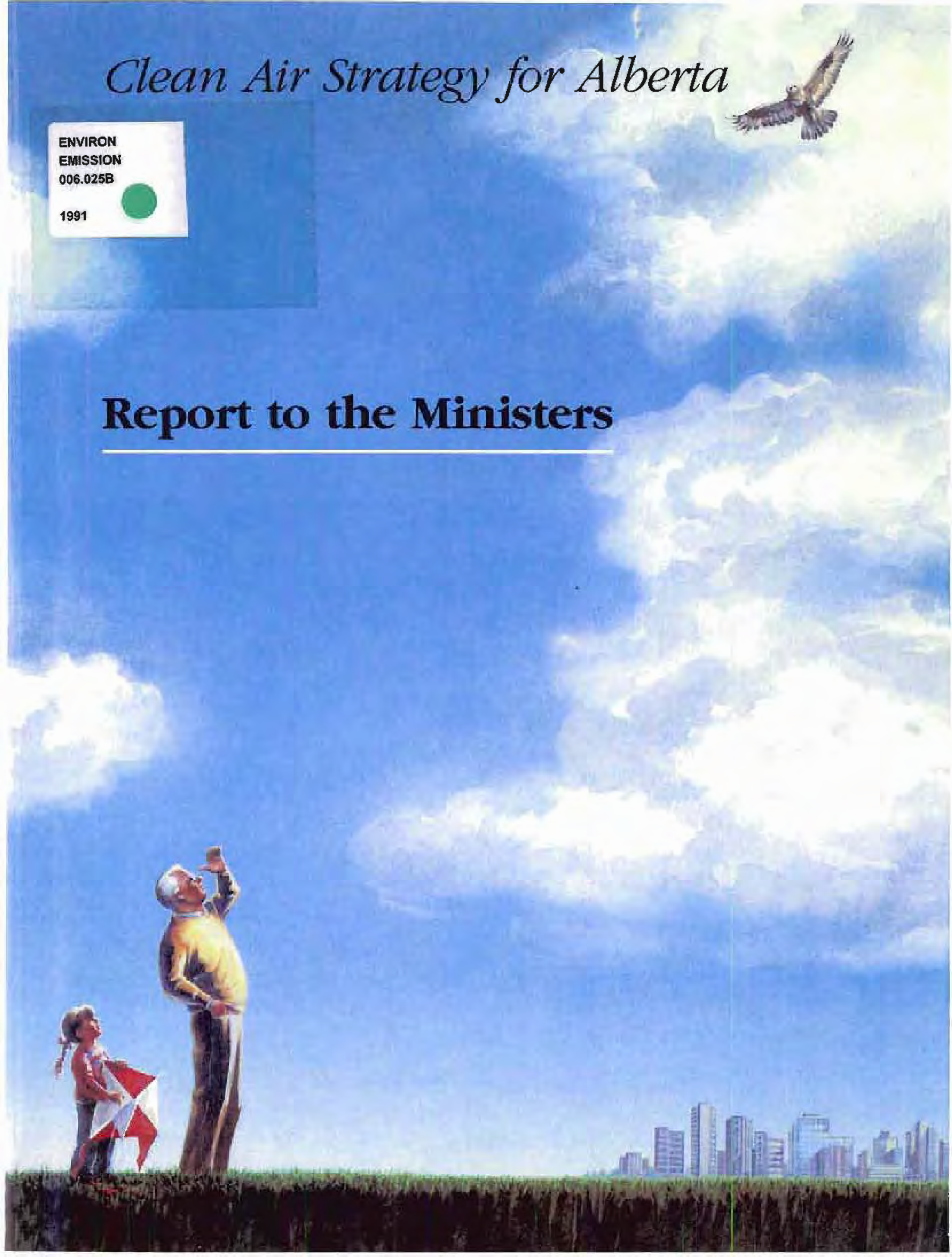
Clean Air Strategy for Alberta

Report to the Ministers



Clean Air Strategy for Alberta

Report to the Ministers

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This *Report to the Ministers* is the culmination of the Clean Air Strategy for Alberta public consultation program. It was to identify and clarify the most important issues regarding energy-related emissions and to outline practical and achievable actions that can be taken by consumers and producers to reduce emissions. A multi-stakeholder advisory group guided the consultation program and the development of this document.

ISBN 0-86499-871-6
Pub. No. I/437
November 1991

Other related publications include the three-volume *Report on the Regional Sessions*:

- ▲ Volume I is the *Moderator's Report* (ISBN 0-86499-830-9, Pub. No. I/416, 1990-91);
- ▲ Volume II is the *Verbatim Transcript* of the public meetings (ISBN 0-86499-831-7, Pub. No. I/417, 1990-91); and
- ▲ Volume III is in two parts and contains the *Written Submissions* (ISBN 0-86499-832-5, Pub. No. I/418, 1990-91).

Report to the Ministers and *Report on the Regional Sessions — Volume I: Moderator's Report* have wide circulation and may be obtained at the address below. Volumes II and III of *Report on the Regional Sessions* are on file at many public libraries for public access and for inter-library loan.

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The Clean Air Strategy for Alberta was announced by Alberta's Ministers of Energy and Environment on March 15, 1990 to encourage public discussion in Alberta on air emissions resulting from the production and use of energy. The initiative was in response to continuing national and international discussions on the impact of fossil fuels on global warming, acid deposition and smog. These concerns are of particular significance for an energy-producing province like Alberta.

Purpose

The Clean Air Strategy for Alberta consultation program had three objectives:

(1) to help identify and clarify the most important issues associated with energy production and use, which need to be addressed in developing a clean air strategy;

(2) to outline practical and achievable actions which can be taken by consumers and producers to reduce emissions; and

(3) to develop policy and program recommendations to present to the provincial government.

Process

The consultation program included: an Issues and Options Workshop involving representatives from major stakeholder groups; Regional Sessions in eight Alberta centres (including written submissions and a schools program); a Summary Workshop; culminating in this *Report to the Ministers*.

This *Report to the Ministers* integrates the many discussions, findings and conclusions of the Issues and Options Workshop and the Regional Sessions, and the background research conducted as part of this process, and has the endorsement of the participants at the Summary Workshop. The *Report* incorporates valuable information provided by the many Albertans who participated in the Clean Air Strategy for Alberta and, while the process has required some interpretation, the *Report* reflects the balance, intent and tone of the discussions. It is noteworthy that while the *Report to the Ministers* incorporates ideas and suggestions put forward by Albertans, it can only begin to capture the thoughtful comments and conversations, and the positive feelings of accomplishment, promise and purpose that participants carried away from the various discussions throughout the process.

New Challenges

The consultation program and background information (Chapters 1-4) identified that Alberta is facing several air quality management challenges:

- ▲ There is a need for a more comprehensive system for managing air quality.
- ▲ Local air quality issues and problems need to be addressed as a priority.
- ▲ Cumulative regional emissions and impacts need to be addressed.
- ▲ A strong commitment to cost-effectiveness and flexibility is needed.
- ▲ Scientific and economic uncertainties need to be addressed.
- ▲ Alberta needs to develop a position on current and anticipated commitments by the federal government to reduce or stabilize emissions.
- ▲ Albertans will need to understand the required commitment and be willing to make necessary lifestyle changes.

Strategic Framework

To respond to the challenges facing Alberta, the Clean Air Strategy for Alberta chose an approach that outlines a prudent yet practical framework for decision-making, rather than attempting to resolve the issues. The framework provides a vision for clean air in Alberta. It states:

The air will be odourless, tasteless, look clear and have no measurable short- or long-term adverse effects on people, animals or the environment.

The vision provides the basis for the development of a mission statement which is as follows:

Alberta's Clean Air Strategy is to provide guidelines for the management of emissions from human activity and encourage appropriate life-styles so as to protect human health and ecological integrity within a provincial, national and international context.

The strategy will be comprehensive but flexible and, through an ongoing consultative process, will employ a wide range of mechanisms available for implementing the strategy, including public education, market-based approaches, legislation, regulation, and research and development.

Beliefs and values that form the philosophical basis for the strategy are also presented in the *Report*. They address concepts of fairness and style of decision-making; protection of human health, environmental quality and economic viability; and outline Albertans' responsibilities to the international community and future generations. Principles to translate the mission statement and beliefs and values into decisions and behaviours are also presented as a basis for planning.

Goals

The following goals have been developed to address the New Challenges (Chapter 5) for air quality management in Alberta and are based on the Strategic Framework (Chapter 6):

Goal A
Implement a comprehensive air quality management system in Alberta that allows for identification of problems, prioritization of issues, allocation of resources, development of action plans and is based on full multi-stakeholder involvement.

Goal B
Identify, evaluate and implement legislative and regulatory opportunities for energy efficiency and conservation.

Goal C
Identify, evaluate and implement cost-effective energy conservation and efficiency opportunities.

Goal D
Identify, promote and implement cost-effective energy developments that contribute to clean air.

Goal E
Strengthen the management approach for all point-source emissions in Alberta in order to avoid adverse effects on human health and the environment.

Goal F
Identify and evaluate a range of options available for managing point-source emissions to encourage greater innovation, improved environmental protection and cost-effectiveness.

Goal G
Develop and implement a zone approach to managing air quality within specific airsheds.

Goal H
Develop innovative and targeted solutions to better manage cumulative emissions in and around urban areas.

Goal I
Manage emissions within western Canada to address regional air quality problems.

Goal J
Encourage collaboration between the provinces and the federal government to pursue actions that are cost-effective and ensure maximum flexibility in addressing national and international air quality issues.

Goal K
Improve the gathering, sharing, integration and application of scientific and technical knowledge and research regarding atmospheric processes and effects on health and ecosystems.

Goal L
Improve public awareness of air quality and enhance the public's capability of making choices and commitment to change through environmental education.

Goal M
Integrate clean air goals into the provincial economic development strategy.

Objectives and Tasks

For each goal, specific objectives and tasks which include responsibilities and timelines, are provided. These are provided as steps toward a new approach to clean air in Alberta. It is recognized that the goals and objectives need to be implemented in the context of the management framework to meet Alberta's long-term decision-making requirements. There is broad-based support that these are goals and objectives that recognize both the opportunities and uncertainties, and provide the basis for management of air quality now and into the future. Priority objectives and tasks are indicated by a star in the *Report*.

Recommendations

The Clean Air Strategy for Alberta recommends, as a priority, that the Government of Alberta:

1) endorse Goal A and implement the associated objectives and tasks which include:

▲ establish a formal structure, which includes an ongoing multi-stakeholder clean air advisory committee, to guide the implementation of goals, objectives and tasks, and to ensure continuing cooperation and consultation between government and interested and affected parties for air quality management in Alberta;

▲ incorporate the recommended decision-making process, outlined in the comprehensive air quality management system, as part of the terms of reference for the new clean air advisory committee; and

▲ broaden the Clean Air Strategy for Alberta to examine air quality issues that were not in the original terms of reference (such as air toxics) and to address those industrial sectors that were not a part of the energy related consultations program (such as agriculture and forestry).

2) endorse Goals B through M as presented in the *Report to the Ministers*; and

3) begin implementing those objectives and tasks which have been identified as priorities (indicated with a star).

Details regarding the recommendations are in Chapters 5 to 7 (blue-edged pages). Background information and the rationale for the need for immediate action are provided in Chapters 1 to 4.

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Acknowledgements

The Clean Air Strategy for Alberta *Report to the Ministers* has been prepared with the assistance of a multi-stakeholder consultation process involving many individuals and organizations. The participation and information provided throughout the process — through the Issues and Options Workshop, the Regional Sessions, the written submissions and the Summary Workshop — all helped in the development of this document.

The contributions of many others were also invaluable throughout the process. The efforts of those who chaired the sessions, made contributions to the background documents and provided assistance in developing this document are greatly valued. The following deserve special mention: Tee Guidotti and Allan Legge who co-chaired the clean air definition group; Vern Millard and Kate Hoos who were instrumental in the delivery of the Regional Sessions; Marianne English, Ken Charters, Abbas Naini and Bob Myrick who helped to develop some of the technical portions of this document; and Gord Lambert, Phil Lulman and Jim Swiss who assisted throughout.

Others who have contributed are too numerous to mention. However, all share the belief that designing a new air quality management system for Alberta must be based on a willingness and ability to define problems common throughout the province, and to develop mutually agreed-upon solutions.

Clean Air Strategy for Alberta

November 15, 1991

Hon. Rick Orman
Minister of Energy
Government of Alberta

Hon. Ralph Klein
Minister of Environment
Government of Alberta

Dear Sirs:

We are pleased to submit our report on a Clean Air Strategy for Alberta. The report is the culmination of one and one-half years of work by the Advisory Group and many others. The *Report to the Ministers* identifies and clarifies the most important issues regarding energy-related emissions and outlines practical and achievable actions that can be taken by consumers and producers to address present and emerging air quality problems.

Public discussion and involvement guided the development of this Clean Air Strategy for Alberta. Public input was encouraged through a broad-based consultative process including two major workshops, regional sessions in eight Alberta centres and consensus building among the organizations represented on the Advisory Group.

The strategy in this *Report to the Ministers* has received wide support from the organizations represented on the Advisory Group and from other Albertans. In particular, the Clean Air Strategy for Alberta recommends, as a priority, that the Government of Alberta:

1) endorse Goal A and implement the associated objectives and tasks which include:

   - establish a formal structure which includes an ongoing multi-stakeholder clean air advisory committee, to guide the implentation of goals, objectives and tasks, and to ensure continuing cooperation and consultation between government and interested and affected parties for air quality management in Alberta;

   - incorporate the recommended decision-making process, outlined in the comprehensive air quality management system, as part of the terms of reference for the new clean air advisory committee; and

   - broaden the Clean Air Strategy for Alberta to examine air quality issues that were not in the original terms of reference (such as air toxics) and to address those industrial sectors that were not a part of the energy-related consultation program (such as agriculture and forestry).

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Alberta ENERGY

Alberta ENVIRONMENT

2) endorse Goals B through M as presented in the *Report to the Ministers*; and

3) begin implementing those objectives and tasks which have been identified as priorities (indicated with a star).

Thank you for the opportunity to have participated in the Clean Air Strategy for Alberta, an initiative we believe is vitally important to all Albertans.

