the upper atmosphere, and this may partially offset the heat-trapping effect of some ozone-depleting substances. The net result of the heating and cooling caused by ODSs is the subject of current scientific investigation.

How do we know that ozone depletion isn't caused naturally?

While it's true that volcanoes and oceans release large amounts of chlorine, the chlorine from these sources dissolves in water so it washes out of the lower atmosphere in rain. CFCs do not dissolve in water and are not broken down in the lower atmosphere. Human-made molecules reach the stratosphere and then release chlorine and bromine. Measurements show that the increase in stratospheric chlorine since 1985 matches the amount of CFCs and other ozone-depleting substances released by human activities.

Do scientists agree on ozone depletion?

Yes. About 300 scientists from around the world worked on the WMO/UNEP Scientific Assessment of Ozone Depletion: 1994. An international consensus about the causes and effects of ozone depletion has emerged. There is still uncertainty on some issues (such as the exact chemical reactions taking place over the northern hemisphere) but most scientists agree that the main cause of ozone depletion is higher levels of chlorine and bromine in the upper atmosphere due to the release of ozone-depleting substances.

What is the difference between the ozone layer and ground-level ozone?

In the upper atmosphere, ozone has a positive effect by protecting the earth from ultra-violet radiation. However at ground level, ozone produced by human activities causes problems. On calm, hot days in the summer, vehicle exhaust, gasoline vapours and other air pollutants collect over urban areas and interact with UV-B radiation to form ground-level ozone. At ground-level, ozone can cause serious eye, nose and respiratory problems in humans and animals, damage plants, field crops, and forests; and cause detrimental effects to many materials.

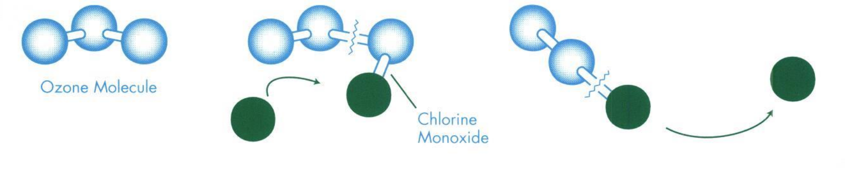
How ODSs destroy stratospheric ozone

Ozone is a molecule made of three oxygen atoms.

Chlorine atoms from CFCs attack the ozone, taking one oxygen atom away and forming chlorine monoxide.

The chlorine monoxide then combines with another oxygen atom, forming a new oxygen molecule and a chlorine atom.

The chlorine can go on to break apart thousands more ozone molecules.



EFFECTS OF OZONE DEPLETION

Stratospheric ozone depletion leads to an increase in the intensity of UV-B rays that reach the earth's surface, where they can disrupt important biological processes, damage a number of materials and affect air quality.

Ultraviolet radiation is divided into three categories of increasing energy: UV-A, UV-B, and UV-C. Almost all of the sun's UV-A rays reach the earth's surface. While both UV-A and UV-B can cause health problems such as skin cancer, premature aging of the skin, and cataracts, UV-A is a low-energy form of UV and has only minimal biological effects. It is the higher-energy UV-B which causes the most damage to living organisms and materials. Fortunately, most UV-B is filtered out by the ozone layer. UV-C, which is very harmful to living organisms, does not reach the earth's surface, as it is completely filtered out by the oxygen in the atmosphere. Some UV-B has always reached the earth's surface, even before evidence of ozone depletion was discovered in the late 1970s. The fact that UV-B can cause biological effects is well demonstrated by the familiar sunburn that follows excessive exposure to the sun. Laboratory and field experiments have shown that a wide variety of chemical and biological processes are affected by increased UV-B. For example, increased UV-B could speed up the formation of smog over urban areas.

Living organisms have adapted to UV-B radiation by developing defense mechanisms to protect themselves. The concern is whether these mechanisms will provide sufficient protection from the increases in UV-B that are anticipated as the result of ozone depletion.

Changes in ultraviolet radiation

In the 1994 Report of the United Nations Environment Program (UNEP) it was noted that decreases in global ozone measurements taken from satellites from 1979 to 1993 imply significant increases in UV-B radiation. Measurements in Argentina, Chile, New Zealand, and Australia showed relatively high UV levels when compared to northern hemispheric latitudes, and only small changes in UV levels in the tropics. Under current CFC phase-out schedules, UV levels are expected to peak around the turn of the century and then gradually decline over the next 50 years as chlorine loadings reduce in the stratosphere.[2]

Effects on human and animal health

The 1991 report of the United Nations Environmental Program (UNEP) Environmental Effects Assessment Panel predicted that a sustained 10-per-cent depletion of the ozone layer would lead to a 26-per-cent global increase in non-melanoma (non-fatal) skin cancer and could mean an additional 300,000 cases per year worldwide. The same amount of ozone depletion would be associated with over one million additional cases of cataracts per year worldwide.[3]

However, anticipated increases in health problems may well be offset by people taking action to protect themselves. In recent years, concern about ozone depletion and the introduction of UV information in weather reports has encouraged widespread public awareness of the issue. Scientists also suspect that increased exposure to UV-B radiation could affect the human immune system, possibly leading to an increase in infectious diseases and a decrease in the effectiveness of vaccinations. In areas of the world already facing high rates of disease, even small increases in UV-B radiation could have significant impact on human health.

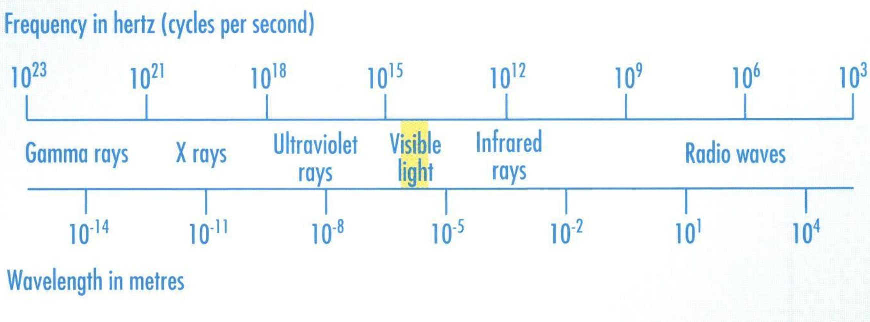
Many of the effects of increased exposure to UV-B radiation will undoubtedly be seen in animal populations around the world as well. Animals are at higher risk because they have limited ways to protect themselves from the increased UV-B radiation.

Effects on terrestrial plants and aquatic ecosystems

There are large differences in sensitivity to UV-B among plant species and even among varieties of the same species. Although scientific investigations are still in their early stages, studies have indicated that some plants would be affected by a sustained ozone loss of 15 to 20 per cent.

A six-year field study conducted in Maryland showed that the UV-B increases that would be associated with a 25 per cent stratospheric ozone loss, resulted in a 19 to 25 per cent soy bean yield loss in a sensitive variety. However, no change in yield was observed in a resistant variety.[4]

The electromagnetic spectrum



These results indicate that agriculture may have to adapt to increased UV-B for the next several years when ozone depletion is expected to be at a maximum. Forests and grasslands areas will also be subjected to increased levels of UV-B radiation; this could have an impact on the biodiversity of the planet.

While results from the study of tree species are limited, the indications of species- and variety-specific susceptibility are similar. However, the trees being planted now are the ones which will be affected. The problem here is that we do not have the opportunity to identify and plant resistant strains. UV-B seems to impact the early growth stages particularly. On older trees, the growing tips are most seriously affected before the bark is formed. Also, evidence indicates that UV-B damage can gradually accumulate over the years, leading to concerns for the health of long-lived species, such as trees.

More than 30% of the world's animal protein for human consumption comes from the sea. Field experiments conducted in Western Canada indicate that increased UV-B would lead to severe disruption of aquatic communities, including damage to bacteria, algae and zooplankton. [5]

These species form the bases of aquatic food chains.

Distribution of phytoplankton is not uniform throughout the world's oceans; the highest concentrations are found at northern latitudes. In the tropics and subtropics higher levels of solar UV-B radiation is thought to be one of the main causes of smaller populations of phytoplankton.