Sincerely,

Bill Anderson
Independent Petroleum Association

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Alberta Environmental Network: Energy/Clean Air Caucus

Nick Bayliss
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David Powell
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INTRODUCTION

Albertans have a strong interest in protecting their environment, now and for future generations. For this reason, the province has been a leader in setting objectives for air and water quality, and land use.

Alberta is the largest producer of hydrocarbon energy resources (i.e. oil, gas and coal) in Canada. The energy industry is a major part of the provincial economy and contributes significantly to the economic well-being of Albertans and Canadians. There are growing concerns, however, both in Canada and worldwide, about the environmental impacts of emissions resulting from the production and use of fossil fuels. The concerns focus on three main areas: acid deposition (acid rain), smog and the greenhouse effect (global warming). Given the energy industry's important role in the economy of Alberta and Canada, these concerns have special significance for Albertans. Consequently, on March 15, 1990, the Alberta government announced a broadly based, public consultation process called the Clean Air Strategy for Alberta.

The purpose of the Clean Air Strategy for Alberta is to develop a strategic plan to achieve clean air, through public discussion on atmospheric emissions resulting from the production and use of energy in Alberta.

The Clean Air Strategy for Alberta has three objectives. These are:

(1) to help identify and clarify the most important issues associated with energy production and use, which need to be addressed in developing a clean air strategy;

(2) to outline practical and achievable actions that can be taken by consumers and producers to reduce emissions; and

(3) to develop policy and program recommendations to present to the provincial government.

To help ensure there is broad-based input from Albertans, and to make certain the public consultation process is effective, a 13-member Advisory Group was established. The Advisory Group comprises representatives from environmental groups, local governments, public health organizations, the native community, the energy, chemical and utilities industries, and provincial government departments. This group is responsible for advising on the consultation process, reviewing and commenting on information materials developed for the Clean Air Strategy for Alberta, and facilitating communications between the Advisory Group and the organizations represented. As well, the Advisory Group has been responsible for guiding the development of this document.

The focus of the Clean Air Strategy for Alberta is on three energy-related air quality issues: acid deposition, smog and global warming. The depletion of the stratospheric ozone layer by chlorofluorocarbons and halons was included for information purposes, although these emissions are not generally associated with energy production, transmission or use.

With respect to global warming, the Clean Air Strategy for Alberta has not addressed forest practices and the use of forests as sinks for carbon dioxide; agricultural practices, impacts and adaptation responses; and other industry and human practices. Estimating these activities and outcomes will be difficult because of the uncertainty regarding what changes will occur globally and the effects in a given region such as Alberta. Additional efforts are necessary for a more complete understanding of these issues before meaningful discussion can occur.

Airborne toxics were not part of the terms of reference of the Clean Air Strategy for Alberta, and therefore were not discussed. Recognizing the significance to human health of these emissions, it is proposed by the Clean Air Strategy for Alberta that these be addressed in a subsequent program. As well, indoor air quality was not addressed as part of the Clean Air Strategy for Alberta.

The Clean Air Strategy for Alberta was carried out in four phases and sought input from both the general public and individuals with specialized knowledge in these matters. To allow adequate time for participation, the consultation process extended from September 1990 to October 1991.

Phase One: Issues and Options Workshop — Participants representing various stakeholder groups addressed the identification of issues associated with energy-related emissions, areas of uncertainty, short- and long-term priorities, options, and suggested areas requiring more information and research. Four major questions emerged:

(1) What is clean air and how do we know when we achieve it?

(2) How do Albertans include economic, environmental and health considerations in decisions regarding clean air?

(3) What can be done to help individual Albertans make responsible choices?

(4) How will Alberta's strategy relate to other provinces and countries?

Additional details are given in the report *Workshop One: Identifying Issues and Options*. Eight information-gathering projects were undertaken in response to needs identified in the workshop. The findings of these projects are contained in *Background Project Reports* (Attachment A) and cover the following topics:

- A Definition of Clean Air
- Full-Cost Accounting
- Market-Based Approaches to Managing Air Emission in Alberta
- Natural Gas and Electric Utility Incentives
- Energy Efficiency Legislation in Alberta and other Jurisdictions
- Inventory of Transportation Initiatives
- Coordination of Science and Technology Relevant to Clean Air Issues
- Energy and Environmental Education Initiatives

Phase Two: Regional Sessions — Albertans had the opportunity to ask questions about clean air issues, present their views and recommend options for action at eight locations in Alberta during November and December 1990. This information was compiled in *The Report on the Regional Sessions — Volume I: Moderator's Report* which is Attachment B. It addresses:

(1) the air quality problems identified in the submissions;

(2) options for reducing emissions; and

(3) suggestions for managing air quality.

Volume One also outlines principles for setting objectives and developing approaches for action. The moderator of the sessions concluded that, "The regional sessions suggest the greatest challenge to implementing an effective clean air strategy is to ensure Albertans understand the required commitment and are willing to make the necessary changes."

Phase Three: Summary Workshop — The workshop was attended by representatives of various stakeholder groups to review and discuss recommendations for implementation of the strategy.

Phase Four: Final Report — The *Report to the Ministers* is based on the findings, conclusions and recommendations of the Issues and Options Workshop, the Regional Sessions and the Summary Workshop. It presents the recommendations of the Clean Air Strategy to the Ministers of Energy and Environment for consideration by Cabinet, and encourages the Alberta government to adopt a pro-active plan of action. A Glossary is included in the *Report* to clarify terms and provide easy reference for defining acronyms.

1.0 EMISSIONS AND THEIR EFFECTS

Energy-related gaseous emissions can lead to acid deposition (acid rain), which causes damage to lakes and soil, and smog (ground-level ozone), which in turn can damage vegetation and cause health problems. There is growing evidence that energy-related emissions can also add to a build-up of heat in the earth's atmosphere and contribute to what is called the greenhouse effect.

Sulphur oxides (SO_X), and nitrogen oxides (NO_X) are chief contributors to acid deposition. Smog is caused mainly by nitrogen oxides and volatile organic compounds (VOCs) interacting with ground-level ozone (O_3). Carbon dioxide, (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), and chlorofluorocarbons (CFCs) and halons are greenhouse gases that contribute to the greenhouse effect.

One region's emissions may seem small, but when combined with emissions from all other regions, the total may be quite large. Table 1-1 shows Canada's and Alberta's contributions to the global emission burden.

Table 1-1. Global, national and provincial emissions (kilotonnes) in 1985

	Global	Canada	**Alberta**
SO_2	37 073 *	3 704	**539**
NO_X	32 224 *	1 887	**440**
VOCs	29 049 *	1 782	**196**
CO_2	21 630 000	538 400	**124 300**
CFCs	660	20	**2**

* Only countries belonging to the Organization for Economic Cooperation and Development (OECD).

Source: *OECD Environmental Data, Compendium 1989*. Organization for Economic Cooperation and Development, 1989.

According to the 1990 Canadian Long Range Transport of Air Pollutants (LRTAP) Assessment Report:

"There is a broad range of health responses associated with exposure to air pollution ranging from the immediate such as aggravation of asthma and hospital admissions, to long-term responses such as chronic lung disease, i.e. bronchitis. Subtle changes in respiratory health can be ascertained using indicators like decreased lung function, decreases in the rates at which inhaled particles are removed from the upper respiratory tract surfaces, and alterations in biochemical and immunological indices. Studies have reported changes in the connecting airways of rabbits which are thought to directly relate to the types of changes that are thought to cause bronchitis after exposure to sulphuric acid mist at concentrations as low as 250 ug/m^3. Slowing of the clearance of particles out of the lung might well lead to increased infection, and longer times for particles to have adverse effects on airway tissue. Acute effects of sulphuric acid on humans are usually more pronounced in asthmatics, and occur rarely below 400 ug/m^3. Effects in normal adults have not been seen below about 900 ug/m^3.

"A recent study in Canada observed small decrements in children's lung function which occurred during times of high air pollution. Acid levels reached a maximum of about 50 ug/m^3, and ozone levels were as high as 143 ppb. In two other Canadian studies comparing respiratory health in a region of Canada which experiences high levels of LRTAP, with a region experiencing very low levels of LRTAP, an average 2% decrement in children's lung function was observed in the more polluted region. Children in the more polluted area also had a higher incidence of upper respiratory infections. It is believed that the observed difference is likely due to the coexistence of acidic aerosols and other pollutants, i.e. O_3, SO_2."

1.1 Sulphur Oxides

Sulphur dioxide (SO_2) is a colourless gas with a pungent, irritating odour and taste and is highly soluble in water. Sulphur dioxide can harm crops and trees, textiles, building materials, animals and people as a result of exposure to long-term low concentrations or short-term high concentrations. Sulphur dioxide is a major contributor to acid deposition; its effects on lakes and forests, crops, materials and buildings have been documented worldwide.

Long-term exposure to acid deposition can increase the acidity of lakes and streams, which in turn can affect or kill living creatures that drink or live in these waters. Acid deposition causes metals to leach from soil; sometimes these metals accumulate to reach toxic levels in water and enter the food chain. Acid deposition can also affect agricultural crops directly or indirectly by reducing soil fertility. Forest growth can be retarded, and leaves and needles damaged. Acid deposition also affects buildings, eroding stone, brick and concrete and corroding metal. The crumbling of the Parthenon in Greece is a well-known example.

Sulphur oxides combine with other substances in the air to produce a haze that reduces visibility. The acidic particles transported in weather systems not only reduce visibility, but can irritate the throat and lungs and, if inhaled, can damage the respiratory system, impair lung function and affect breathing.

Crop effects, according to the world literature review prepared by the Alberta Acid Deposition Research Program, are as follows:

"Low concentration SO_2 exposures can cause an increase in growth and yield in plants growing in sulphur deficient soils. Several studies, however, have shown significant decreases in growth and yield due to SO_2 . . . . Red clover is the most sensitive Alberta species followed by winter grains, wheat, and rye; next in sensitivity are other grains, barley, spring wheat, and oats; at the less sensitive end of the scale is alfalfa; the least sensitive of the species studied is canola. Alfalfa has been determined by other investigators to be very sensitive to SO_2. Perennial grasses are more sensitive to SO_2 than alfalfa. Annual grasses seem to be significantly less sensitive to SO_2 than alfalfa.

"Forage, grain, and grass species can be ranked for relative sensitivities as follows:

clover > winter grains > spring grains > alfalfa > canola

and

winter grains > alfalfa > other grasses

"Exposure to simulated strongly acidic precipitation resulted in reduced yields in 14 out of 19 species reviewed in this report. There were no field surveys found that documented a reduction in yield due to ambient acidic wet deposition. The mechanisms by which acidic precipitation inhibits plant growth, or alters plant form, are not known; foliar injury has not been directly correlated, nor have short-term changes in soil conditions been identified. Root growth tended to be inhibited more than did shoot growth, i.e. there tended to be an increase in the shoot to root ratio.

"In general, dicots were more likely to show inhibited growth than were monocots. No experiments reported an inhibition of growth, for any species, above pH 4.0. The groups of crops more susceptible to reductions in yield were root, cole, leafy, tuber, legume, fruit, grain, seed forage, and leafy forage crops, arranged in descending order of sensitivity. Below pH 3.5, there is a yield loss of 5 percent per drop in pH unit.

"The formation, development, and survival of pods, flowers and fruits are sensitive to acid rain at moderately low pHs (below pH 4.0). Pollen viability appears to be more sensitive in herbaceous species than in woody species, but data are inconclusive. Acidic wet deposition may interfere with anthesis, fertilization, and fruit set, development and maturation, as well as seed germination and seedling emergence. In perennial species, acidic wet deposition may have cumulative effects on fruiting. For flowering plants, the brief bloom period is very vulnerable to external influences, and may coincide with seasons of high acidity rainfall.

"Foliar damage resulting from exposure to simulated acidic wet deposition has been experimentally shown to lower marketable yield of truck crops, lower plant resistance to pathogens, and has been linked with reduced plant productivity.

The threshold for foliar injury from simulated acidic wet deposition was between pH 3.0 and 3.5 for the 36 crop species reviewed. The groups of crops most susceptible to visible injury were, from most to least susceptible, root, leafy, cole, legume, fruit, grain, and leafy and seed forage crops, respectively. The potential for economic loss was greatest for leafy, cole, and fruit crops. Monocots, such as wheat, barley, and timothy, were resistant to foliar injury above pH 2.5. There is a low risk of foliar injury to field grown vegetation from exposure to current ambient levels of acidity; however, increased emissions may pose a risk to sensitive plants and plant communities.

"Most nutrients are leached from foliage faster as the acidity of precipitation increases, as are some organic compounds. Changes in carbohydrate and protein content of feed crops are of widespread economic concern, as well as indications of significant physiological responses of plants to acidic wet deposition."

1.2 Nitrogen Oxides, Volatile Organic Compounds and Ozone

Nitrogen oxides (NO_X) are also an important contributor to acid deposition. About 30 per cent of the acidity of rain in the Eastern United States is due to nitrogen oxides. Nitric oxide (NO) has no colour, odour or taste and by itself is a non-toxic gas; however, it is readily converted in air to nitrogen dioxide (NO_2). Nitrogen dioxide is a reddish-brown gas with a pungent, irritating odour. At high concentrations, nitrogen dioxide is potentially toxic to plants, can injure leaves and reduce growth and yield. In combination with either ozone (O_3) or sulphur dioxide, nitrogen dioxide may cause injury at even lower concentration levels. As one of the components of smog, nitrogen dioxide is known to irritate the lungs and increase susceptibility to respiratory infections. Nitrous oxide (N_2O) is a greenhouse gas. As well, it contributes to ozone depletion in the stratosphere.

Chemicals containing hydrogen, carbon and possibly other elements that evaporate easily (with the exception of methane) are known as volatile organic compounds (VOCs). Many individual volatile organic compounds are known or suspected of having direct toxic effects on humans ranging from causing cancer to damaging the nervous system.

The Canadian Council of Ministers of the Environment (CCME) Management Plan for NO_x/VOC identified the following significant impacts:

(a) Health Effects

"Elevated ozone levels have been shown to cause adverse effects on human health. Human health effects include immediate, short-term changes in lung function and increased respiratory symptoms such as cough and pain on deep breathing. Studies of healthy individuals in controlled chambers show that exposure to ozone results in a decrement in lung function and causes respiratory symptoms at concentrations as low as 0.12 ppm if moderate to heavy exercise is taken for a period of several hours. Prolonged exposure (for up to 6.5 hours) to ozone concentrations in the range of 0.08 to 0.12 ppm show progressively larger lung function decrements as duration of exposure at moderate exercise levels increases. Studies in which exercising adults and children were observed in the natural summer atmosphere (containing ozone, sulphates and H_2SO_4) indicate that induced decrements are slightly larger than those obtained in chamber experiments where only ozone was present. Even though lung function decrements are transient (i.e. the effect disappears following the termination of ozone exposure) it is the opinion of most health professionals that these decrements do represent an adverse health effect. Epidemiological studies have established correlations of ambient air ozone concentrations with hospital admissions for acute respiratory diseases.

"Ozone is strongly suspected of playing a role in the long-term development of chronic lung diseases. While not dismissing the short-term effects of ozone, many health professionals appear to be more concerned that repeated exposure to ozone over a lifetime may result in permanent impairment of the lung. New epidemiologic research suggests that accelerated rates of decline of lung function with aging occur among residents of communities with high ozone concentrations. Clinical studies of humans have recently shown that prolonged exposure to low ozone concentrations results in progressively larger changes in respiratory function and symptoms with time. Animal studies have shown that prolonged ozone exposure can cause biochemical and structural injury to the lung. Some of these changes are suspected of playing a role in the development of chronic lung disease, although inherent uncertainties in extrapolating from animal data make it difficult to assess human risk from these studies. Current consensus in the U.S. is that chronic exposure to existing ozone concentrations is an important health issue and will be carefully considered during the review of the current primary ozone standard.

(b) Vegetation Effects

"The effects of ozone on vegetation have been well documented. Vegetation damage is usually in the form of foliar injury which reduces productivity. It is estimated that at many locations throughout the southern and eastern halves of the United States, rural ozone concentrations are high enough to reduce yields of economically important crops by 1 to 20 percent compared to yields that would be expected if ozone concentrations were at natural background levels. The most heavily affected crops include soybeans, wheat, cotton, and some types of produce. Agricultural benefits of about $2 billion would be anticipated in the U.S. if rural ozone concentrations could be reduced by 25 percent.

"Most Canadian research has focused on ozone injury to crops in southern Ontario, where the highest growing season ozone levels occur. Ozone sensitive crops in this area include beans, tomatoes, tobacco, potatoes, corn, soybeans, and wheat. It is estimated that the combined losses in

Ground-level ozone (also a major contributor to smog) is produced in the lower atmosphere from photochemical reactions involving volatile organic compounds and nitrogen oxides, often called ozone precursor substances. Because these reactions depend on both sunlight and temperature, ozone concentrations tend to be highest on hot, sunny days. A number of highly toxic air pollutants can also be formed during the photochemical reactions, leading to ground-level ozone formation. Depending on atmospheric conditions and pollutant mix, major cities can act as either generators or sinks for ozone. With the movement of these pollutants downwind, the potential for ozone elevation or suppression is extended considerable distances.

1.3 Carbon Dioxide and Methane

Carbon dioxide (CO_2) is a colourless, odourless, non-toxic gas. Carbon dioxide is produced when any substance containing carbon is burned. Plants absorb carbon dioxide through photosynthesis, and plants and microorganisms in the soil return some carbon dioxide to the atmosphere through respiration. Carbon dioxide can be captured and used to make dry ice and carbonated soft drinks. Methane (CH_4) is also a colourless, odourless, non-toxic gas which is a major constituent of natural gas. Increased emission levels of emissions of these gases from human activity, as well as several

crop production and revenues to ornamental plant growers in southern Ontario from ozone is $17 to $70 million per year, depending on the frequency of ozone episodes.

"Ozone causes foliar injury and reduced growth rates in sensitive trees of several species. Exposure to ozone can lead to increased susceptibility to diseases and other stresses, increased mortality of individual trees, and eventually to overall decline of affected species. All of these effects of exposure to ozone have been observed in forests in the mountains bordering the Los Angeles basin. Ozone damage has also been observed in ponderosa and Jeffrey pine at other locations in California. With regards to forests in eastern North America, both the extent of forest decline and causal mechanism remain controversial, although ozone has been suggested as a causal or contributing agent in reported decline of red spruce, yellow pine and sugar maple. Given the general air quality in eastern North America, which includes a mix of wet and dry deposited pollutants, it is suggested that air pollution stress has become an important factor influencing the growth of sensitive tree species."

The Intergovernmental Panel on Climate Change (IPCC), which was established in the fall of 1988 under the auspices of the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO), set up three working groups to develop an international consensus on, respectively, the science, the impacts, and potential response strategies with respect to climate change. IPCC in its Climate Change, The IPCC Scientific Assessment report said:

"We are certain of the following:

• there is a natural greenhouse effect which already keeps the Earth warmer than it would otherwise be.

• emissions resulting from human activities are substantially increasing the atmospheric concentrations of the greenhouse gases: carbon dioxide, methane, chlorofluorocarbons (CFCs) and nitrous oxide. These increases will enhance the greenhouse effect, resulting on average in an additional warming of the Earth's surface. The main greenhouse gas, water vapour, will increase in response to greenhouse effect and further enhance it.

"We calculate with confidence that:

• some gases are potentially more effective than others at changing climate, and their relative effectiveness can be estimated. Carbon dioxide has been responsible for over half the enhanced greenhouse effect in the past, and is likely to remain so in the future.

• atmospheric concentrations of the long-lived gases (carbon dioxide, nitrous oxide and the CFCs) adjust only slowly to changes in emissions. Continued emissions of these gases at present rates would commit us to increased concentrations for centuries ahead. The longer emissions continue to increase at present day rates, the greater reductions would have to be for concentrations to stabilise at a given level.

• the long-lived gases would require immediate reductions in emissions from human activities of over 60 percent to stabilise their concentrations at today's levels; methane would require a 15-20 percent reduction.

"Based on current model results, we predict:

• under the IPCC Business-as-Usual (Scenario A) emissions of greenhouse gases, a rate of increase of global mean temperature during the next century of other greenhouse gases such as nitrous oxide, ground-level ozone, CFCs and even water vapour, are increasing the amount of heat trapped in the atmosphere. However, the magnitude and timing of this greenhouse effect, and the impact of atmospheric change on the climate of countries and regions, is uncertain.

The World Health Organization (WHO) summarizes the potential health impacts of the greenhouse effect as being many and varied, ranging from direct effects of stress and heat/humidity to indirect effects on nutritional requirements, food production, and the increasing the potential for vectors of communicable diseases. WHO states that humans can deal with wide extremes of environmental variations much better than any other species, and can live in virtually every climate on earth as long as there exists a growing season long enough to provide food. When climate affects a population, individuals with low capacity for adapting to change will suffer first, with stress being relatively high because of their higher vulnerability or reduced resistance capacity. Climatic stress becomes a risk factor specifically for individuals with failing functions of the cardiovascular, respiratory, renal, endocrine and immune systems; those with underdeveloped regulatory systems such as infants and children; or those with reduced gross regulatory functions, such as the elderly and physically handicapped.

Famines and food shortages may result from a number of factors such as changes in the composition of vegetation, soil

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about 0.3°C per decade (with an uncertainty range of 0.2°C to 0.5°C per decade); this is greater than that seen over the past 10,000 years. This will result in a likely increase in global mean temperature of about 1°C above the present value by 2025 and 3°C before the end of the next century. This rise will not be steady because of the influence of other factors.

• under the other IPCC emission scenarios which assume progressively increasing levels of controls, rates of increase in global mean temperature of about 0.2°C per decade (Scenario B), just above 0.1°C per decade (Scenario C) and about 0.1°C per decade (Scenario D).

• that land surfaces warm more rapidly than the ocean, the high northern latitudes warm more than the global mean in winter.

• regional climate changes different from the global mean, although our confidence in the prediction of the detail of regional changes is low. For example, temperature increases in Southern Europe and central North America are predicted to be higher than the global mean, accompanied on average by reduced summer precipitation and soil moisture. There are less consistent predictions for the tropics and the Southern Hemisphere.

• under the IPCC Business-as-Usual emission scenario, an average rate of global mean sea level rise of about 6 cm per decade over the next century (with an uncertainty of 3 – 10 cm per decade), mainly due to thermal expansion of the oceans and the melting of some land ice. The predicted rise is about 20 cm in global mean sea level by 2030, and 65 cm by the end of the next century. There will be significant regional variations . . . .

. . . "Our judgement is that:

• Global — mean surface air temperature has increased by 0.3°C to 0.6°C over the last 100 years, with the five global-average warmest years being in the 1980s. Over the same period global sea level has increased by 10-20 cm. These increases have not been smooth with time, nor uniform over the globe.

• The size of this warming is broadly consistent with predictions of climate models, but it is also of the same magnitude as natural climate variability. Thus the observed increase could be largely due to this natural variability; alternatively this variability and other human factors could have offset a still larger human-induced greenhouse warming. The unequivocal detection of the enhanced greenhouse effect from observations is not likely for a decade or more.

• There is no firm evidence that climate has become more variable over the last few decades. However, with an increase in the mean temperature, episodes of high temperatures will most likely become more frequent in the future, and cold episodes less frequent.

• Ecosystems affect climate, and will be affected by a changing climate and by increasing carbon dioxide concentrations. Rapid changes in climate will change the composition of ecosystems; some species will benefit while others will be unable to migrate or adapt fast enough and may become extinct. Enhanced levels of carbon dioxide may increase productivity and efficiency of water use of vegetation. The effect of warming on biological processes, although poorly understood, may increase the atmospheric concentrations of natural greenhouse gases . . ."

acidity and erosion, altered habitat for pests of all kinds and salt water intrusion (from elevated sea levels). Starvation and malnutrition could occur on an unprecedented scale. These occurrences could lead to great increases in the migration of "ecological refugees" (who now number in the many millions). Such climatic events could result in a disruption in the existing balance between food requirements and food production, or could simply cause a relative and temporary decrease in food yield without having any dramatic impact on the nutritional and general health of the population.

1.4 Chlorofluorocarbons and Halons

Chlorofluorocarbons (CFCs) and halons are man-made chemicals that exist as gases or liquids. Chlorofluorocarbons contain chlorine, fluorine and carbon. Halons are similar but contain bromine or iodine. They are neither toxic nor flammable, and were first manufactured in 1930 under the trademark Freon. Chlorofluorocarbons and halons have a lifespan in the atmosphere of 60 to 110 years.

Chlorofluorocarbons and halons have two major effects in the atmosphere. Although these effects are different, they are often confused. The effects are:

(1) greenhouse effect — chlorofluorocarbons and halons act as greenhouse gases (considered major contributors to greenhouse effect); and

(2) stratospheric ozone-depletion effect — chlorofluorocarbons and halons are not destroyed in the lower atmosphere but waft slowly upward toward the stratosphere where they eventually break down.

Each of the chlorine or bromine atoms released in that breakdown is capable of destroying tens of thousands of ozone molecules — thus contributing to the thinning of the protective stratospheric ozone layer. In the stratosphere (at altitudes of 15 to 35 km) the ozone layer acts as a natural filter to absorb most of the sun's damaging ultraviolet rays — rays that burn the skin and cause some forms of skin cancer.

1.5 Air Toxics

Air toxics are substances that can have either an immediate or a long-term harmful effect on human life or health. The quality of life in Canada depends greatly upon the beneficial use of chemicals. There are over 20,000 chemical substances in use in Canada today, and 100 to 200 new chemicals are added every year. Some of these chemicals and some by-products of manufacturing have proven to be toxic to man and/or to the ecosystems. The health effects of air toxics include lung damage, liver and kidney impairment, and cancer.

Some air toxics are VOCs and are related to energy production and use. These include arsenic compounds, benzene, beryllium compounds, cadmium compounds, chlorobenzenes, chloroform, chromium compounds, dichloromethane, ethyl benzene, ethylene dibromide, ethylene dichloride, formaldehyde, hydrogen chloride, lead compounds, mercury compounds, methyl tertiary-butyl ether, nickel compounds, polycyclic aromatic hydrocarbons, reduced sulphur compounds, toluene and xylenes. Some of these compounds are known cancer-causing agents.

Over the past 13 years, as a response to government action and regulations across Canada, there has been an 85 per cent

The National Action Strategy on Global Warming lists a number of potential impacts of particular significance for Canada:

"• shift of climatic zones several hundred kilometres northward over the next 50 years; flora and fauna would lag behind these climatic shifts, and the rate of climate change may be too fast for some species to survive;

• potential for northward expansion of agricultural crops where soils permit, up to the southern boundary of the Canadian Shield;

• increased drought risks, especially in the Prairies;

• shift northwards of forest ecosystems but with narrower boundaries for some species; increased fire, insect and disease attacks are probable;

• large changes in water resources; potential decrease in net basin run-off of 25 to 50 per cent in the Great Lakes-St. Lawrence system; lower summer soil moisture in the Prairie provinces, and larger flood flows in northern rivers;

• adverse effects on human health associated with more frequent and intense heat waves in cities, and the poleward spread of tropical diseases;

• significant degradation of permafrost within the next 40-50 years, overlying ecosystems and wildlife habitat could be significantly altered affecting northern indigenous people; structures such as pipelines and buildings would be seriously threatened;

• acceleration of sea-level rise and modification of ocean temperatures and circulation; sea-level rise would increase shore erosion, change coastal ecology, affect wetlands and important fisheries and necessitate significant costs for coastal protection; ocean changes will impact on fish distribution and migration routes."

reduction in levels of lead contained in air that urban Canadians breathe. The elimination of all lead additives in gasoline in 1990 has further contributed to this reduction.

The U.S. Environmental Protection Agency (EPA) originally identified seven air toxics: arsenic, asbestos, benzene, beryllium, mercury, vinyl chloride and radionuclides other than radon, but under the 1990 Clean Air Act, 189 toxic air pollutants are to be regulated. Many individual states in the U.S. have established programs to control the most important air toxics within their jurisdictions.

Environment Canada has also developed a Priority Substances List containing 44 substances identified as potentially hazardous and in need of assessment as to their degrees of toxicity and level of hazard. By 1994, all 44 substances will have been assessed and Environment Canada will report on the necessary regulatory action to be taken under the Federal Environmental Protection Act. Further, Canada is participating in international efforts to control and assess commercially important and widely traded chemical substances. Currently, some 1,500 substances that are consumed in high volumes account for more than 90 per cent of the international trade in chemicals. Canada is responsible for the assessment of 30 of these substances.