Solar UV-B radiation has been found to cause damage to early developmental stages of fish, shrimp, crab, amphibians, and sea animals. Even at current levels solar UV-B radiation is a limiting factor and even a small increase in UV-B exposure could result in significant reduction in the populations of consumer organisms.[6]

Effects on air quality

Reductions in stratospheric ozone allow higher levels of UV-B radiation to penetrate to the lower atmosphere, causing an increase in the chemical reactivity of several gases often found in the air that we breath. Pollutants, such as vehicle exhaust, gasoline vapours and industrial emissions interact with UV-B radiation increasing the production and destruction of ground level ozone and other oxidants such as hydrogen peroxide (H_2O_2). These gases are known to have adverse effects on human health, plants and outdoor materials; and are of particular concern in urban areas with high levels of air pollution.

Effects on materials

UV-B radiation can cause discolouration and loss of strength in wood and plastic materials. Increased levels of UV-B would mean these materials would require special treatment to reduce damage and more frequent replacement.

[2] Environmental Effects of Ozone Depletion: 1994 Assessment, United Nations Environment Program

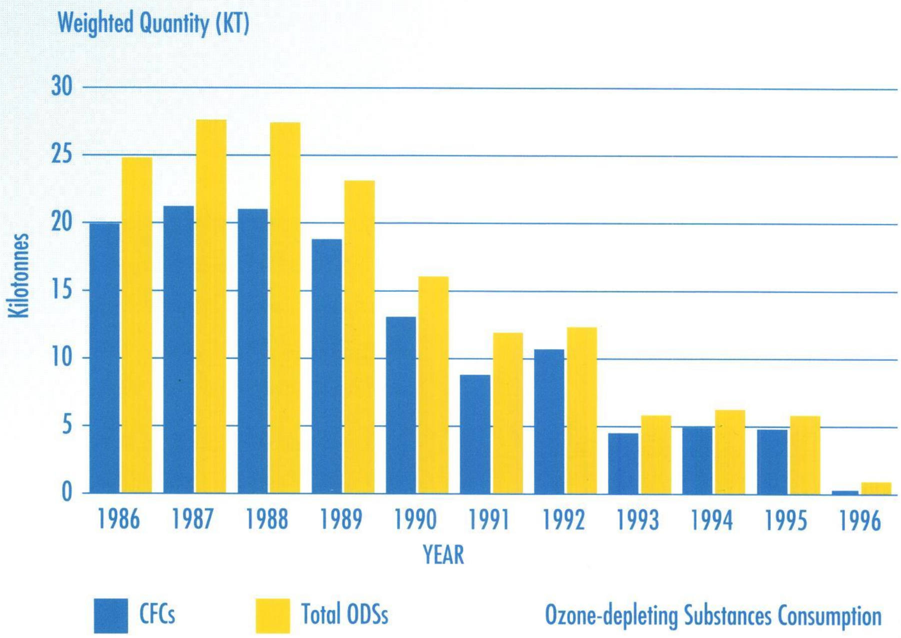
[3] Environmental Effects of Ozone Depletion: 1991 Update, Panel Report Pursuant to Article 6 of the Montreal Protocol on Substances that Deplete the Ozone Layer Under the Auspices of UNEP, November 1991.

[4] Teramura, A. H., J. H. Sullivan, and L. H. Ziska (1990b) "Interaction of elevated UV-B radiation and CO2 on productivity and photosynthetic characteristics in wheat, rice, and soybean", Plant Physiology 94:470-475.

[5] Bothwell, M. L., D. Sherbot, A. C. Roberge, R. J. Daley, "Influence of natural UV-radiation on lotic periphytic diatom community growth, biomass accrual and species composition: Short-term versus long-term effects", Journal of Phycology, 1993, vol.29, p.24-35.

[6] United Nations Environment Program, Environmental Effects of Ozone Depletion: 1994 Assessment, Pursuant to Article 6 of the Montreal Protocol.

Ozone-depleting Substances Consumption in Canada



NOTES:

1. Consumption = Production + Imports - Exports
2. Weighted Quantity = Actual Quantity x ODP (ozone-depleting potential)
3. CFC – Chlorofluorocarbons (CFC-11, 12, 113, 114 and 115)
4. Total – 1986 to 1990 data does not include HCFCs and methyl bromide.
5. Consumption for 1996 includes quantities used under essential use exemptions.

THE HISTORY OF DEVELOPMENTS ON THE OZONE ISSUE

1957

Global monitoring of the ozone layer begins in Canada and around the world, as a potential aid to weather forecasting.

1960

Canada takes responsibility for the World Ozone Data Centre — the global collection of data on the thickness of the ozone layer.

1974

American scientists Molina and Rowland hypothesize that CFCs may damage the ozone layer.

1977

The United Nations Environment Program (UNEP) establishes the Co-ordinating Committee on the Ozone Layer (CCOL). In May, the UNEP Governing Council adopts the World Plan of Action on the Ozone Layer.

LATE '70s/EARLY '80s

Some countries, including Canada, ban non-essential uses of CFCs as propellant in some aerosols (e.g. hair sprays, deodorants, anti-perspirants).

1981

UNEP initiates negotiations aimed at developing a global convention to protect the ozone layer and establishes a working group.

1985

International framework treaty: the Vienna Convention for the Protection of the Ozone Layer. British scientists first report the discovery of the Antarctic ozone hole.

1986

Canada becomes the first country to launch studies of the Arctic ozone layer. Canada is the first country to ratify the Vienna Convention (June 4).

1987

The Montreal Protocol on Substances that Deplete the Ozone Layer is signed in Canada by 24 countries, including Canada, on September 16.

1988

The Montreal Protocol is ratified by Canada on June 30.

1989

The Montreal Protocol comes into force on January 1. All Parties to the Protocol to freeze production and consumption of CFCs at 1986 levels, starting July 1.

1990

The London Amendment to the Montreal Protocol is adopted by the Second Meeting of the Parties to the Montreal Protocol held in London, England, on June 29. Canada is the first country to ratify the London Amendment to the Montreal Protocol (July 5).

1991

Scientists from around the world agree that CFCs are depleting the ozone layer in both the northern and southern hemispheres. The Third Meeting of the Parties to the Montreal Protocol is held in Nairobi, Kenya, in June.

1992

The Copenhagen Amendment to the Montreal Protocol is adopted by the Fourth Meeting of the Parties to the Montreal Protocol, held in Copenhagen, Denmark, in November.

1993

New Canadian ozone observatory is established in the high Arctic. The Fifth Meeting of the Parties to the Montreal Protocol is held in Bangkok, Thailand, in November.

1994

Canada ratifies the Copenhagen Amendment to the Montreal Protocol (March 18) The Sixth Meeting of the Parties to the Montreal Protocol is held in Nairobi, Kenya, in October.

The updated UNEP scientific assessment report reconfirmed the role of chlorine and bromine compounds in ozone depletion.

1995

The Seventh Meeting of the Parties to the Montreal Protocol is held in Vienna, Austria, in December. Ozone researchers Paul Crutzen from the Netherlands, and Americans Molina and Rowland receive the Nobel Prize in Chemistry.

1996

The Eighth Meeting of the Parties to the Montreal Protocol is held in San José, Costa Rica, in November.

1997

The Ninth Meeting of the Parties to the Montreal Protocol is hosted by Canada in Montreal, in September. This occasion marks the 10th anniversary of the signing of the Protocol.

THE MONTREAL PROTOCOL

For more than a decade, Canada has been at the forefront of international efforts to protect the ozone layer. Canada played a leading role in the development of the Montreal Protocol, which was signed on September 16, 1987, in Montreal, Quebec. The city was selected in recognition of Canada's instrumental role in bringing the Vienna Convention and the Protocol to fruition.

Since the early 1980s, Canada has been a strong proponent of the need for international controls on ozone-depleting substances. On June 4, 1986, Canada became the first country to sign the Vienna Convention. The Vienna Convention was a framework for controls development that also facilitated co-operation on research; the Protocol sets out the actual measures to implement controls on the production and consumption of ozone-depleting substances.

The Montreal Protocol is hailed as the first truly international effort to co-operate on protecting the environment. It is also the first international mechanism designed to address an arising global environmental problem.

The 1994 Report of the World Meteorological Organization — Scientific Assessment of Ozone Depletion — confirmed that the releases of several major ozone-depleting substances have slowed, demonstrating that the collective actions of the Parties of the Montreal Protocol are having a positive impact.[7]

[7] World Meteorological Organization Global Ozone Research and Monitoring Project - Report No. 37, Scientific Assessment of Ozone Depletion: 1994

Montreal Protocol phase-out schedule for ozone-depleting substances*

The focus of the Montreal Protocol is the control of production and consumption of bulk ODSs. (Consumption is defined as production + imports - exports)

HALONS

100% elimination by January 1, 1994**

CFCS, HBFCS, METHYL CHLOROFORM, CARBON TETRACHLORIDE

100% elimination by January 1, 1996**

HCFCS

Freeze consumption at base level beginning January 1, 1996

35% reduction of consumption by January 1, 2004

65% reduction of consumption by January 1, 2010

90% reduction of consumption by January 1, 2015

100% elimination by January 1, 2020 ***

METHYL BROMIDE

Freeze production and consumption beginning January 1, 1995 at 1991 levels****

25% reduction of production and consumption by January 1, 2001****

50% reduction of production and consumption by January 1, 2005****

100% elimination by January 1, 2010****

* Applicable to developed countries.