2.0 PROTECTING THE ATMOSPHERE

There is worldwide concern about the effects on the atmosphere of emissions discussed in the previous section. In response to this concern, governments and others have taken action at global, national and local levels.

2.1 International Agreements

2.1.1 Sulphur Dioxide

In 1985, Canada signed a protocol developed by the United Nations Economic Commission for Europe (UN-ECE) agreeing to a 30 per cent reduction in national sulphur dioxide (SO_2) emissions. In view of the substantial acid deposition problem in Eastern Canada, the reduction was implemented as a 50 per cent decrease in emissions for all provinces east of Saskatchewan. This protocol is scheduled to be renegotiated in 1994.

At its November 29, 1990 meeting, the Canadian Council of the Ministers of Environment announced a Canadian emission cap of 3.2 million tonnes of sulphur dioxide for the year 2000. This cap is included in the Canada-U.S. Agreement on Air Quality, along with a continuation of the existing 2.3 million tonnes per year cap on sulphur dioxide emissions in the seven easternmost provinces, which is to continue until 1994. Under the 1990 revisions to the U.S. Clean Air Act, and according to the terms of the Canada-U.S. Agreement on Air Quality, U.S. emissions of sulphur dioxide will be reduced by 9 million tonnes below the 1980 levels by the year 2000.

2.1.2 Nitrogen Oxides and Volatile Organic Compounds

In 1988, under the auspices of the United Nations Economic Commission for Europe (UN-ECE), Canada, the United States and 24 other member countries signed an international protocol to control nitrogen oxides (NO_X) emissions. The basic obligations listed in the protocol require countries to:
(1) ensure that either their total national emissions of nitrogen dioxide or their transboundary flows do not exceed their 1987 levels by 1994; (2) ensure, within two years of entry-into-force of the protocol, that major new sources of nitrogen oxide emissions use pollution-control technologies selected from the best available economically feasible technologies, and also that pollution-control measures be introduced on the major existing sources depending on the need and feasibility of doing so; and (3) begin negotiating, within six months of entry-into-force of the protocol, further measures and schedules to control nitrogen oxide emissions to the level required to achieve the agreed-upon environmental quality targets, with the first step to commence in 1996.

The 27 signatories of the UN-ECE nitrogen oxides protocol have agreed to freeze their emissions at the 1987 levels by the year 1994. Twelve countries have pledged to cut emissions by 30 per cent and members of the European community have adopted a plan to reduce nitrogen oxides from large combustion sources by 10 per cent by 1993 and 30 per cent by 1998. Under the Canada-U.S. Agreement on Air Quality, the United States will reduce nitrogen oxide emissions by 2 million tonnes from 1980 levels by the year 2000, a commitment that is reflected in the 1990 Amendments to the U.S. Clean Air Act. By the year 2000, Canada will reduce stationary-source nitrogen oxide emissions by 50,000 tonnes to achieve a total reduced emission level of 870,000 tonnes.

A working group has been established under the UN-ECE to develop recommendations for an emissions control protocol on volatile organic compounds (VOCs). The protocol is expected to address the role of volatile organic compounds in both ozone formation and as toxic air pollutants. Proposals under consideration range from stabilization to 30 per cent reduction.

At the World Conference — Changing Atmosphere: Implications for Global Security in Toronto (held in June 1988), working groups made several recommendations, including:

- "Set energy policies to reduce the emissions of CO_2 and other trace gases in order to reduce the risks of future greenhouse effect. Stabilizing the atmospheric concentrations of carbon dioxide is an imperative goal. It is currently estimated to require reductions of more than 50 percent from present emission levels. Energy research and development budgets must be massively directed to energy options which would eliminate or greatly reduce carbon dioxide emissions and to studies undertaken to further refine the target reductions."; and
- "Reduce CO_2 emissions by approximately 20 percent of 1988 levels by the year 2005 as an initial global goal. Clearly, the industrialized nations have a responsibility to lead the way, both through their national energy policies and their bilateral and multilateral assistance arrangements. About one-half of this reduction would be sought from energy efficiency and other conservation measures. The other half should be affected by modifications in supplies."

Following the meeting, a Canada-wide coalition of environmental organizations was formed (now called the Climate Action Network). Since that time, this group has called repeatedly for committing to a 20 per cent reduction of 1988 carbon dioxide levels by the year 2005 as an immediate goal.

2.1.3 Greenhouse Gases

In February 1989, Canada and 23 other countries signed the Hague Declaration, which recognized the need for a global convention on climate change. Subsequently, in November 1989, a meeting of government ministers from 76 countries was held in Noordwijk, The Netherlands. It emphasized the importance of establishing quantified targets and schedules to limit or reduce emissions of greenhouse gases. Further, attendees recognized the need to stabilize atmospheric concentrations of greenhouse gases, while ensuring stable development of the world economy.

The regional conference of 34 countries of the UN-ECE (including Canada), which was held in Bergen in May 1990, advanced the degree of international recognition of the seriousness of the problem of climate change. Ministers of all represented countries agreed to commit to establishing national strategies and/or targets and schedules following completion of the report of the Intergovernmental Panel on Climate Change (IPCC). Those strategies, targets and schedules are to be in place no later than the start of negotiations for a framework convention; this convention will focus on climate change to stabilize and, as much as possible, limit or reduce carbon dioxide emissions and other greenhouse gas emissions. Canada and most other countries expressed the view that the first step must be to stabilize emissions at the present levels by the year 2000 at the latest.

Following The Second World Climate Conference in Geneva, the United Nations resolution of December 21, 1990, called for the formation of an Intergovernmental Negotiating Committee to develop a Framework Convention on Climate Change for the June 1992 UN Conference on Environment and Development (UNCED) to be held in Rio de Janeiro, Brazil.

The development of a Framework Convention on Climate Change will be the international driving force for reducing emissions responsible for global warming. The intent is to have a written agreement listing a series of commitments which is ready for signing by the June 1992 UNCED meeting. The commitments could include targets and schedules for the reduction of all greenhouse gas emissions and agreements on funding mechanisms and technology assistance for developing countries. It also is likely that the agreements will address forests as sinks (or reservoirs) for carbon dioxide. Canada is committed to the overall process and is co-chairing a working group dealing with the legal mechanisms needed to implement the agreements.

The range of support for the Framework Convention varies. Many developing countries see their greenhouse gas emissions increasing in the future and want to have the leeway to allow this to occur. Other countries, especially those with economies in transition (e.g. Eastern Europe), would like the Convention limited to general principles, with target and other commitments to be dealt with after June 1992. Most Western countries favour specific commitment in the convention and have already made their own national commitments at home.

Greenhouse gas targets announced by some countries are summarized in Table 2-1.

Table 2-1. Actions on greenhouse gases announced by some countries

Country	Target
Australia	Interim goal: stabilization at 1988 levels by year 2000, and 20% reduction by year 2005.
Austria	20% reduction by year 2005.
Canada	**Stabilize emissions at 1990 levels by year 2000.**
France	Stabilize CO_2 emissions at 1990 levels by year 2005.
Germany	30% reduction in CO_2 emissions by year 2005.
Japan	Stabilize at "1990-per-capita levels" by year 2000.
The Netherlands	Stabilization target of 1989-90 levels by 1995, with 3 to 5% reduction by year 2000.
New Zealand	Reduction of 20% from 1990 levels by year 2000.
Norway	Stabilization during the 1990s.
Sweden	Annual reduction of 5 to 10 million tonnes CO_2.
United Kingdom	Stabilize CO_2 emissions at 1990 levels by year 2005.
United States	No commitment on CO_2

Source: *What is Global Warming in 1990 and the Year Ahead*, Washington International Energy Group, 1990.

2.1.4 Chlorofluorocarbons and Halons

There is an international commitment to reduce the use of chlorofluorocarbons and other stratospheric ozone-depleting substances. International discussions began in 1981 and led to the 1985 Vienna Convention, which established monitoring and scientific assessment activities. In 1987, most members of the international community (including Canada) agreed to The Montreal Protocol on Substances that Deplete the Ozone Layer. The protocol set a schedule for reducing use of chlorofluorocarbons and halons by the year 1999 to 50 per cent of the levels used in 1986. At a meeting in Helsinki in 1989, participating nations agreed to accelerate that timetable to reach an 85 per cent reduction by 1999. This agreement was reinforced at the meeting in London in June 1990, and now calls for essentially a complete phase-out of production by the year 2000. Many of the major CFC-producing countries are independently committed to an even faster phase-out schedule for CFCs. Thirteen countries, including Canada, issued a separate declaration of their determination to take all possible appropriate measures to phase-out CFCs as soon as feasible, but no later than 1997. The Montreal Protocol established a US$240 million fund to assist developing countries in adhering to the strengthened protocol.

A summary of international agreements is provided in Table 2-2.

2.2 Canadian Initiatives

2.2.1 Sulphur Dioxide

An intensive research effort on the Long Range Transport of Atmospheric Pollutants (LRTAP) has been under way in Eastern Canada for over a decade. This Canadian effort was coordinated with a similar effort in the United States called the National Acid Precipitation Assessment Program (NAPAP).

Significant advances have been made in determining the emissions of sulphur dioxide and nitrogen oxides, their concentrations in ambient air, the associated deposition of acids, and the damages to the environment as a result of emissions from these pollutants. The Eastern Canadian Sulphur Dioxide (SO_2) Control Program is well under way. The seven Eastern provinces — Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland — are implementing programs and regulations that will reduce sulphur dioxide emissions from the base level of 4,516 kilotonnes in 1980 to 2,300 kilotonnes in 1994. The emission-control programs focus on 10 major sulphur dioxide emitters in Eastern Canada, all within the mining and energy sectors. The 10 companies that are the source of these emissions will invest a total of $1.7 billion between 1987 and the end of 1993 in projects that will help the companies meet the emission-reduction requirements. Significant decreases in sulphur dioxide concentrations in air and sulphate accumulations in precipitation (up to 30 per cent) have been observed at a number of sites in Eastern Canada over the last decade. These sites are located in, or downwind of, regions in which sulphur dioxide emissions have decreased by more than 10 per cent. During the 1980s, there has been little change in nitrate levels in precipitation, which is consistent with the constant nitrogen dioxide emission rates.

2.2.2 Nitrogen Oxides and Volatile Organic Compounds

At its November 20, 1990 meeting, the Canadian Council of Ministers of the Environment (CCME) agreed in principle on a national plan to prevent or reduce ground-level ozone. The *Management Plan for Nitrogen Oxides (NO_X) and Volatile Organic Compounds (VOCs)* represents Phase I of a multi-phase NO_X and VOC control program aimed at fully resolving ground-level ozone problems in Canada by the year 2005. The Phase I plan contains 58 specific initiatives for reduction of NO_X and VOC emissions, and 24 study initiatives designed to provide information to be used for preparing a second edition of the plan in 1994. The initiatives for reducing levels of NO_X and VOCs are to be implemented for the most part over the four-year period from 1991 to 1994. The initiatives are to affect numerous mobile and stationary sources that emit NO_X and/or VOCs, ranging from automobiles to power plants to solvents such as paints and coatings.

The measures in the Phase I plan establish a strong prevention program nationally, and compile a comprehensive set of remedial actions in the primary ozone problem areas. Combined, these prevention and remedial programs ensure that no new ozone problems are created where none exist and that air quality in existing problem areas is significantly improved. Peak ozone concentrations in key problem areas are to be reduced by 15 to 35 per cent from current levels by the year 2005, and the length of time humans and vegetation are exposed to unacceptable ozone levels will be reduced by 40 to 100 per cent within the problem areas.

The package of initiatives in Phase I of the *Management Plan for Nitrogen Oxides (NO_X) and Volatile Organic Compounds (VOCs)* comprise the base plan. It is recognized that there may be alternatives to the base plan initiatives which could achieve equivalent reductions in NO_X and VOC emissions in the same time frame, while offering improved cost effectiveness. The plan allows for substitution of "environmentally equivalent" alternatives to the base plan through a CCME approval process.

The plan will result in significant costs to governments and industry. Its implementation depends somewhat on how the public receives it and accepts the need for lifestyle changes to improve and conserve the environment. The government cost to implement the plan is estimated at $100 million over the

Table 2-2. Summary of international protocols and agreements

Year	Place	Type	Issue	Major Provision
1979	Geneva	convention	long-term transport	cooperative program for monitoring and evaluations
1985	Helsinki	protocol	acid rain	30% reduction of SO_2
1985	Vienna	convention	ozone depletion	monitoring and scientific activities
1987	Montreal	protocol	ozone depletion	CFC reduction by 50%
1988	Sofia	protocol	nitrogen oxides	freeze at 1987 levels by 1994
1989	Noordwijk	declaration	climate change	need for global convention
1989	Helsinki	statement	ozone depletion	CFC reduction of 85% by 1999
1990	London	statement	ozone depletion	CFC production phase-out by 2000
1990	Bergen	declaration	climate change	national strategy development

Source: Alberta Environment, 1991.

five-year period from 1991-1995. The cost to emitters for reducing NO_X and VOCs is estimated at $855 million per year by 2005; more than 80 per cent of this will be borne by producers and consumers of automobiles, thermal electricity and paints/coatings.

2.2.3 Greenhouse Gases

In August 1989, the Federal-Provincial-Territorial Energy Ministers Task Force on Energy and the Environment recommended in its report, *Reducing Greenhouse Gas Emissions*, that near-term actions to reduce greenhouse gas emissions should be attractive on their own merits, with the most cost-effective actions involving energy conservation and improved efficiency. Electricity demand-management programs were viewed as a cornerstone of any reduction programs in the short term. The Task Force also recommended that a greenhouse gas response should include scientific research to refine current understanding of climate change and its effects, and to examine possible carbon sinks. Research should also focus on developing the skills needed to monitor and predict climate change. Plans should be developed to assist in adapting to the significant changes that may occur despite the measures taken to reduce greenhouse gas emissions (because of the existing accumulation of gases in the atmosphere).

The second report of the Task Force found that the main sources of carbon dioxide emissions vary widely across the country and, consequently, the potential reductions and the reduction measures also vary. The Task Force reported to the Canadian energy ministers' meeting in Kananaskis that achievement of a 20 per cent reduction of carbon dioxide emissions from 1988 levels by year 2005 would cause significant economic dislocation and would require major changes in lifestyle. Notwithstanding, all members agreed that working toward the stabilization and eventual reduction of carbon dioxide levels was a sensible course of action. A study commissioned by the energy ministers predicted, on the basis of a number of very broad assumptions, $100 billion dollar net savings from conservation measures employed across Canada to reach the 20 per cent reduction goal. Another study commissioned by Imperial Oil Limited concluded that stabilizing greenhouse gas emissions could cause a decline of cumulative real gross domestic product by over $100 billion.

At its November 1990 meeting, (the Canadian Council of the Ministers of Environment) released a proposed National Action Strategy on Global Warming for public consideration. Public input was considered by CCME in finalizing the strategy at its meeting in 1991. The strategy recommends the following three-pronged approach:

(1) limiting greenhouse gas emissions;

(2) anticipating and preparing for potential climatic changes within Canada; and

(3) improving scientific understanding and the ability to predict climate change.

On March 25, 1990, the House of Commons Standing Committee on the Environment released its final report on the greenhouse effect, and urged Canadians to commit to a 20 per cent reduction of greenhouse gases as a minimum interim objective.

Toronto has become the first major city to enact the carbon dioxide reduction goals recommended at the June 1988 Toronto Conference on the Changing Atmosphere. In January 1990, the City of Toronto adopted an ambitious plan to reduce carbon dioxide emissions by 20 per cent from 1988 levels by the year 2005. Vancouver, Regina and Ottawa have also announced their intention to meet this same commitment.

2.2.4 Chlorofluorocarbons and Halons

At its November 1990, meeting CCME also endorsed a chlorofluorocarbons elimination strategy, which spells out the roles and responsibilities of governments regarding ozone layer protection. This will facilitate rapid phase-out of CFCs. The strategy is being applied to a national action plan for reclaiming and recycling CFC refrigerants and halons.

2.2.5 Western Canadian Agreements

Ministers from the departments of environment, energy and natural resources from the four Western provinces, Yukon and the Northwest Territories met in Regina on February 20, 1991, and endorsed a framework for regional cooperation on

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Summary of the City of Toronto's January 1990 plan to reduce carbon dioxide emissions:

Acting on a report by the city's Special Advisory Committee on the Environment, the City Council recommended formation of an Interdepartmental Coordinating Committee to organize corporate response to the initiative and endorsed a wide range of objectives, including:

(1) a reduction in the number of light-duty vehicles used by the city employees (currently 1,200) and the provision of city-owned bicycles for short trips;

(2) a move to bring city parking authority rates in line with private sector rates;

(3) request to all companies in the downtown area to reduce automobile commuting by their staff, including senior executives;

(4) encouragement to provide bicycle laws and bicycle parking facilities;

(5) a remote tail pipe emission-sensing project;

(6) a comprehensive energy audit program; and

(7) initiation of a home retrofitting program to increase energy efficiency in home appliances and light fixtures.

environmental issues. The Western Accord on Environmental Cooperation, includes the following key elements:

- ▲ adoption of common principles for environmental assessment developed at the meeting of the CCME in November 1990;
- ▲ pursuit of joint interprovincial and federal-provincial strategies for managing regional environmental issues;
- ▲ development and sharing of environmental research and information;
- ▲ coordination and balancing of standards and procedures for environmental protection; and
- ▲ establishment of a priority list of issues requiring immediate attention.

This Accord built on a 1980 agreement among the governments of British Columbia, Alberta, Saskatchewan, Manitoba, the Northwest Territories and Canada which outlined the following principles for cooperative action:

(1) maintain a high standard of air quality throughout Western and Northern Canada;

(2) protect sensitive areas by controlling emission sources and influencing actions in adjacent provinces;

(3) work towards harmonized air quality standards where appropriate;

(4) develop an integrated air quality monitoring network;

(5) have open exchange of scientific, technical and monitoring data; and

(6) cooperate on scientific activities such as the establishment of scientific criteria for sulphate, nitrate and hydrogen ion target loadings, the monitoring of air quality trends, and the identification of areas sensitive to pollutant deposition.

2.2.6 The Green Plan

Canada's Green Plan for a Healthy Environment **was announced on December 11, 1990. This comprehensive, five-year environmental action plan is described as "a coordinated package of actions to help Canadians work together in partnership to achieve, within this decade, a healthy environment and a sound, prosperous economy." There are several Green Plan initiatives that relate to clean air:**

- ▲ assurance that citizens today and tomorrow will have the clean air, water and land essential to sustaining human and environmental health;
- ▲ virtual elimination of the discharge of persistent toxic substances into the environment;
- ▲ stabilization of carbon dioxide and other greenhouse gas emissions at 1990 levels by the year 2000;
- ▲ phasing-out CFCs by 1997, and phasing-out methyl chloroform and other major ozone-depleting substances by the year 2000;
- ▲ attainment of a 50 per cent reduction of sulphur dioxide emissions in Eastern Canada by 1994;
- ▲ capping of acid rain-related emissions in Eastern Canada beyond 1994;
- ▲ extension of the acid rain control program to emissions in Western Canada; and
- ▲ all of Canada's urban smog problems will be fully solved by 2005.

2.3 Alberta Environmental Initiatives

2.3.1 Alberta's Environment Toward the 21st Century

In January of 1990, the Government of Alberta presented its environmental vision to the public in a document entitled *Alberta's Environment Toward the 21st Century*. The document explained the government's commitment to achieving the protection, improvement and wise use of the environment, now and in the future. It also outlined the following 10 environmental principles:

(1) shared responsibility by individual citizens;

(2) leadership through leading-edge research, technologies and environmental protection standards;

(3) public involvement that provides Albertans with every opportunity to understand and provide advice on decisions affecting the environment;

(4) action in environmental protection by anticipating problems and preventing or mitigating environmental impacts of actions resulting from policies, programs, decisions and development activities;

(5) polluters pay for the costs of preventing environmental impacts and reclaiming affected areas;

(6) legislative and regulatory action that is comprehensive and responsive to public needs;

(7) integrated decision-making through a process that ensures wise use of resources while considering the need for economic growth and prosperity;

(8) intergovernmental cooperation with other provinces, the territories and the federal government to achieve environmental protection, and improvement and wise use of the environment, always recognizing the constitutional responsibilities;

(9) sustainable development that ensures the current use of resources and the environment does not jeopardize prospects for their use in the future; and

(10) improving the environment for future generations.

2.3.2 Alberta Environmental Protection and Enhancement Act

After reviewing the comments of Albertans on the principles and policies, a draft Alberta Environmental Protection and Enhancement Act (AEPEA) was presented for public consideration. The draft Act incorporates nine existing acts into a single new act, providing effective and integrated environmental legislation for Alberta. Key features of the proposed legislation are:

- establishment of a legislated environmental impact assessment (EIA) process;
- increased public consultation and participation in all aspects of environmental protection and enhancement activities;
- timely and effective enforcement mechanisms;
- increased penalties — fines of up to $1 million and jail terms up to two years;
- increased public access to information;
- statutory requirements for waste reduction and recycling;
- mandatory spill reporting and clean-up;
- a single approval process covering all aspects and recognizing the interdependence of water, air and land;
- 25-year owner/operator liability for site clean-up and reclamation costs; and
- liability of corporate officers and directors for environmental offenses.

The Environmental Legislation Review Panel held public meetings across the province in October and November of 1990 to obtain public input for the proposed AEPEA. The panel submitted its report and recommendations to the Minister of the Environment in January 1991. The revised AEPEA Act (Bill 53) was tabled in the Alberta legislature in June 1991. It does not include all the rules necessary for general application of the legislation, however. Regulations will be developed to accompany the Act; these will provide the means for carrying out the intent of the Act. Currently, there are 39 environmental regulations which are part of the acts being incorporated into the AEPEA. These regulations are also being revised to reflect changes in the Act. As well, new regulatory areas are being addressed, with the most significant being procedural regulations related to environmental impact assessment, approvals and boards of review.

2.3.3 Round Table on the Environment and the Economy

In May 1990, Alberta announced the formation of the provincial Round Table on the Environment and the Economy in response to recommendations by Canada's National Task Force on the Environment and the Economy. There are 25 members on the Round Table, including two provincial cabinet ministers (Environment and Economic Development and Trade) representing a wide range of interests, views and sectors of expertise throughout the province. The Alberta Round Table will report to Cabinet on ways of achieving sustainable development as well as integrating environmental and economic decision-making. The Round Table describes its mission as working to achieve sustainable development by providing leadership, policy advice and long-term strategies to government, business and the general public.

2.3.4 Other Initiatives

In 1973, the Canadian Petroleum Association (CPA) became a charter member of the provincial environment minister's Alberta Petroleum Industry/Government Environmental Committee (APIGEC). In 1988, the CPA adopted an environmental code of practice for the industry, updated its environmental operating guidelines, and prepared guidelines for environmental audits and public consultation. The CPA has an environmental research committee with a mandate to coordinate and advise on issues, priorities and external relations.

Other industrial associations have also been active in environmental protection. The Independent Petroleum Association of Canada (IPAC) has a long-term goal of: ". . . encouraging and supporting sound environmental policies and practices to achieve the sustainable development of Canada's crude oil and natural gas resources." IPAC also is involved in APIGEC.

Under the auspices of the Electric Utility Planning Council, Alberta utility companies are involved in a variety of initiatives in Alberta and through the Canadian Electrical Association to test new emission prevention and abatement measures. The utility companies have also supported the acid deposition research program and studies of market-based incentives. District heating and demand reduction are also being evaluated.

The Coal Association of Canada has committed itself to improved efficiencies, low-impact coal processing and combustion technologies, waste-heat recovery and applied research in these areas.

The cities of Calgary and Edmonton are active in promoting improved air quality. Both cities have energy conservation programs for buildings and plants, and expend funds annually on retrofits to obtain energy savings. The cities are converting an ever-increasing number of the smaller city-operated vehicles to propane, and are also investigating other alternative fuels. Recently, Calgary initiated several air quality enhancement projects. The Air Improvement Resolution (AIR Calgary) program encourages motorists to leave their vehicles at home 1 out of 10 work days and use alternative transportation. Both cities are working on improving public transit to encourage more users, and are monitoring alternative energy-saving pilot projects for buses with a view to implementing proven technologies at the earliest practical date. Edmonton is developing an air quality management plan and its electrical utility, Edmonton Power, is investigating the feasibility of a district heating scheme that could involve most of the buildings in the city's core. Both cities are discouraging the use of products containing or manufactured with CFCs (e.g. a preferential purchasing policy that favours non-CFC products).

The provincial government has been actively involved in non-regulatory environmental initiatives. Many Alberta government departments and Crown corporations including Environment; Energy; Alberta Oil Sands Technology and Research Authority; the Alberta Research Council; Alberta Agriculture; Energy Resources Conservation Board; and Alberta Transportation have been funding and carrying out research into areas such as cleaner energy production technologies and the impact of emissions on various sectors of the provincial economy. The government also has an incentive program to encourage renewable energy resource development called the Southwest Alberta Renewable Energy Initiative. In addition, the government runs environmental and energy efficiency education/awareness programs, including programs for both formal and non-formal education, as well as industrial, building and fleet energy audits.

Environmental non-government organizations (ENGOs) have been active, both individually and collectively, in identifying specific local air quality concerns and raising public awareness of the general issues. From 1984-87, the Sour Gas Coalition helped shape more stringent sulphur recovery guidelines for sour gas processing plants. In 1988, the Alberta Environmental Network (AEN) formalized a standing committee of environmental groups working on energy and air quality issues, known as the AEN Energy/Clean Air Caucus. This caucus has facilitated ENGO participation in the federal NO_X/VOC management plan, the federal Green Plan, and the Clean Air Strategy for Alberta. Nationally, some 60 environmental groups, including 16 from Alberta, are working in a coalition CAN-net Canada to develop and promote a Canadian response strategy to climate change. Alberta groups have been at the forefront of energy conservation education and the implementation of energy efficiency programs. For example, the Environmental Resource Centre developed its school-based "Destination Conservation" program which is now being used across Canada.

3.0 AIR QUALITY IN ALBERTA

Previous chapters focused on the general effects of emissions and the actions taken at various levels. This chapter concentrates on the Alberta situation and provides Alberta emissions data, summarizes current air quality in the province, describes studies on environmental effects and indicates some potential effects that could occur with changes in air quality. Appendix 1 summarizes Alberta guidelines and objectives for source emissions and ambient air quality.

3.1 Emissions

Although natural sources of gases are being considered, the Clean Air Strategy for Alberta is concerned primarily with increasing concentrations of energy-related emissions stemming from human activity. Alberta emissions of sulphur dioxide, nitrogen oxides, volatile organic compounds and carbon dioxide are compared with those of other jurisdictions in Table 3-1. The distribution of Alberta emissions by economic sector is illustrated in Figure 1 (percentages may not total 100 due to rounding). Historical and forecast emissions are shown in Figure 2. All forecasts were based on a business-as-usual scenario.

Canada's sulphur dioxide emissions are about 15 per cent of those of the United States, and Alberta's emissions are about 15 per cent of Canada's. Of the estimated 539 kilotonnes of sulphur dioxide emitted in Alberta in 1985, sour gas plants accounted for just under a half, oil sands more than one-quarter, and coal-fired electrical power plants about one-sixth.

The majority of man-made nitrogen oxides results from the burning of fossil fuels, although there is some contribution from agricultural operations. Alberta contributed about 23 per cent of the 1,887 kilotonnes of nitrogen oxides emitted annually in Canada (as estimated by Environment Canada in 1985). The 440 kilotonnes of nitrogen oxide emissions in the province in that year were attributable as follows: slightly more than one-third to the oil and gas industry, a little less than a third to transportation, and one-sixth to electricity generation. Environment Canada forecast that Alberta's nitrogen oxide emissions in the year 2005 would be 528 kilotonnes without the Management Plan for NO_X/VOC, and 473 kilotonnes with implementation of the plan. This is a reduction of 10 per cent, but an increase of 7.5 per cent from 1985 levels.