** Subject to the Essential Use Provision. A use qualifies as "essential" only if it is necessary for the health, safety or is critical to the functioning of society and there are no available technically and economically feasible alternatives or substitutes. Production and consumption of a controlled substance for an essential use will be permitted post-phase-out only if all economically feasible steps have been taken to minimize the essential use and associated emissions, and the substance is not available in sufficient quality or quantity from existing stocks of banked material. Parties are to nominate possible essential uses for evaluation. Recommendations arising from the evaluation process will be considered by a meeting of the Parties for a final decision.

*** Consumption for service of refrigeration and air-conditioning equipment up to 0.5% is allowed only until 2030.

**** Excluding quantities used for quarantine and pre-shipment applications.'

REVISING THE PROVISIONS OF THE PROTOCOL

The Montreal Protocol is science based and relies on UNEP Assessment Panels to guide its revisions. The provisions of the Protocol have been dramatically altered by subsequent meetings of the Parties to the agreement.

The First Meeting of the Parties to the Montreal Protocol took place in Helsinki, Finland, in 1989. Some countries agreed that CFCs should be phased out altogether by the year 2000.

The Second Meeting of the Parties was held in London, England, in June 1990. In addition to agreeing on tighter controls for CFCs and halons, the countries represented at that meeting agreed to amend the Protocol by adding carbon tetrachloride and methyl chloroform on the list of ozone-depleting substances, and placing controls on their production and consumption.

The Third Meeting took place in Nairobi, Kenya, in June 1991.

The Fourth Meeting of the Parties to the Montreal Protocol, held in Copenhagen, Denmark in November 1992, resulted in a further acceleration of the scheduled phase-out of several ozone-depleting substances. In addition, HCFCs, HBFCs, and methyl bromide were added to the list of substances subject to control, a definition of essential uses was agreed upon, and resolutions were adopted to encourage recovery, recycling, leakage control, and the destruction of ODSs.

The Fifth Meeting of the Parties was held in Bangkok, Thailand, in November 1993. Participants expanded the list of approved ODS destruction technologies. As well, the Parties agreed not to grant exemption for the production and consumption of halons on the basis of essential use. The agreement was reached because there are existing stocks of banked and recycled halons, and suitable alternatives to halons are available.

The Sixth Meeting took place in Nairobi, Kenya, in October 1994.

At the Seventh Meeting of the Parties held in Vienna, Austria, in December 1995, the countries represented agreed to adjust the Protocol to add a phase-out schedule for methyl bromide and to reduce the base level of HCFC consumption.

The Eighth Meeting of the Parties was held in San José, Costa Rica, in November 1996. The Parties agreed to replenish the Multilateral fund for 1997 to 1999, and actions were taken to improve financial and technology transfer mechanisms.

Special provisions

The Montreal Protocol is complex. It necessarily recognizes that the sources of the ozone-depletion problem and its impacts are dispersed around the globe. In an effort to be inclusive rather than exclusive, the Protocol contains a number of special provisions to respond to the specific circumstances of some countries (i.e. developing countries, countries with low production levels, and countries with different economic and political structures).

At the Second Meeting of the Parties to the Montreal Protocol, participants recognized that developing countries would need more than a little extra time in which to control their emissions of ozone-depleting substances. The Parties agreed to the establishment of a mechanism to provide financial and technological support to developing country Parties in order to help them comply with the provisions of the Protocol. A financial support mechanism called the Multilateral Fund now exists.

The Fund is financed by developed countries, with contributions from other sources including the United Nations Development Program (UNDP). Canada contributes approximately $5 million (US) per year to the Multilateral Fund, in addition to providing office space in Montreal for the Fund's International Secretariat. The Parties to the Montreal Protocol agreed to commit total contributions of $540 million (US) for 1997 to 1999. Replenishment of the Fund is periodically negotiated.

For the past four years, Environment Canada has been actively involved in providing assistance to selected developing countries (including Chile, China, Brazil, India, and Venezuela) through bilateral arrangements under the Multilateral Fund. Assistance includes both industry-to-industry and government-to-government training, and information exchange.

CANADIAN SCIENCE AND THE OZONE LAYER

Canada has a long and active history in ozone research that dates back to the 1930s when Canadian scientists began studying the upper atmosphere as a potential aid to weather forecasting.

Under the auspices of the United Nations World Meteorological Organization, Canada has operated the World Ozone and UV Data Centre, and published Ozone Data for the World since the 1950s.

Canada began monitoring ozone levels over Toronto in the late-1950s and currently has monitoring stations at Goose Bay, Labrador; Halifax, Nova Scotia; Montreal, Quebec; Toronto, Ontario; Alert and Resolute, Northwest Territories; Churchill and Winnipeg, Manitoba; Saskatoon and Regina, Saskatchewan; Edmonton, Alberta; and Saturna Island, British Columbia.

As well, the Government of Canada has strengthened Canadian ozone-depletion research efforts. This included the establishment of a permanent High Arctic Ozone Observatory on Ellesmere Island in 1993. The Arctic Observatory is part of Canada's contribution to domestic and international ozone research. The Observatory provides an increased understanding of Arctic ozone depletion and its influence on the ozone layer over the rest of Canada. The Observatory is also intended to create partnerships among Canadian universities and the international scientific community.

In addition to the Arctic Observatory, Canada is contributing to international research as a participant in joint research programs with the United States, Japan, Europe, and Russia.

In the spring of 1992, Environment Canada launched Ozone Watch, a weekly report to provide Canadians with the most up-to-date information on the status of the ozone layer. Later that year, in response to heightened concern among Canadians about the hazards of excessive exposure to the sun, Environment Canada launched its UV Index program, which provides daily information on the intensity of the sun's ultraviolet rays.

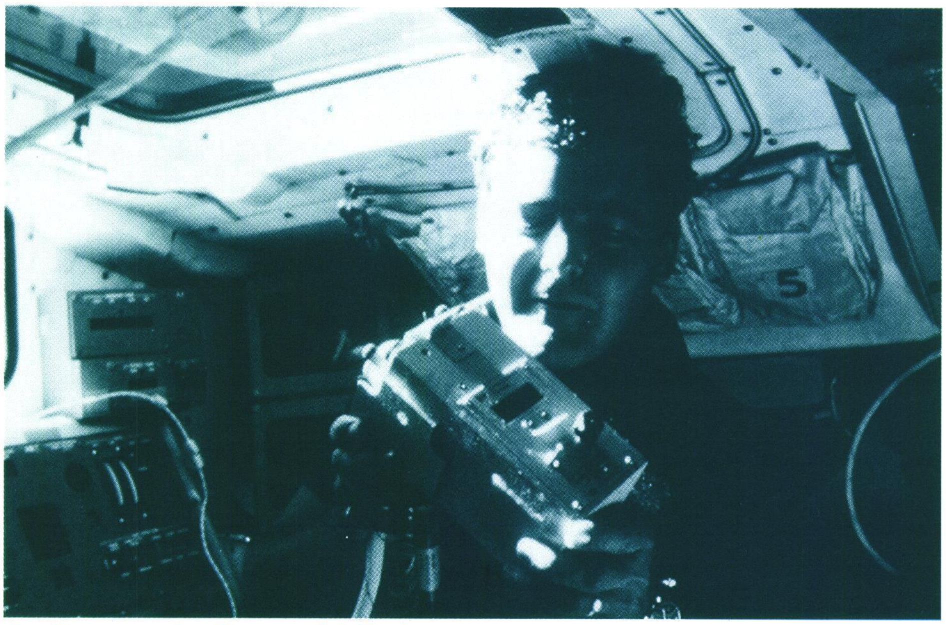


PHOTO: CANADIAN SPACE AGENCY

Canadian astronaut Marc Garneau with the Sunphotometer

In November 1993, Environment Canada released the results of a study which confirmed that the thinning of the stratospheric ozone layer in recent years has led to increases in ultraviolet (UV) levels at the earth's surface. Canada's long record of high-quality measurements of both ozone and UV contributed to the success of this study.[8]

Current research in Canada, Europe, and Australia has confirmed the importance of intermittent solar UV radiation as a risk factor for skin cancer. Studies have shown that high levels of intermittent UV-B exposure during childhood and adolescence can result in an elevated risk for malignant melanoma in later life. Canada's ozone watch and the UV index programs promote solar avoidance, especially for children.

Canadian scientists have made significant contributions to ozone research with the development of two ozone-measuring instruments: the Sunphotometer and the Brewer Ozone Spectrophotometer.

The Sunphotometer was developed by Environment Canada scientists to measure gases and haze in the atmosphere. It was first used by Canadian astronaut Marc Garneau on his historic space flight in 1984. An updated version of the instrument flew with astronaut Steve MacLean in 1992.

The Brewer Ozone Spectrophotometer was patented in 1986 by scientists with Environment Canada's Atmospheric Environment Service, and is the most practical and accurate ozone-measuring device available. Sci-Tech, a Saskatchewan company, has manufactured over 100 units of the Brewer which are being used in about 30 countries.

In Canada there is concern about the cumulative effects of increased UV-B radiation and the linkages with other atmospheric issues such as, climate change, acid rain, biodiversity, and toxic chemicals. To better understand the interaction and relative importance of atmospheric stressors, studies of UV-B impacts on Canadian ecosystems are integrated with existing ecological research, monitoring, and assessment programs. The impact of increased UV radiation on important species in agricultural, forestry, and freshwater and marine ecosystems, as well as certain materials, are being studied.

OZONE-DEPLETING SUBSTANCES

Research on the effects of ozone depletion includes a joint effort by the National Water Research Institute (NWRI) and the National Hydrology Research Institute (NHRI). The NWRI/NHRI UV-B Project is a six-year study to assess the impacts of increased UV-B radiation on aquatic ecosystems. One major goal of the study is to enable scientists to predict physiological as well as ecological responses to different levels of UV-B radiation. In response to the number and breadth of the effects of UV-B levels on aquatic chemistry, organisms, processes, communities and ecosystems, the research has become increasingly focused on the identification of opportunities to minimize or adapt to these impacts.

The National Research Council of Canada is actively engaged in researching and developing alternatives to CFCs.

In addition, applied research and development carried out by Canadian industry is credited with numerous technological innovations that are helping to achieve control of ozone-depleting substances at home and around the globe. (See "Success Stories" section)

[8] Kerr, J.B., C.T. McElroy, "Evidence for large upward trends of Ultraviolet B radiation linked to ozone depletion", Science, November 1993, vol. 262, page 1032.

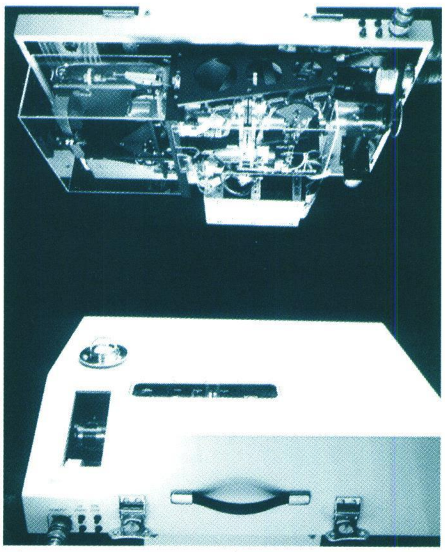


PHOTO: SCI-TECH INSTRUMENTS INC.

The Brewer Ozone Spectrophotometer

Most of the chemicals that destroy ozone share some common characteristics: they are stable compounds (i.e., they do not break down easily in the lower atmosphere) that contain either chlorine or bromine. Their ozone-depleting potential (ODP), however, varies according to each compound's specific chemical formula. (See the table on page 12.)

As a result of the implementation of the Montreal Protocol, the most damaging ozone-depleting substances (ODSs) are no longer manufactured in developed countries. (See "The Montreal Protocol".) Hydrochlorofluorocarbons (HCFCs) and methyl bromide are the only ones that are still manufactured in developed countries, but are scheduled for elimination.

The following is a description of the main ozone-depleting substances that have been targeted for elimination under the Montreal Protocol, the applications for which they were developed and the measures taken by Canada to control their use.

HCFCs

Except for a few Hydrochlorofluorocarbons (HCFCs) already in use in Canada — mainly used as refrigerants — most HCFCs have been developed for use as transitional chemicals to replace the more damaging ozone-depleting substances, mainly CFCs. HCFCs have only two to five per cent of the ozone-depleting potential of CFCs, which makes them a good temporary replacement for applications where alternatives completely safe for the ozone layer are not yet available.

Their main uses include foam blowing, refrigeration and air conditioning, solvent cleaning and, to a lesser extent, aerosols and fire protection.

Canada plans to limit HCFCs to use as substitutes for CFCs and other ODSs, eliminate non-recoverable uses by 2010, and to ban production for domestic use and importation by 2020 (except for 0.5 % for servicing of existing air conditioning and refrigeration equipment using HCFC-123. Phase-out of HCFC-123 is expected to occur by 2020-2030).

Canada's consumption of HCFCs increased from 3,700 metric tonnes in 1988 (just prior to the start of controls on consumption of CFCs) to 9,600 metric tonnes in 1996.

Methyl bromide

Methyl bromide (MeBr) is an important contributor to ozone depletion in the stratosphere. For this reason it has been listed for control under the Montreal Protocol. Methyl bromide is not manufactured in Canada, but is registered for use under the Pest Control Products Act. MeBr uses include soil fumigation and fumigation of some food production facilities. It is also used in some transportation and quarantine applications, related to the import and export of food and other agricultural products.

Methyl bromide has been the agricultural and structural fumigant of choice in the past for many applications. As a result, alternatives are often either not well known, developed, accepted or allowed by regulatory authorities. The importance of information to assist methyl bromide users, particularly in developing countries, to switch to methyl bromide alternatives can not be underestimated. Canada is playing a key role in the transfer of information to developing countries at the same time it is providing information to its own domestic producers and processors to reduce methyl bromide use and emissions.

Canada plans to phase out methyl bromide — simultaneous to the United State's phase-out — by 2001, except for certain critical uses, quarantines and pre-shipment applications. Consumption levels have been frozen at 1991 levels, and controls are in place to achieve a 25 per cent reduction by 1998. Canada has one of the most stringent methyl bromide control programs of the Parties to the Montreal Protocol. Canada's MeBr consumption was approximately 150 metric tonnes in 1996.

CFCs

Chlorofluorocarbons (CFCs) were first developed in the 1920s to replace sulphur dioxide as a coolant gas. In the 1930s they began to replace ammonia for cooling uses. Their non-toxicity, non-flammability, stability and heat-absorption effectiveness earned them early respect as wonder chemicals of the 20th Century. In the late 1940s they began to be used as the propellant in aerosols, a usage which escalated to a peak in the late 1970s. The applications of CFCs expanded to include the production of packaging, insulating and other foams. In the 1980s they were widely used as coolants in refrigerators and air conditioners, as solvents in degreasers and cleaners, as a diluent in sterilant gas mixtures, and as blowing agents in the production of foams.

When CFCs were identified as an ozone-depleting substance in the late 1970s, aerosols became the main target of public action. Canada's consumption of CFCs that year was approximately 20,000 metric tonnes, which represented two per cent of the world's total. Elimination of production and import of CFCs in Canada occurred on January 1, 1996. In 1997, small quantities of CFCs are still imported for the production of medical inhalers, as approved by the Montreal Protocol.

Halons

Halons are very effective for extinguishing fires. They do not leave a solid residue and are not a threat to people when used at the recommended concentrations. The combined characteristics of halons make them suitable for all types of fire-extinguishing equipment, ranging from industrial/commercial total-flooding equipment to the hand-held fire extinguishers popular for office and home use.

Although halons do not present a direct hazard to people, they have a very high ozone-depleting potential (ODP). In fact, halon 1301 — which is largely used in total-flooding systems — has the highest ODP of all known ozone-depleting substances (10 times greater than that of CFC-11).

Although Canada has never produced halons, they have been imported. Canadian halon imports peaked in 1988 at 792 metric tonnes. The importation of newly produced halons has been banned since January 1, 1994.

Carbon tetrachloride

The leading application of carbon tetrachloride in Canada was as a "chemical feedstock" (i.e., a basic ingredient) in the production of CFCs. As CFCs are no longer produced in Canada the major use of carbon tetrachloride has also been eliminated. Under the Montreal Protocol, small quantities of carbon tetrachloride can be used in laboratory applications where no appropriate alternatives exist.