Alberta emits the fourth largest amount of volatile organic compounds in Canada. In Alberta, motor vehicles are responsible for a little more than one-half, the use of solvents produces about one-fifth, and petrochemicals yield one-seventh of the total emissions. In 1985, emissions from man-made sources amounted to 196 kilotonnes in Alberta. In the year

Table 3-1. Alberta emissions (kilotonnes) in 1985 compared with other jurisdictions

Jurisdiction	Population (millions)	SO_2	NO_X	VOC	CO_2*
Alberta	**2.4**	**539**	**440**	**196**	**124 300**
British Columbia	2.9	105	253	294	90 900
Manitoba	1.1	469	82	71	12 500
New Brunswick	0.7	138	46	45	19 400
Newfoundland	0.6	43	34	36	7 300
Northwest Territories	0.05	2	14	5	1 300
Nova Scotia	0.9	170	74	52	17 700
Ontario	9.1	1 457	558	631	164 300
Prince Edward Island	0.1	2	6	11	1 500
Quebec	6.5	693	223	356	66 700
Saskatchewan	1.0	86	155	83	31 800
Yukon	0.02	1	2	2	700
Canada	**25.4**	**3 704**	**1 887**	**1 782**	**538 400**
United States	245.8	20 998	18 633	20 020	4 808 000
Japan	122.8	1 079	1 416	1 301	990 000
United Kingdom	55.8	3 867	2 303	2 355	558 000
Australia	16.8	1 479	915	423	241 000
Sweden	8.5	231*	390	446	62 000
OECD countries	—	**37 073**	**32 224**	**29 049**	**21 630 000**

* 1988 figures

Source: Alberta Environment, 1991.

2005. VOC emissions are forecast to be 180.1 kilotonnes in the absence of the NO_x/VOC Management Plan, and 165.0 kilotonnes with implementation of the plan; a 15.7 per cent reduction from 1985 levels.

Although Canada produces only two per cent of the world's energy-related carbon dioxide emissions, it is one of the world's highest emitters on a per capita basis. Canada's cold climate, long transportation distances, energy-intensive export industries (minerals and timber), lifestyle, relatively low energy prices, and consumer inefficiencies all contribute to this level of carbon dioxide emissions.

In Canada, Alberta is the largest per capita emitter of carbon dioxide, and produces 22 per cent of the Canadian total. The oil and gas industry — gas processing, oil sands, pipelines and refineries — is responsible for about one-third of Alberta's man-made carbon dioxide emissions. Coal-generated electricity (more than 85 per cent of Alberta's supply) is responsible for another one-third, and one-third is from the end use of energy in business, industry, homes and transportation.

Alberta's carbon dioxide emissions are not all from products consumed by Albertans. At least three-quarters of the carbon dioxide from the energy industry is related to the production of oil and gas exported from Alberta for use in other provinces and the United States. In 1988, it was estimated that through products used by Albertans, 87,000 kilotonnes of carbon dioxide were emitted. This is only slightly higher than the per capita emissions of British Columbia and Saskatchewan.

Estimates of methane production in the province vary widely. In a University of Alberta study on wetlands in Alberta, it was estimated that cattle, sheep, pigs, horses and wild grazing animals annually release 2.2 kilotonnes of methane, while coal burning and well blowouts contribute about 0.34 kilotonnes of methane. A similar inventory by Environment Canada of 1985 methane emissions suggests that Alberta's emissions were about 165 kilotonnes, of which a little more than half was from coal production and one-fifth from stationary fuel combustion. The Canadian Gas Association estimates that leakage from natural gas pipelines is about 0.3 per cent; however, studies using European data suggest leakages could be as high as 4 to 10 per cent. The Canadian Petroleum Association has commissioned a study of emissions of methane and VOCs in the upstream oil and gas industry. Results are expected by the end of 1991.

Alberta's use of CFCs was estimated to be about 2000 tonnes per year in 1986. Of this, two-fifths were used in refrigeration and air conditioning, one-third in foam blowing and one-eighth in cleaning solvents. Companies using foam blowing in Alberta have stopped using CFCs. Annual use of CFCs can be expected to drop as they are replaced by other compounds.

No estimate has been made of the quantities of air toxics released in the province. As with the other gases, the quality of inventories of air toxics varies widely in quality.

Table 3-2 shows a subjective assessment of the quality of various inventories.

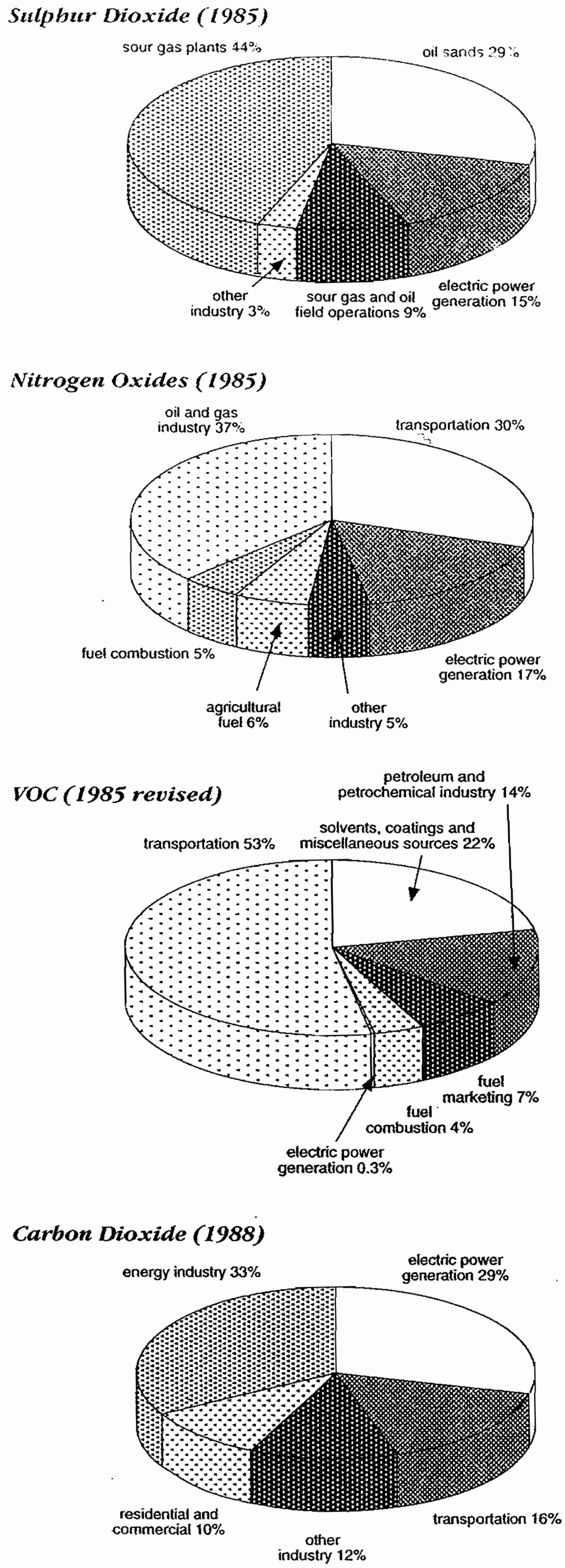


Figure 1. Sectoral distribution of Alberta emissions

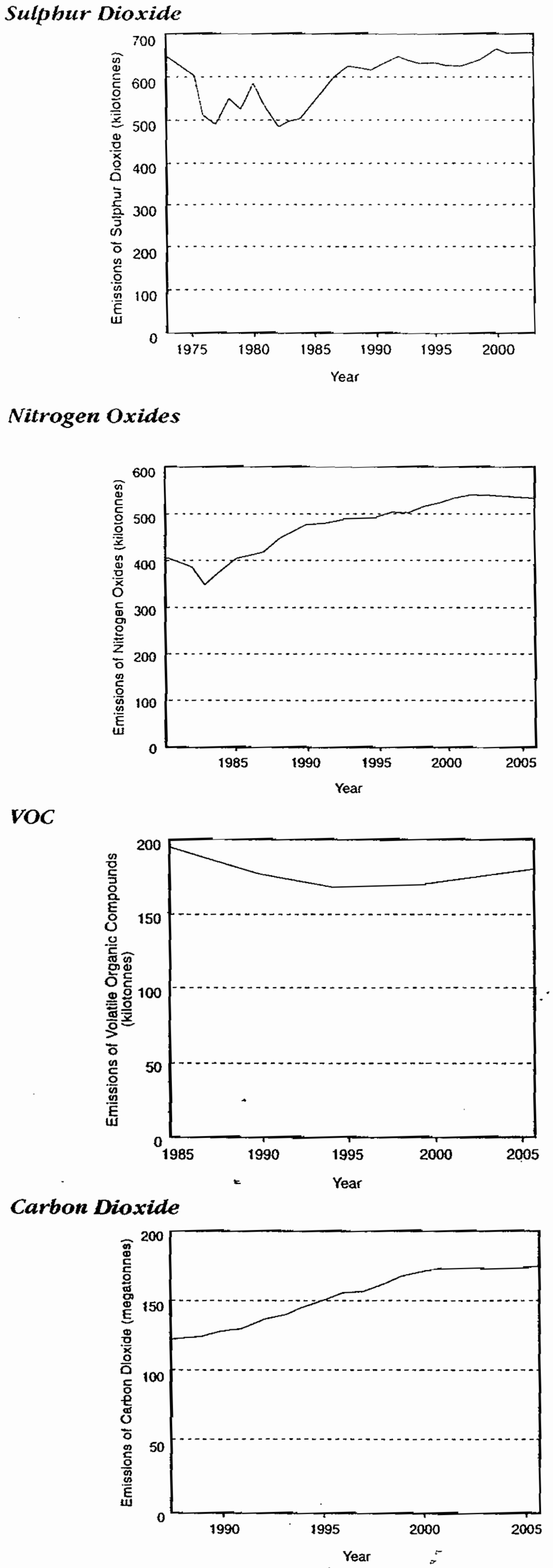


Figure 2. Historical and forecast Alberta emissions

Table 3-2. Subjective assessment of quality of inventory data

Gas	Quality of Data
sulphur dioxide (SO_2)	very good
nitrogen oxides ($NO + NO_2$)	good
nitrous oxide (N_2O)	poor
volatile organic compounds (VOC)	fair
carbon dioxide (CO_2)	good
methane (CH_4)	poor
chlorofluorocarbons (CFCs)	good
halons	good
air toxics	very poor

Source: Alberta Environment, 1991

3.2 Ambient Concentrations

Sulphur dioxide, nitrogen oxides, ground-level ozone, total hydrocarbons (mostly methane) and coefficiencies of haze (dust and smoke) are routinely monitored by Alberta Environment at Edmonton, Calgary, Fort Saskatchewan, Fort McMurray and Fort MacKay (see Figure 3). Monitoring of volatile organic compounds has recently been initiated. Carbon dioxide was monitored during the Acid Deposition Research Program (ADRP) only from 1985 to 1987. Industry monitors ambient air quality near their plants. Figure 4 shows the maximum one-hour concentrations compared to the annual average concentrations from monitoring stations in Alberta and selected provinces and states. Data presented in this figure were obtained from National Air Pollution Surveillance Network reports and annual reports for the selected jurisdictions. Note that there are differences in the number of stations per jurisdiction and the year of the data.

The one-hour average sulphur dioxide concentrations at the Edmonton, Calgary and Fort Saskatchewan monitoring locations are generally much lower than the Alberta objective of 0.17 parts per million. In 1989, however, maximum one-hour average concentrations at these locations were 35 per cent of the objective. Much higher sulphur dioxide concentrations have been observed in Eastern North America. For example, a maximum one-hour sulphur dioxide concentration of 0.73 ppm was observed in Ontario as compared to 0.48 ppm in Alberta. In 1989, the annual average sulphur dioxide concentration in Alberta (0.003 ppm) was 23 per cent of that observed in California (0.013 ppm). Maximum one-hour average sulphur dioxide concentrations often approach the objective of 0.17 ppm at the Fort McMurray monitoring station, and a peak of 0.16 ppm was observed in 1989.

The one-hour regulation for sulphur dioxide was exceeded occasionally at the Fort MacKay monitoring station in 1989 when a maximum one-hour average concentration of 0.48 ppm was recorded. Sulphur dioxide concentrations at Fort MacKay have been the highest in the province (Figure 5).

Nitrogen dioxide concentrations at all Alberta monitoring locations did not exceed either the one-hour or the 24-hour standards in 1989. Nitrogen dioxide concentrations have been found to be generally higher in Quebec, California and Ohio. Lower annual average and maximum one-hour nitrogen dioxide concentrations are observed in the maritime provinces. The maximum one-hour average nitrogen dioxide concentration recorded in Alberta in 1989 was 0.17 ppm, as compared to 0.39 ppm in Quebec. The highest annual average nitrogen dioxide concentrations in Alberta are observed at the Edmonton and Calgary industrial monitoring stations as well as the Calgary downtown monitoring location (Figure 5). The annual average standard for nitrogen dioxide was exceeded in 1989 at the Calgary downtown monitoring location where a concentration of 0.035 ppm was observed. This value is 117 per cent of the annual average standard for nitrogen dioxide of 0.030 ppm.