Smaller quantities of carbon tetrachloride were used in fire extinguishers, as a dry cleaning agent, and as an ingredient in pesticides, pharmaceuticals, paints and solvents. Because of concerns with regard to its toxicity and human health, virtually all of these uses have ceased. Total elimination of production and import of carbon tetrachloride has been in place since January 1, 1995.

1,1,1-trichloroethane

1,1,1-trichloroethane, more commonly known as methyl chloroform, was popular because of its versatility and efficiency as a solvent in cleaners, degreasers and adhesives. It first appeared as a substitute for carbon tetrachloride in the mid-1950s, and by the 1980s was widely used by the electronics and equipment manufacturing industries. In 1987, Canada consumed approximately 16,000 metric tonnes of this solvent. The manufacture and importation of methyl chloroform was been banned since January 1, 1996. (except for small quantities still required for used in laboratory applications allowed by the Montreal Protocol.)

The ozone-depleting potential of the most common ODSs

CFC-11	1.0
CFC-12	1.0
CFC-113	0.8
CFC-114	1.0
CFC-115	0.6
Halon 1211	3.0
Halon 1301	10.0
Halon 2402	6.0
Carbon tetrachloride	1.1
Methyl chloroform	0.1
HCFC-22	0.055
HCFC-123	0.02
HCFC-141b	0.11
HCFC-142b	0.065
Methyl bromide	0.6

CANADA'S OZONE LAYER PROTECTION PROGRAM

After signing the Montreal Protocol in 1987, Canada began development of a control program to meet its new international commitments. At minimum, the program had to achieve the controls and timetable provided for in the Protocol.

Canada's timetable set target dates that exceeded the original requirements of the Montreal Protocol. At the Copenhagen Meeting of the Parties to the Montreal Protocol, an accelerated schedule for the phase-out of ozone-depleting substances was adopted, bringing the Protocol timetable more into line with the domestic targets established by Canada.

The Federal/Provincial Working Group

A Federal/Provincial Working Group on Controls Harmonization (Ozone-depleting Substances) was established in 1989. The Group's membership includes representatives from all provinces and both territories, as well as the federal government. The major focus of the Working Group has been to facilitate the introduction of harmonized regulations to reduce emissions of CFCs and other ozone-depleting substances. Differences in provincial regulations have occurred to some extent, partly as a result of different approaches and priorities. Because such differences can impact on the business community, the Working Group continues its efforts to improve regulatory effectiveness and harmonization. In addition, matters such as destruction, conversion and storage of ozone-depleting substances, and information exchange continue to be addressed by the Group. In 1995, the Working Group carried out consultations across Canada on strengthening the Canadian ozone layer protection program. Based on the results of the consultations, recommendations targeting the main areas of concern were submitted to the Canadian Council of Ministers of the Environment, which endorsed them at their meeting of May 1995.

The National Action Plan

Charged with developing a co-ordinated national strategy to eliminate emissions of ozone-depleting substances in Canada, and to harmonize the control measures taken by governments, the Working Group (lead by Environment Canada) prepared the National Action Plan for the Recovery, Recycling, and Reclamation of CFCs. It was endorsed by the Canadian Council of Ministers of the Environment in October 1992.

The National Action Plan is being revised to incorporate the recommendations of the Environment Canada 1995 report "Strengthening Canada's Ozone Layer Protection Program" and refocus the activities of the Federal Provincial Working Group. Its focus — originally set mainly on the recovery, recycling and reclamation of CFCs from refrigeration and air-conditioning systems — will encompass all aspects of pollution prevention and all industry sectors using ozone-depleting substances. The National Action Plan identifies the tasks necessary to ensure that harmonized, progressive actions take place to control all ozone-depleting substances.

Regulations and Programs

In Canada, the federal and provincial governments are responsible for regulating various aspects of ozone depleting substances in the country. Federal and provincial regulatory programs are complementary, and form an integral part of Canada's Ozone Layer Protection Program. The federal government is generally responsible for issues deemed to be in the national interest, and as such is responsible for implementing the provisions of the Montreal Protocol, including controls on the manufacture, import, and export of ODSs under the Canadian Environmental Protection Act. Provincial governments are responsible for the regulation of emissions and discharges to the environment, and govern the implementation of ODS recovery and recycling programs, and emission controls under provincial regulations.

Federal ODS regulations and codes of practice

Before drafting regulations, Environment Canada's practice is to meet and consult with affected industry stakeholders to discuss possible control measures, and the feasibility of various options including voluntary approaches, regulations, permit systems etc. In the case of ODSs, economic instruments in the form of transferable allowances and permits were agreed to be the most suitable control measure to ensure compliance with the Montreal Protocol. This approach allowed industry flexibility in the methods they could choose to eliminate the use of ODSs. Environment Canada found that industry's involvement in the decision making process was a key factor in the high rate of compliance with regulations.

Federal regulations are in place under the Canadian Environmental Protection Act. The *Ozone-depleting Substances Regulations* ensure Canada is in compliance with the Montreal Protocol regarding ODS consumption. Amendments are made as required to reflect changes in reduction and phase-out schedules adopted by the Parties to the Montreal Protocol. At present, only HCFCs and methyl bromide consumption is still allowed. Both substances are controlled under regulations by a system of allowances and permits that is similar to the systems that were used for other ozone-depleting substances before they were phased-out. The second Regulations, the *Ozone-depleting Substances Products Regulations*, deal with the control of certain manufactured products containing ODSs, such as small pressurized CFC containers, aerosols, and plastic foam food packaging.

Under the same Act, two Environmental Codes of Practice have also been developed. They serve as valuable references for both the private and public sectors, recommending practices for pollution prevention, emission reduction, environmental management and preventive maintenance. The *Environmental Code of Practice for the Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems* provides national guidelines for the reduction and eventual elimination of emissions of ODSs used in these systems. The Environmental *Code of Practice on Halons* provides direction to halon owners and users on managing halon stocks in a manner to reduce, and eventually eliminate, halon emissions to the atmosphere.

Provincial and municipal regulations

Provincial and municipal regulations have been developed to complement federal regulations. Most Canadian provinces have now implemented mandatory recovery and recycling of ozone-depleting substances legislation. Provincial regulatory requirements to minimize ODS emissions include proper labeling of equipment containing ODSs, training for equipment service providers, and methods to be used to install, remove, repair or service products containing an ODS. Provincial regulations also prohibit the recharging of leaking equipment, and products containing or made with ODSs. Many of the provincial regulations reference the "codes of practice", and make compliance with the codes mandatory under the law.

Several Canadian municipalities have also established ozone protection regulations. The city of Burnaby has passed by-laws mandating the recovery of CFCs and halons. Fines are assessed to individuals and

Training for recovery and recycling of refrigerants.

companies that ignore by-law provisions. The city of Montreal has developed a purchasing policy that mandates the use of alternative ozone-friendly products and technologies.

Training for recovery and recycling

One of the most important components of the National Action Plan is training for the people involved in the recovery and recycling of ozone-depleting substances. In consultation with the relevant service industry associations, and based on the original addition of the *Environmental Code of Practice for the Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems*, Environment Canada developed a training program for technicians involved in the servicing of refrigeration and air-conditioning equipment. When this report was last revised, approximately 75,550 servicing technicians had already taken this course. Canada's National Action Plan — especially its training component — can also be considered as a valuable product that Canada can export to the rest of the world.

Consultations

Stakeholder consultations began in 1987 and have become an ongoing part of Canada's Ozone Layer Protection Program. Constructive co-operation among government, industry, non-governmental organizations (NGOs), and scientists has allowed Canada to be a leader in the battle against ozone depletion. Industry has contributed important information about its patterns of use of ozone-depleting substances, and its perspective on the technical and economic implications of various proposed controls. This information was key to the development of Canada's regulations and position for negotiations under the Montreal Protocol. Canadian industries have been very proactive in responding to the threat to the earth's ozone-layer. Their participation in the consultations and involvement in the development of control programs has allowed Canada to meet objectives for reductions in ODSs well before target dates set by the Montreal Protocol. NGOs have also played an important role through research, education and advocacy activities.

As well, two multi-stakeholder groups have been formed, namely the Halon Roundtable and the Methyl Bromide Government/Industry Working Group. The groups exist to facilitate information exchange and discussion concerning these two specific sectors using ozone-depleting substances.

Halon Roundtable

The Halon Roundtable is a voluntary forum with representative from all major sectors of fire prevention and protection in Canada. Members include distributors, installers, and manufacturers of fire protection equipment, as well as certification agencies, legislators, environmental interest groups, and users. The Halons Roundtable met on several occasions during 1992 and 1993 to develop a system for management of halon inventories in Canada. Achievements included the development of requirements for servicing companies and the reconditioning of equipment; and the establishment of a Clearing House to track the movement of recycled halon in Canada.

Industry/Government Working Group on Methyl Bromide

A Methyl Bromide Working Group was established to provide a consultative forum where interested stakeholders such as growers, end users, fumigators, pesticide manufacturers, research organizations, and government and non-government organizations can discuss and provide strategic direction on effective implementation of Canada's program for the control of methyl bromide. The mandate of the group is also to identify priorities for research and registration of alternatives in each end use; discuss, review and make recommendations on the adoption of alternatives, including institutional barriers, if any, to such adoption; and to discuss opportunities for joint researching, demonstration and adoption of new alternative technologies. The Group is co-chaired by Agriculture Canada, Environment Canada, and an industry representative. This informal group acts as a supplement to - not a replacement for - other consultative mechanisms and related advisory bodies.

Information transfer and education programs

Environment Canada has undertaken information transfer and education programs as part of the effort to reduce consumption of ozone-depleting substances. For example, a three-stage communications program on the phase-out of methyl chloroform (MCF) was put in place in 1994 to alert users of MCF to the implications of the phase-out, and to facilitate the movement to alternatives. In addition, a list of alternatives and suppliers has been compiled, and is updated periodically to provide information and guidance to users of ozone-depleting substances looking for alternative substances or technologies.

An education initiative on the protection of the ozone layer has been undertaken by Environment Canada in partnership with the Knowledge of the Environment for Youth (KEY) Foundation. The initiative resulted in the development and implementation of teacher-friendly curriculum materials (manuals for students and teachers, as well as background material) for use in schools across Canada. The initiative is based on the recognition that Canada's education systems have an important role to play in encouraging appropriate actions and discouraging damaging behaviors.

International co-operation

Canada can be proud of its role in the effort to save the ozone layer, having played a leading role in negotiating the Protocol and being among the first to ratify the accord. Through its bilateral projects, it has also been successful in providing developing countries with the technology and expertise they need to comply with the Protocol.

Since the creation of the Multilateral Fund, Canada has participated in bilateral projects with several developing countries: Brazil, Chile, China, India, and Venezuela. Environment Canada, as lead agency, is responsible for negotiating, approving, and implementing these bilateral projects. These projects are considered highly desirable as they assist developing countries in meeting their phase-out schedules and consequently their commitments to the Protocol.

Environment Canada's Green Lane

Environment Canada is committed to providing the information necessary for Canadians to become better environmental citizens. One of the expressions of this commitment is Environment Canada's Green Lane.

The Green Lane is Environment Canada's home on the Internet's World Wide Web. The Green Lane has information ranging from documents on environmental issues to an up-to-date weather forecast for all regions of Canada. There is a section devoted to actions people can take to help the environment, and links to other World Wide Web sites concerned with the environment.

This report is one of the many Environment Canada publications now available on the Internet. You can visit the ozone site on the Green Lane at http://www.ec.gc.ca/ozone

What individuals can do to help protect the ozone layer

Individuals have an important role to play in protecting the ozone layer.

BUY OZONE-FRIENDLY PRODUCTS

Consumer pressure led industry to agree to a voluntary reduction of CFCs in spray cans during the 1970s. Look at the labels on products you buy. If they contain or were manufactured with an ODS, consider buying an alternative.

REFRIGERATORS

If your refrigerator or freezer needs to be repaired, make sure to call a certified technician who will recover and recycle the CFC coolants, instead of just replacing them. Make sure that old appliances containing CFCs are disposed of properly. Several municipalities have programs in place to recover refrigerant before disposing of appliances.

AUTOMOBILE AIR CONDITIONERS

Make sure your air conditioner is regularly serviced by a shop that captures and recycles the CFCs. If it requires major repairs, ask your garage if there is an approved retrofit procedure for converting to an alternative refrigerant that doesn't destroy ozone.

SUCCESS STORIES – FINDING ALTERNATIVES

Canada has reduced its use of ozone-depleting substances much faster than required under the Montreal Protocol or its own regulations. In no small part, this success is because industry — driven by consumer demand and the built-in incentives of economic savings and improved performance — is moving faster than laws require. Canadian businesses are among those that are setting the new standards for industry and regulation around the world.

Canadian businesses have also been able to benefit from the bilateral arrangements available under the Montreal Protocol Multilateral Fund. Bilateral arrangements made directly with developing countries are highly desirable because they help achieve the environmental objective of eliminating ozone-depleting substances, provide international leadership visibility for Canada and Canadian business, promote the development of Canadian environmental industries and spin-off business opportunities, and have no net cost (since Canada contributes to the Fund whether or not bilateral arrangements are negotiated).

The following are selected examples of Canadian companies and industry organizations that have taken up the challenge to protect the ozone layer.

Dow Chemical

Dow Chemical, once a major user of CFCs in Styrofoam insulation, made a switch to HCFCs in 1989, ten years ahead of the then-current Canadian CFC phase-out objective.

Dupont Canada

DuPont Canada, once the largest manufacturer of CFCs in Canada, shut down its CFC manufacturing facility in February 1993, almost three years before the revised phase-out date. The company currently manufactures HCFC-123 — a refrigerant that is 98-per-cent less ozone depleting than the refrigerant it replaces.v

The Heating, Refrigerating, and Air Conditioning Institute of Canada (HRAI)

In early 1990, **HRAI** - the national trade association of manufacturers, suppliers, wholesalers, and contractors in the Canadian heating, ventilation, air conditioning and refrigeration industry, along with Environment Canada began work on a joint initiative to develop a communication and training package for handling CFCs. This initiative was largely based on the HRAI Action Guideline for Reduction of Use of Controlled CFCs which was developed to change practices in the handling and use of chlorofluorocarbons (CFCs). HRAI contributed to the development of Environment Canada's *Environmental Code of Practice for the Reduction of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems.*

Recovery and recycling

In Atlantic Canada, reclamation of CFCs is no longer the expensive and complicated ordeal it once was for contractors servicing or disposing of equipment, thanks to **Refrigerant Services**. This new division of Climate Supply, a wholesale distributor of refrigeration and air-conditioning equipment, has been analyzing and reclaiming CFCs since 1994. Unlike American companies which sell recovery tanks to contractors, the Dartmouth company rents tanks to clients at a small cost. The tanks can be returned with any amount of refrigerant inside. The gas is processed to remove contaminants, certified, and then bottled for resale. To overcome the problem of cross-contamination frequently encountered when refrigerants are recovered, Refrigerant Services has also designed and built an innovative "separation machine", the only one of its type in North America able to separate CFCs economically. The company currently has a patent pending, and is planning to extend this service to other parts of Canada through wholesale distributors.

Blue Bottle®

The Blue Bottle® was first developed to collect medical refrigerant propellants, but has since found a number of additional uses in preventing the release of CFCs. **Cryo-Line Supplies** Inc. purchased the Licensed Technology for North America in 1996, and has since expanded the use of the product across Canada. To date, approximately 15% of the chiller installations in Canada now have Cryo-Line products as part of their containment strategy. The Blue Bottle® is also being used in the automotive industry, and by pharmaceutical companies to capture unused refrigerants in the manufacture and testing of "puffers". Some municipalities are also showing interest in the technology for the collection of refrigerants from household white goods prior to disposal or recycling.

Automotive air conditioning

In September 1992, **Chrysler Canada Ltd.** received the prestigious Environmental Protection Agency Stratospheric Ozone Protection Award for its leadership in eliminating chlorofluorocarbons (CFCs) from vehicle air conditioning systems and

Recovery of refrigerants from automotive air conditioning.

facility processes. Chrysler Canada began phase out of CFC refrigerants in August of 1992, and since 1995 all new vehicles produced by Chrysler have been completely CFC free.

The use of CFCs are also being eliminated from manufacturing processes at Chrysler. In 1992, Chrysler introduced the industry's first integrated rear-position child seat for its minivans, and built them with CFC-free polyurethane foam materials.

Chrysler is continuing to work with Federal governments and suppliers to find safe substitutes. Hydrofluorocarbon HFC-134 is a safe replacement for vehicle air conditioning refrigerants; however, since it is not a "drop-in' substitute, vehicle air conditioning systems have been redesigned.[9]

Commercial air conditioning

The **First Canadian Place** is a 3.5 million square foot shopping concourse and commercial office tower in downtown Toronto. The facility cooling plant includes nine chillers, ranging in capacity from 767 to 1340 tons, and are charged with 1600 to 2600 lbs of R-11.