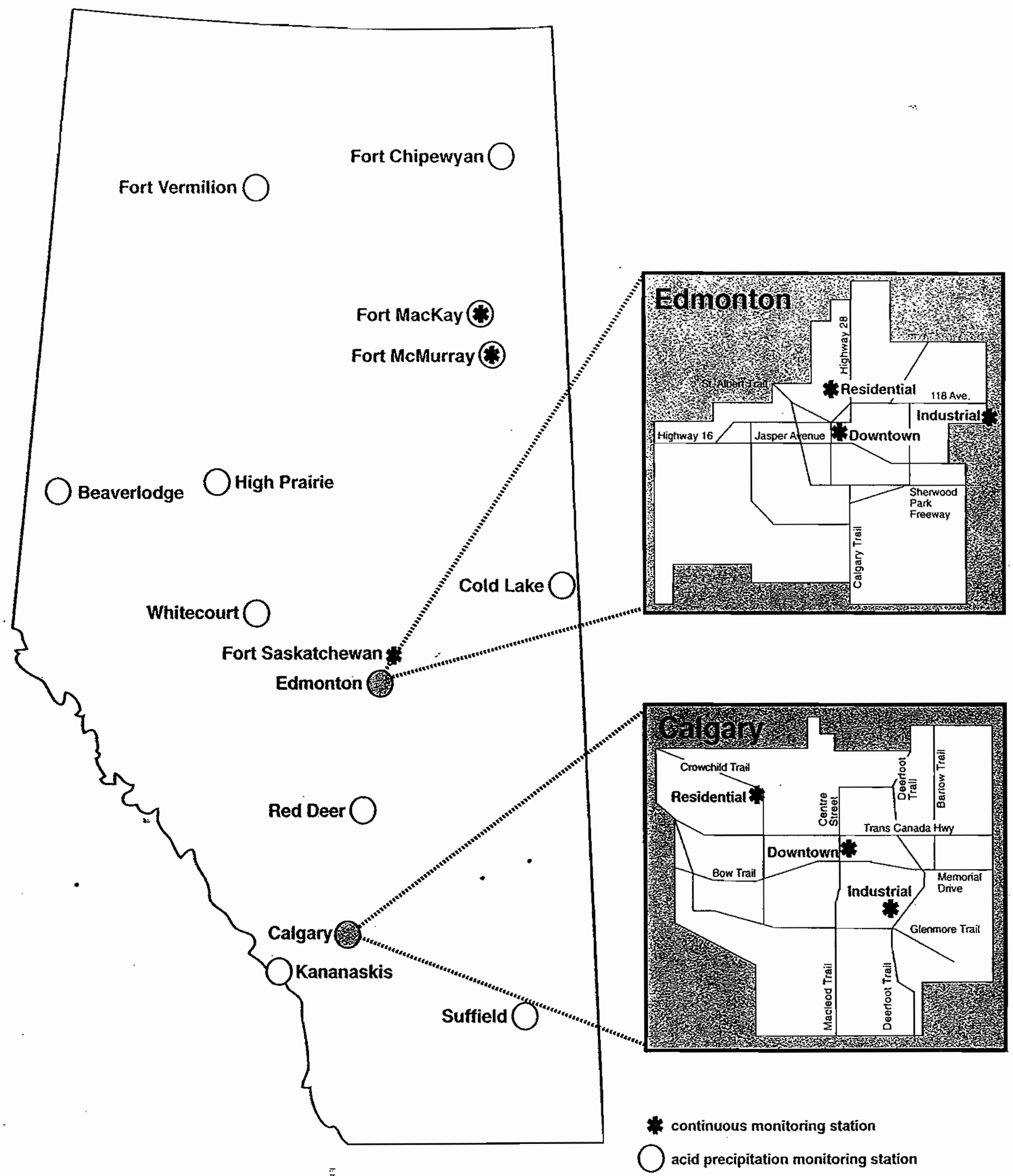


Figure 3. Location of Alberta Environment air quality monitoring stations in 1989

The highest annual average ozone concentration recorded at an Alberta Environment monitoring station in 1989 was 0.024 ppm, which was observed at the Calgary residential monitoring location. This station also recorded the maximum one-hour ozone concentration in Alberta of 0.106 ppm (Figure 5). In that same year, relatively high annual average ozone concentrations were also recorded at Fort Saskatchewan and Fort McMurray monitoring locations. The highest annual average ozone concentrations in Canada were observed in the maritime provinces, while the highest maximum one-hour concentrations were recorded in Ontario and Quebec. Ozone concentrations in California were found to be significantly higher than those anywhere in Canada. For example, in 1989 the annual average and highest one-hour ozone concentrations recorded in Alberta were 66 per cent and 33 per cent, respectively, of those observed in California.

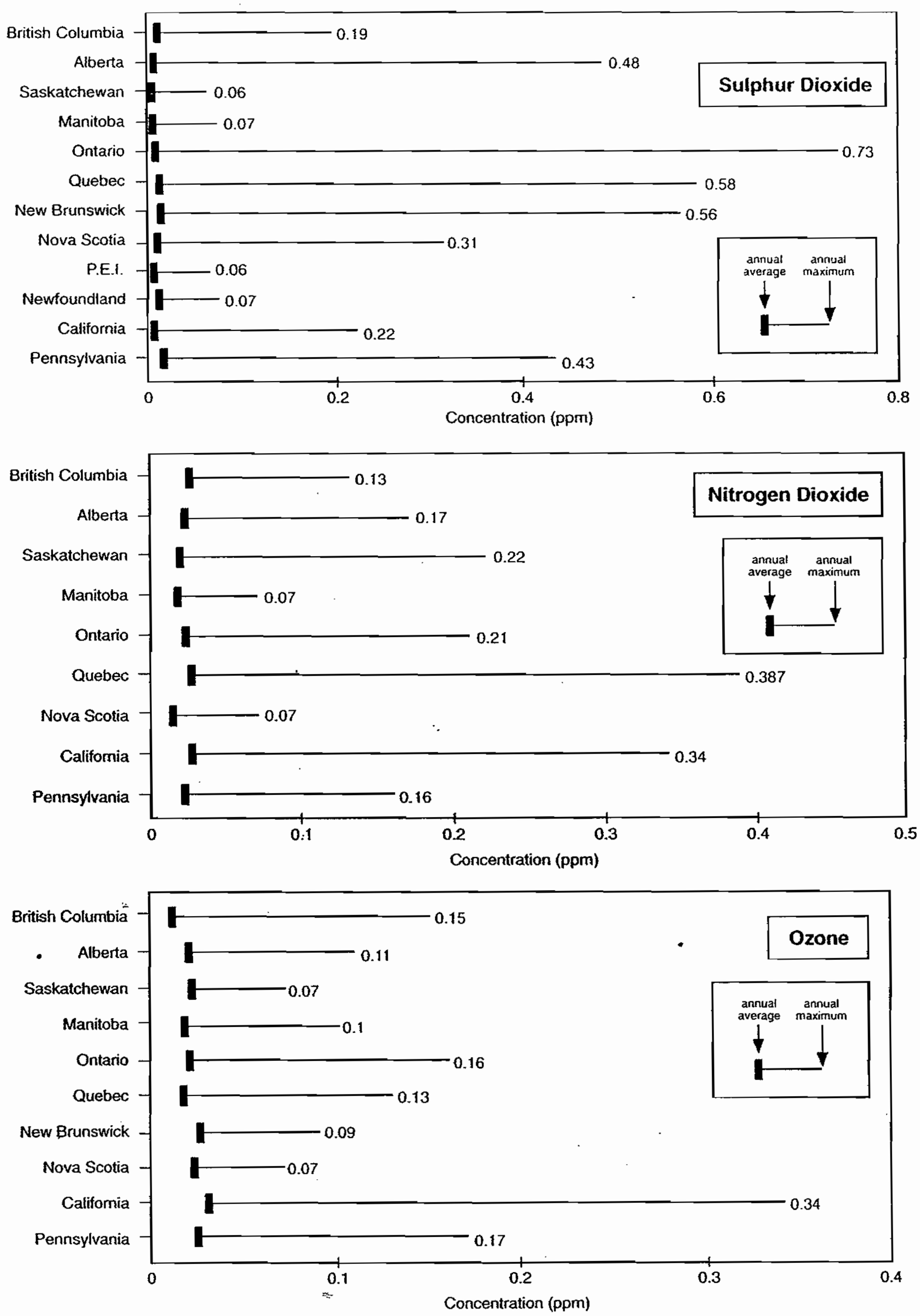


Figure 4. Annual and maximum one-hour concentrations for Alberta and other jurisdictions

The term total hydrocarbons (THC) refers to the combined concentration of two broad categories of organic compounds: reactive and non-reactive hydrocarbons. The non-reactive component is primarily methane, usually present in the atmosphere at concentrations of about 1.5 ppm. The reactive components are volatile organic compounds other than methane, which are usually present in much lower concentrations. Air quality objectives do not exist in Alberta for maximum permissible THC concentrations, nor do they exist in most other jurisdictions. The highest annual average THC concentrations in Alberta are generally recorded at the Edmonton downtown and residential, and the Calgary downtown monitoring locations. Episodic high THC concentrations up to 16 ppm are evident at the Edmonton industrial and Fort McMurray monitoring stations (Figure 5).

Carbon dioxide was monitored from November 1985 to October 1987 at three locations in Alberta as part of the ADRP. Two stations were located near Crossfield, north of Calgary, and one at Fortress Mountain, south of Calgary (Figure A4). Data collected from these locations showed similar annual averages between 345 and 349 ppm; this compares well with the published global value of about 350 ppm.

Precipitation quality is monitored on a monthly basis by Alberta Environment at 12 stations located throughout the province (Figure 3). Precipitation samples are routinely analyzed for various ions. Uncontaminated precipitation is slightly acidic (pH of 5.6) due to the presence of carbon dioxide. The pH of precipitation samples collected in 1989 by Alberta Environment indicated that the Northeastern sector of the province generally had the most acidic precipitation (lowest pH). A pH of 4.7 was recorded as an annual volume weighted average at Fort McMurray. Maximum wet sulphate deposition rates were recorded in Calgary and Cold Lake where values of 7.8 kilograms/hectare/year (kg/ha/yr) and 7.2 kg/ha/yr were recorded, respectively. These values are well below the objective for Eastern Canada of 20 kg/ha/yr for wet sulphate, which was established to protect moderately sensitive aquatic ecosystems. For 1987, the highest acidifying potential in the province was observed at the Edmonton precipitation monitoring station where a value of 8.1 milliequivalent per metre squared per year (meq/m^2/yr) was recorded. This value is slightly less than the lower limit of the interim acid deposition critical loading value of 12 meq/m^2/yr recommended for Western and Northern Canada. The next highest acidifying potential values were also recorded at Red Deer (1.2 meq/m^2/yr) and Cold Lake (0.04 meq/m^2/yr).

On a routine basis, no dry deposition rates are being measured owing to the complexity and cost of the equipment and techniques required. Dry deposition was measured, however, during the two years data was collected by the ADRP.

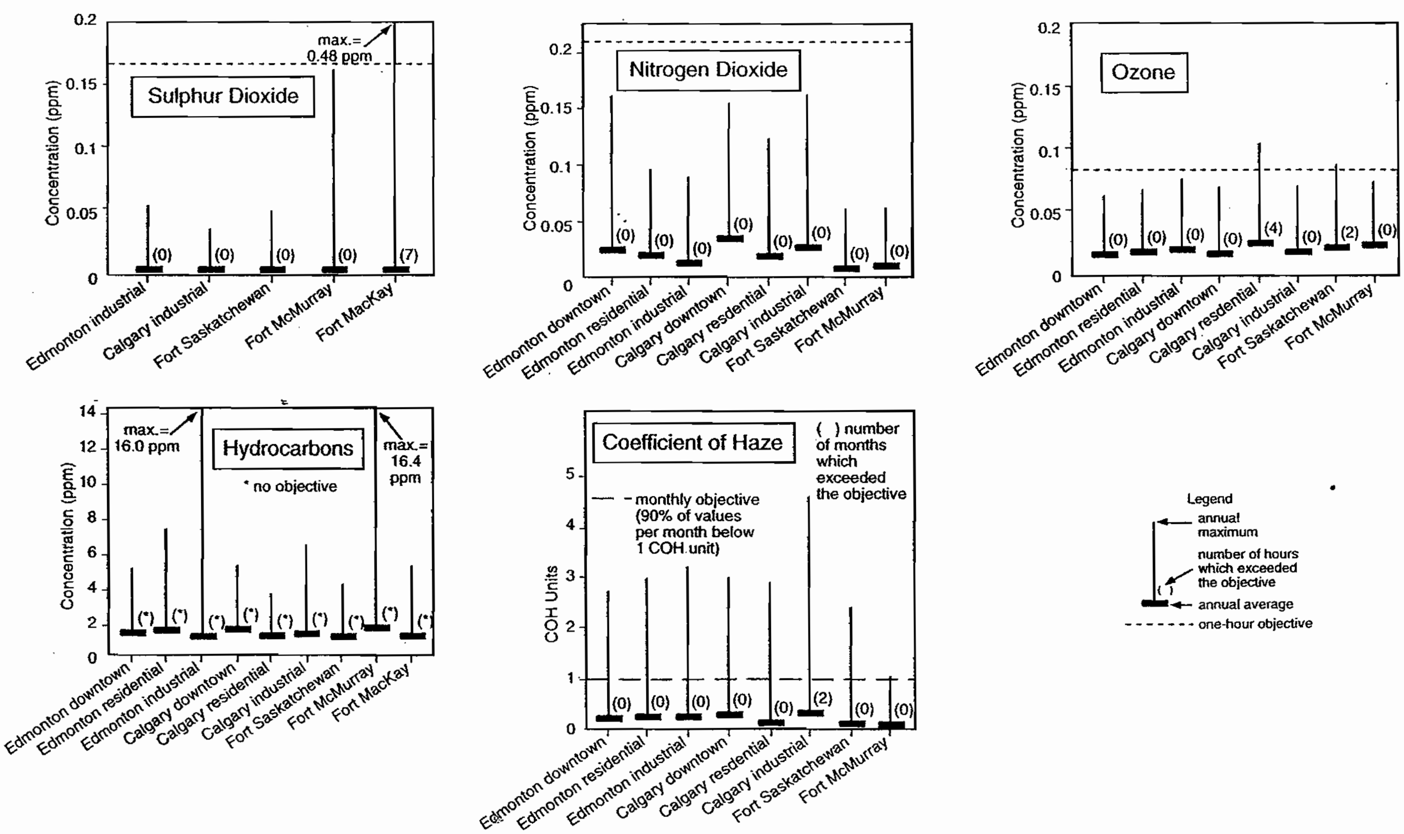


Figure 5. Average and maximum concentrations at Alberta Environment monitoring stations in 1989

The lowest rate of sulphate deposition was at Fortress Mountain with 3.7 kg/ha/yr and a dry-to-wet deposition ratio of 0.5. The highest rate of sulphate deposition was at the Crossfield East air quality monitoring station with 17.7 kg/ha/yr and a dry-to-wet ratio of 1.6. The Crossfield West air quality monitoring station was intermediate at 14.6 kg/ha/yr and a ratio of 1.5. Model estimates for other regions of Alberta gave ratios of dry sulphate to wet sulphate deposition ranging from 0.5 at Beaverlodge to 2.0 at Cold Lake. Earlier measurements near Edmonton gave a ratio of 4.8, while long-range transport models gave ratios between 0.7 and 3.2 with an average of 1.9.

Odour is one of the most commonly reported environmental complaints in Alberta. In 1989, 532 odour complaints were received by Alberta Environment, which was about 25 per cent of the total complaints received. Many atmospheric pollutants can cause odours, depending on the concentration of the pollutant and the sensitivity of the receiving individual. Volatile organic compounds and air toxics can lead to odour complaints, as can nitrogen dioxide, hydrogen sulphide, sulphur dioxide, mercaptans, ammonia and hydrocarbons. Odour is a common complaint in areas that are located close to industrial activities. For example, in the Fort McMurray and Fort MacKay regions, 162 odour complaints were received by Alberta Environment in 1990. An odour response program has been initiated in that area to follow up on these complaints.