With the advent of CFC phase-out and possible shortages of CFCs the management company responsible for the property was faced with a difficult situation. Costs to replace or retrofit the building's 9 chillers were beyond their budget limitations and available alternatives could not meet the buildings requirements.

Since existing equipment was performing well, and was leak-free with many years of useful service still remaining, the company decided to develop a comprehensive CFC management plan that included a strict preventive maintenance program. Units are inspected to identify potential leaks and upgraded as required. Chillers and CFC storage areas are routinely inspected using leak detection equipment, and a refrigerant accountability report is completed whenever refrigerant is added to a chiller. Purge units are set for manual operation, and recovery and recycling of all refrigerant is required during service and repair.

Extreme care and caution is necessary to achieve an effective conservation and compliance program; however, it can be an effective means to prevent releases of CFCs to the environment.[10]

While **Marks and Spencer Canada** stores carry a wide range of goods from clothing to groceries, 40 percent of their sales are in frozen foods. The company had 550 refrigeration units in its stores across Canada. Types of equipment varied with location and included portable units, roof-top compressor-run units, open-faced display units, and walk-in coolers. All contained refrigerant R502 - a mixture containing CFCs.

Many of the Marks and Spencer stores had experienced problems with equipment over the years and a number of the company's refrigeration units required replacement. The company worked with its supplier, Standard Mechanical, to consider available alternatives and eventually selected DuPont alternative HP-62 as the refrigerant of choice. Approximately 100 units were replaced annually over a five year period. Priority of replacement was determined by the age of the equipment and its operating and maintenance history. The new equipment installed has proven to be as reliable as the CFC units.

Due to the planned, proactive approach taken by Marks and Spencer, well in advance of the CFC phase-out in Canada, the company was able to integrate equipment replacement into their plans for store renovations and avoid the higher costs and shortages of CFCs and equipment that occurred later.[11]

Canadian flexible and rigid foam industries

In the mid 1980s, CFCs were in wide use in the production of flexible and rigid foams. With the signing of the Montreal Protocol and concerned with the state of the ozone layer, Canadian foam manufacturers moved quickly to find alternatives to the use of CFCs in their processes. Some were actively involved in the development of a UNEP Flexible and Rigid Foams Technical Options Report. Canadian foam product manufacturers have now eliminated the use of CFCs through a series of changes to product chemistry and manufacturing processes.

Lily Cup, a Canadian manufacturer of foam plastic food and beverage containers, switched from CFCs to carbon dioxide (CO_2), which is not ozone depleting.

Although CO_2 is a leading greenhouse gas, Lily Cup is using only recycled CO_2 - avoiding adding to either ozone depletion or the global climate change problem.

FOAMEX International, a manufacturer of flexible polyurethane foams used in furniture, bedding, carpet underlay and automotive applications, eliminated the use of 400,000 pounds of CFC-11 at the Toronto plant from 1987 to 1993. All products manufactured by FOAMEX are now CFC free. The plant manager at the time, Craig Barkhouse, was given a Stratospheric Ozone Protection Award by the U.S. Environmental Protection Agency in recognition of his work in reducing the use of CFCs within the industry.

CKF Inc., a Canadian company involved in the food service industry in the manufacture and distribution of both molded pulp fibre and expanded polystyrene foam containers, replaced CFC-12 as a blowing agent with HCFC-22 in late 1988 and finally to iso-butane by 1994. CKF Inc. no longer uses ozone depleting substances in their operations.

Phasing out cleaning uses of CFCs

Northern Telecom has set an example of the success that can be achieved with a commitment to phase out ozone-depleting substances. In 1987, Northern Telecom was the single largest Canadian user of solvents containing ozone-depleting compounds such as CFCs. Globally, the company used about one million kilograms annually to clean printed circuit boards after the component parts had been soldered on to the board. Northern Telecom pledged to eliminate the use of CFC solvents from all its operations by the end of 1991. The company worked with chemical manufacturers to find a formula for new flux compounds (used to clean the component parts before they are soldered) that leave only traces of residue on the circuit boards, eliminating the need for clean-up with solvents. The new "no-clean" formula is also cost effective. The company spent about $1 million on research and development between 1988 and 1991, and saved about $4 million over the same period on the costs of solvent purchase and disposal of used solvent, and through the elimination of a step in the manufacturing process. In 1989, Northern Telecom co-founded the Industry Co-operative for Ozone Layer Protection (now called the International Co-operative for Environmental Leadership), made up of multinational companies that have agreed to share information on the alternatives to ozone-depleting solvents. Sharing the new technology internationally has not only helped to reduce the use of ozone-depleting solvents, it also earned Northern Telecom the Financial Post 1993 Appropriate Technology Award.

Elimination of 1,1,1-trichloroethane as a mold release agent

As part of the ozone depleting substance phase-out program, **Ford Motor Company of Canada Limited** targeted 1,1,1-trichloroethane for phase-out as a mold release agent at all their casting operations. A project team including members of management, foremen, hourly personnel, and suppliers studied options for an alternate mold release agent to 1,1,1-trichloroethane. Various trials were performed and a water-based poly-siloxane emulsion, with no volatile organic compounds (VOCs) was chosen. In addition to preventing the release of an ozone depleting substance to the environment, air quality within the plants was improved because the new alternative did not contain VOCs and cost savings were realized because the new release agent is less expensive. 3,200 kg per year of 1,1,1-trichloroethane was eliminated from the Windsor Casting Plant, and similar substitutions have successfully been made at other Ford of Canada casting operations.[12]

Integrated pest management at the Quaker Oats Company of Canada

Quaker Oats is a cereal company with a strong environmental awareness. Long before the concern about methyl bromide surfaced, the philosophy at Quaker Oats Company of Canada was to use the lowest possible levels of any pesticide. Quaker's integrated pest management system is based on a comprehensive sanitation program and the use of heat treatments pioneered by the company to significantly reduce the use of methyl bromide.

Employees are trained to recognize pests, habitats, and pest conditions that lead to problems, and have the same level of awareness and concern for sanitation as they do for product quality. Routine cleaning regimes, and rigid supplier standards, receiving practices, employee training, as well as monitoring systems are used to effectively control pest problems.

Sanitation considerations are important factors in the design and purchase of equipment. New equipment for Quaker plants must withstand high temperatures or be mobile to facilitate sanitation measures. Heat treatments are conducted four to six times each year to control pests. The cereal plant is out of commission for 36 to 40 hours or about 8 to 12 hours less than with methyl bromide. As a result of effective sanitation and heat treatments, some sections of the Quaker cereal plant have not been chemically fumigated for years. In other sections, methyl bromide is now only used twice a year. A full description of the heat sterilization process has been published by K. Sheppard, in: "Insect Management and Food Storage and Processing", American Association of Cereal Chemists, 1994.[13]

Methyl bromide alternatives

Hedley Technologies Inc., and Agriculture and Agri-Food Canada (Winnipeg Research Centre) have conducted collaborative research in the development of alternatives to methyl bromide, a fumigant used to eliminate pests from crops and produce. One product of this research is a new formulation of diatomaceous earth called Protect-It™. Diatomaceous earth is a natural chalk-like substance composed of microscopic plant skeletons called diatoms. When pests come in contact with diatomaceous earth, they die from dehydration. Protect-It™ can be used to protect grain in storage from infestation. It can also be used as a structural insecticide for flour mills, food processing facilities, grain storage warehouses and transportation vessels.

In 1980, as the result of a successful demonstration project using predators for biological pest control in a commercial vegetable greenhouse, **Applied Bio-Nomics Ltd.** was formed to research, develop, and market live biological control agents. Over the past 13 years Applied Bio-Nomics has pioneered the commercial use of biological controls in western Canada where more then 98% of commercial cucumber and tomato greenhouses now use predator insects to control pests. Approximately 20 species of predators are commercially available for use in Canada. The effectiveness and the value of these predators makes the use of pesticides very infrequent. Pesticides, such as methyl bromide, are only used in response to an extreme problem.

Bromosorb® Technology System

Knowzone Solutions Inc. of Canada has recently acquired the rights to the Bromosorb® Technology to capture and recycle methyl bromide. Methyl bromide can be captured from structures, commodity fumigation chambers or soil beds, then recycled for later use. The equipment uses a zeolite adsorbent to capture the methyl bromide after a fumigation. Only a small fraction of the methyl bromide used in fumigation is consumed by the commodity or its containers; most is available for capture and recycling. After capture, the methyl bromide is recycled by heating the zeolite, releasing the compound for either reuse for another fumigation or capture in containers for later use.

Fire-Scope 2000

Fire-Scope 2000 was developed by **Securiplex Inc.** of Dorval, Quebec as an environmentally friendly alternative to conventional total flooding systems using Halon, CO_2, or chemical-based systems. This new technology uses water combined with compressed air or nitrogen to produce a fine spray of water to rapidly extinguish intense fires with very limited amounts of water. The effect of the combined air and water pressures improves the penetrating capability of the water spray — an essential element for effective fire suppression — and prevents re-ignition because of its high performance cooling characteristics. The company also offers extinguishing systems that use a mixture of argon and nitrogen where the use of water, foam or dry powder may have a harmful effect - such as the protection of computer cabinets and electrical enclosures.

Hospital developed a systematic approach to CFC phase-out

Early in 1995, **Chedoke-McMaster Hospital** in Hamilton, Ontario switched to a new non-CFC sterilization system to replace their existing 12/88 CFC-EtO Unit.

Chedoke-McMaster Hospital is a 660-bed full-service hospital. Following the development of federal and provincial ODS regulations, the hospital initiated a process to phase-out the use of CFC Sterilants. Data was collected on the operating costs of the CFC system to compare potential equipment alternatives identified through literature searches, supplier information, and the experiences of other hospitals. Comparisons were made on equipment size and capacity; cycle time, pressure, temperature; operating costs, capital costs; biological indicators for validation; occupational health and safety issues; residuals; aeration required; accessories; limitations; in-service/training; regulatory requirements; and availability. Possible options were narrowed to two pieces of equipment, both of which were equally suitable. The final choice was the Johnson and Johnson Sterrad System.

The new system was found to have a user-friendly design and was easily installed with little labor required or disruption to the hospital's operations. A two-day training workshop was provided by the supplier for two hospital employees, and a representative of Johnson and Johnson was present on-site for the first two weeks of operation to ensure a smooth transition to the new system. Since implementation, no technical or performance problems have been noted. Hospital staff emphasize that effective equipment selection requires a thorough and systematic analysis of alternatives to ensure that the most appropriate equipment is selected to suit the needs of the facility.[14]

Asthma inhalers and the environment

There are over one million asthma suffers in Canada. Conventional asthma drugs have been administered through chlorofluorocarbon (CFC)-based metered dose inhalers (MDI). CFCs are released into the atmosphere when the inhaler is produced and when it is used. A number of alternative asthma products are now being marketed in Canada that have distinct environmental advantages over conventional asthma products.

The Diskhaler® (Glaxo), the Rotohaler® (Glaxo), and the Turbuhaler® (Astra) are all CFC-free MDIs. In addition to the environmental advantages, these dry inhalers are considered to be more effective in administering asthma therapy. The new generation dry powder delivery systems, such as the Turbuhaler® manufactured by Astra Canada, administer therapy without the use of carriers, propellants and other additives that can cause side effects in patients. CFC propellants used to produce the pressure that creates the aerosol in conventional asthma products are inhaled into the lungs as vapor and liquid droplets and can cause bronchoconstriction and cough. Studies have shown that patients using the new Turbuhaler® exhibited fewer coughs and have fewer problems with activation and inhalation than with the previous (CFC)-based metered dose inhalers.[15]

3M Canada responded to the Montreal Protocol by using its expertise in fluorochemical technology to create a CFC-free alternative for use in industry. After screening over one hundred potential substances with regard to physical, chemical and environmental properties, 3M's team of scientists developed - 3M™ HFE (Hydrofluoroether) fluids. These new products were introduced to the market in May 1996, and have been listed as " acceptable without restrictions" by the U.S. Environmental Protection Agency and have been approved for use in Japan, Canada, and Europe. Hydrofluoroalkanes (HFAs) have been approved in 35 countries as a propellant for common asthma medications and are now used in more than half the metered dose inhalers used globally.

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CANADIAN BILATERAL PROJECTS

Halon use reduction and bank management in Venezuela

Traditional North American suppliers of halons to Venezuela ceased production at the end of 1993. Venezuela realized that with assistance this posed an opportunity to phase-out imports rather than establishing supply relationships with new suppliers. Responding to Venezuela's request, Canada provided bilateral assistance in implementing a halon 1301 use reduction and bank management program.

Taylor/Wagner, Canadian fire-protection consultants, developed a complete halon program in co-operation with the Fondo Venezolano de Reconversión Industrial y Tecnología (FONDOIN). The program included the creation of an advisory committee, changes to fire codes and technical standards, training of engineers, and workshops for all major halon use sectors. Thanks to both Taylor/ Wagner and FONDOIN's excellent work, the program has been so successful that Venezuela no longer needs to import newly produced halons.

Halon recovery and reconditioning equipment was provided by Control Fire Systems of Canada. The equipment is operated by a Venezuelan fire equipment company selected by FONDOIN and the Fire Equipment Trade Association of Venezuela. FONDOIN and the fire equipment industry have entered into an agreement to allow all fire equipment companies and halon owners in Venezuela have access to this service.

Workshops on ODS reduction in India

Environment Canada, in collaboration with the Confederation of Indian Industry (CII) and the United Nations Environment Program (UNEP), hosted three ozone-depleting substances (ODSs) reduction workshops in India. The workshops targeted small and medium-size enterprises, and were held in Delhi, Madras, and Mumbai. The workshops focused on the refrigeration and air conditioning, foams, and aerosols sectors. Representatives of Canadian companies gave sector-specific presentations on existing alternative technologies.

For more information on bilaterals provided by Canada please see the booklet *' Montreal Protocol, Business Opportunities'*.

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GLOSSARY OF ACRONYMS AND TERMS

ACRONYMS

CFCS

Chlorofluorocarbons — stable chemicals containing chlorine and fluorine.

HBFCS

Hydrobromofluorocarbons — chemicals containing chlorine, fluorine, bromine and hydrogen that were never commercialized in Canada.

HCFCS

Hydrochlorofluorocarbons — chemicals containing chlorine and fluorine that also contain hydrogen; therefore making them less stable and less damaging to the ozone layer than CFCs.

HFCS

Hydrofluorocarbons — chemicals with fluorine and hydrogen, but no chlorine or bromine. They do not damage the ozone layer.

MB

Methyl bromide — a pesticide containing bromine which contributes to ozone depletion.

MCF

Methyl chloroform — a chlorine-containing chemical used for metal cleaning and in other solvents.

ODP

Ozone-depleting potential — a measure of the capability of a particular chemical to destroy ozone, measured against CFC-11 which has an ozone-depleting potential of 1.

ODSS

Ozone-depleting substances — chemicals that damage the ozone layer. UNEP United Nations Environment Program.

UNDP

United Nations Development Program.

UV

Ultraviolet radiation — natural radiation from the sun, which can be damaging to living organisms in high doses. An intact ozone layer screens out most UV radiation before it reaches the earth's surface.

WMO

World Meteorological Organization.

TERMS

CHEMICAL FEEDSTOCK

A basic chemical ingredient in the manufacture of other chemicals.

CONTROLLED SUBSTANCES

The ozone-depleting substances scheduled for reduction and elimination under the provisions of the Montreal Protocol.

HALONS

Bromofluorocarbons — stable, gaseous chemicals containing bromine and fluorine used for extinguishing fires. (Halon 1211 also contains chlorine.)

HARMONIZATION

Process of ensuring that all provincial and federal regulations and controls are consistent and not conflicting.

MELANOMA

A type of skin cancer which (depending on which layer of skin is affected and when treatment is provided) can either be cured or is fatal.

PHOTOCHEMICAL REACTION

A chemical reaction in which light plays an integral part.

RETROFIT

Upgrading of existing equipment or facilities (e.g., to allow the use of another chemical).

TRANSITIONAL SUBSTANCE

A chemical which can replace a controlled substance and reduce impact on the ozone layer, but which, for some reason (e.g., toxicity or ozone-depleting potential), is not ideal and is therefore considered a temporary solution.

Disclaimer

Although a number of companies and specific technologies are discussed in this publication, their mention does not constitute an endorsement by the Government of Canada. Nor is the Success Stories section reviewing the contributions of Canadian industry to reducing ozone loss intended to be exhaustive. Environment Canada encourages all Canadians to work toward eliminating their use of ozone-depleting substances.