Atmospheric contaminants have the ability to absorb, scatter or reflect light and interfere with visibility. The soiling index, or coefficient of haze (COH), is a measure of particulate matter (dust and smoke) in the atmosphere which may reduce visibility. Although the actual visibility of atmospheric pollutants is not measured by Alberta Environment, the department does monitor the COH on a continuous basis at eight locations in Alberta. Alberta Environment has established a guideline that 90 per cent of the COH readings per month are to be less than 1.0 COH unit. Exceedances of the guidelines for COH were recorded in January and November 1989 at the Calgary industrial monitoring location (Figure 5). The guidelines have not been exceeded at any other Alberta Environment monitoring station. High values are much more frequent at the Edmonton and Calgary monitoring stations than at the Fort Saskatchewan and Fort McMurray monitoring units.

3.3 Present and Potential Effects of Emissions in Alberta

General effects of gaseous emissions are discussed in Section 1.0 and initiatives to deal with them are described in Section 2.0. This section reports the principal results of studies on the present and potential effects of emissions in Alberta. According to the World Health Organization, "health is a state of complete physical, mental and social well-being, not merely the absence of disease or infirmity." The effects of gaseous emissions on the well-being of a person can be classified as psychological or biological, adverse or non-adverse, reversible or irreversible. It is also known that some individuals are more susceptible to effects than others. Thus, local health concerns can arise even when ambient air quality is such that the general population would not experience any effect.

Most of these health concepts can also be extended to apply to an ecosystem. For the purposes of this document, an ecosystem is defined as any unit that includes all of the organisms in a given area interacting with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity and material cycling within the system. Due to the inseparable nature and interdependence of the components of ecosystems, any change that occurs in one component potentially affects all components of that ecosystem. Thus, small amounts of gaseous emissions entering a system containing sensitive species may induce disturbances leading to deterioration of the ecosystem.

3.3.1 Acid Deposition

The Acid Deposition Research Program (ADRP)

The Acid Deposition Research Program was formed in 1983 as a result of more than 10 years of work to study and address the environmental consequences on the environment of acid forming gases. It was also designed to provide a scientific basis for sound, long-term environmental management and regulatory control with respect to these gases. Joint funding for the program was provided by the Alberta government and industry.

The biophysical research component of ADRP concluded that in several areas of the province identified as being sensitive to acid deposition, increased industrialization would increase the environmental risks due to the associated pollution. Regional-scale impacts of acid deposition on crops, soils and surface waters were not demonstrated, and were likely absent at the time the research was completed. The possible exception was the prediction of a slight reduction in alfalfa growth (yield) northwest of Edmonton. Future potential large increases in the average level of acid deposition, however, were judged to be a threat to alfalfa and other similarly susceptible vegetation in areas that experience high concentrations of ozone. It was further noted that such increased deposition of acidic and acidifying pollutants could lower the pH of soils and surface waters in susceptible areas, principally those associated with forests. Appendix 2 contains a more complete account of ADRP findings.

The background monitoring station operated by ADRP at Fortress Mountain found that on more than 280 occasions over the 24-month monitoring period, the ambient ozone concentration exceeded the 0.08 ppm one-hour air quality objective/standard for Alberta. It was concluded that the majority of these high ozone concentrations were neither generated locally nor were they due to direct stratospheric intrusion, but rather were the result of long-range transport from British Columbia and the State of Washington, U.S.A.

The Acid Deposition Research Program noted that with respect to alfalfa yield reduction, exposure to sulphur dioxide and elevated ozone levels could have an additive or enhanced effect. Both the ADRP and earlier studies found that rural remote sites in Alberta experience relatively high ozone concentrations typical of the mid-latitude troposphere. High elevation sites often have annual averages of 0.03 to 0.04 ppm, compared to about 0.02 ppm at lower elevations.

The Medical Diagnostic Review (MDR) component of ADRP reported two main results. First, the study team did not detect evidence to perpetuate the concerns about excess mortality, high rates of cancer, diminished respiratory function, dangerous levels of trace metals in the body, higher rates of miscarriages, stillborns and birth defects, and delayed or abnormal childhood development. Second, with respect to symptoms or how people feel concerning possible contamination of their environment, there was a small difference which suggested greater concern and more awareness of health among residents in the study area.

Western and Northern Canada Acid Deposition/Long-Range Transportation of Atmospheric Pollutants Program (LRTAP)

In 1980, the governments of British Columbia, Alberta, Saskatchewan, Manitoba, Northwest Territories and Canada adopted an acid deposition management strategy for the protection of sensitive ecosystems. This strategy contained four basic elements:

- ▲ determining the sensitivity of the Western and Northern Canadian environment to acid deposition;
- ▲ establishing target loadings that are suitable for the sensitivity of this environment;
- ▲ monitoring to ensure compliance with the targets; and
- ▲ establishing emission management plans as necessary.

A coordinated research and monitoring program to address these elements was started in 1982, and the accomplishments are shown in Table 3-3.

Acid deposition is linked closely to medium- and long-range transportation of gaseous emissions. During the period of transport from the source to the receptor, chemical transformations take place, leading to the formation of acids and acidifying substances. This means that wet deposition will affect ecosystems at great distances from the source. Measurements at Cree Lake, Saskatchewan, have detected sulphur from Alberta's oil sands plants near Fort McMurray. Computer modelling suggests that more than three-quarters of the sulphur emissions from Northeast Alberta leave the province. Because of wind patterns, Saskatchewan, Manitoba and the Northwest Territories all receive deposition from these sources. The ecosystems in the receiving areas are all classified as highly sensitive. Strong concerns for the potential effects of acid rain in Northeastern Alberta and Northern Saskatchewan surfaced during the Alberta Energy Resources Conservation Board hearings on the Esso Resources Cold Lake Heavy Oil Recovery Project in November 1978.

Table 3-3. Summary of Western and Northern Canada Acid Deposition/LRTAP Program, 1981-1991

Goal	Accomplishments
Determine Sensitivity	- soils and geology sensitivity mapping (1988) - surface waters sensitivity mapping (1988)
Establish Target Loadings	- interim critical loading report (1990)
Monitor for Compliance	- provincial wet deposition networks - federal deposition monitoring expanded to Manitoba, Saskatchewan and Alberta
Manage Emissions	- emissions inventory (1986) - Atmospheric Environment Service model applied to Western Canada (1984) - medium-range (mesoscale) modelling task group (1985) - statistical and Lagrangian models tested (1989, 1990) - control technology options for acid gas emissions (1987) - application of Lagrangian mesoscale model to limit source emissions using critical loadings in terms of acidifying potential and effective acidity (under way)

Source: Western and Northern Canada Acid Deposition/LRTAP Technical Committee, 1989.

3.3.2 Nitrogen Oxides, Volatile Organic Compounds and Ground-Level Ozone

The effects of nitrogen oxides on native vegetation near compressor installations in Alberta were studied in the mid-1980s. Pine seedlings were exposed to concentrations equal to Alberta's ambient air quality objective; increased photosynthesis was observed but no visible symptoms of damage developed. Field surveys of vegetation near compressor installations found no visible symptoms attributable to nitrogen oxides, although visible injury related to sulphur dioxide, hydrocarbons and salt was observed. When mixtures of gases are present, the visible injury threshold for the most sensitive plant species is much lower. For example, when nitrogen oxide combines with sulphur dioxide, injury will occur at concentrations of one-quarter and one-half the ambient objectives, respectively. No research on the effects of gas mixtures has been carried out in Alberta.

During the cold part of the year, Alberta's cities act as sinks for background ozone through the reaction with nitric oxide to form nitrogen dioxide. Recent studies show that under warm, stagnant conditions, photochemical ozone is produced downwind of the cities. In the presence of natural VOCs, this can lead to elevated levels of the other types of oxidants in smog. Rural ozone can be generated from the interaction of

VOCs with nitrogen oxides in the presence of sunlight. Model results show that with rural nitrogen oxide levels below 1 ppb, production of ozone will be small even if substantial amounts of VOCs are present. Under these conditions, elevated ozone levels occur only when polluted air is moved by the wind from urban areas. However, at higher levels of nitrogen oxides, substantial ozone concentrations can be generated with modest levels of VOCs. Alberta has relatively high total nitrogen oxide emissions, but the sources are quite widely dispersed with a lower percentage of emissions found in the large urban areas as compared with any other province. The ADRP predictions of concentrations of nitrogen oxides in Alberta showed that a large portion of the province, from Lethbridge to High Prairie, would have concentrations of nitrogen oxides greater than 1 ppb. Thus, there is a potential for rural Alberta to experience photochemical smog given sufficient VOC emissions from either natural or man-made sources. The effects of photochemical smog on vegetation and human health are described in subsection 1.2.

3.3.3 Global Warming

The subject of climate change has been debated by scholars and others for hundreds of years. Most of the interest in Alberta, as in other agricultural areas, was focused historically on the occurrence of drought. Alberta studies and publications from the 1970s generally examined a variety of natural causes for climatic fluctuations, with land-use changes and pollution viewed as being relatively minor additional disturbances. In the 1980s, however, it became apparent that increasing emissions of greenhouse gases could potentially produce climate change of unprecedented magnitude and rate. Data from some 250 Alberta climatological studies carried out from 1975 to 1986 have been synthesized. From this synthesis, a number of gaps have been identified in the understanding of the linkages between climate and the activities of Albertans.

A preliminary study of the Alberta fossil fuels industry by Alberta Oil Sands Technology and Research Authority (AOSTRA), *The Greenhouse Effect and the Alberta Fossil Fuels Industry*, suggests that international action taken to limit emissions of greenhouse gases would benefit the natural gas sector, but the coal and oil sectors would suffer reduced markets.

The Environment Council of Alberta published a discussion paper called *Climate Warming? Exploring the Answers*, which provides general information on climate change as well as a background and context for discussion of the issue.

An analysis of Alberta climate records by the Alberta Research Council in *Towards a Strategy for Adapting to Climate Change in Alberta* reveals that the 1980s were warmer than normal by 0.2° to 1.4°C, depending upon location. As well, a longer-term warming trend, with an average increase up to 1.3°C per century, was also detected. No consistent changes in annual precipitation were detected.

The *Literature Review on the Greenhouse Effect and Global Warming*, also produced by the Alberta Research Council, examines 501 publications and finds most supported a predicted global temperature increase of 3.0° to 3.9°C, with a somewhat greater (i.e. up to 6°C) predicted warming at higher latitudes, for a doubling of carbon dioxide. The Intergovernmental Panel on Climate Change's (IPCC) report, however, emphasizes the scientific uncertainty surrounding these predictions and suggests that the best estimate of the predicted global temperature increase for a doubling of carbon dioxide is 2.5°C. Furthermore, the IPCC points out that there could be a delay in realizing this temperature increase because of heat storage in the oceans. Thus, the realized temperature increase, at the time when the atmospheric concentrations of greenhouse gases becomes equivalent to a doubling of carbon dioxide, should only be about 1.5° to 2°C. Most of the 501 publications reviewed in the Alberta Research Council report suggest that the concentration of greenhouse gases will reach an effective doubling of carbon dioxide by about 2050, but few of the papers referred specifically to Alberta.

The Alberta Research Council also analyzed results from three General Circulation Models (GCMs) and concludes that under a doubling of carbon dioxide, Alberta would, on average, be 3° to 7°C warmer and would receive, on average, 7 to 30 per cent more precipitation resulting in a climate similar to present-day Colorado. Some GCM results suggest decreases in precipitation in the summer months. It has been suggested that an increase in precipitation of 10 per cent or more would be required to offset the increased evaporation due to warmer temperatures. It is not known how climate variability would change if atmospheric carbon dioxide doubles. The best available estimates suggest a decrease in year-to-year temperature variability and an increase in annual precipitation variability.

The potential impacts of climate change on Alberta's economy are difficult to predict because many of the linkages between economic activities and the climate are not well-known or they are related to climate variables which are not predicted by GCMs. With respect to agriculture, Environment Canada predicts, in its *Climate Change Digest — The Effects of Climate and Climate Change on the Economy of Alberta*, that a doubling of carbon dioxide would change the extent and distribution of ecoregions, as follows:

- ▲ productivity of grassland regions would be halved because of changes to arid grassland;
- ▲ the aspen parkland would become grassland;
- ▲ the boreal mixed wood region would become grassland; and
- ▲ the total agricultural land area would increase by 28 per cent.

Assuming the average production per farm (in constant dollars) remains the same, the total provincial number of farmers supported would remain effectively unchanged and the total value of agricultural production may diminish by five per cent.

Regionally, however, there would be significant impacts. Table 3-4 shows the implied regional change in the number of farms and agricultural production within the province as a result of changes in productive capacity. The number of farms in Southern Alberta would decrease to approximately half, while the boreal mixed wood region in the north would increase by 50 per cent. However, this simple analysis does not account for the probable adaptive strategies that would be used by farmers through changing crop types and varieties, irrigation, etc., which could mitigate the potential adverse impacts in Southern Alberta. This analysis also does not consider whether the quality of the soil in the boreal mixed wood region could support agricultural activity. In addition, there would be substantial costs and environmental impacts associated with clearing and breaking new land, transportation to market and changes in infrastructure.

Table 3-4. Projected impact of carbon dioxide doubling on farming in Alberta

	Number of Farms		Value of Average Farm Production (dollars)	
Region	Current	Projected	Current	Projected
South	14 735	8 314	1 163 000	582 000
Central	21 702	14 731	1 652 000	1 006 000
North	21 340	34 100	1 185 000	2 387 000

Source: Climate Change Digest — The Effects of Climate and Climate Change on the Economy of Alberta, Atmospheric Environment Service, Environment Canada, 1989.

While there are historical linkages between climate and forestry, the main linkage is a relationship between forest fire occurrence and precipitation. The distribution of precipitation over the year is of equal or greater importance than the total quantity. The expansion of the grassland area northward and the resulting reduction in a real coverage of the boreal mixed wood region in Alberta suggest a significant timber loss is probable in forest development. The expected increase in biomass production due to the enhanced carbon dioxide atmosphere will offset this slightly.

4.0 WHAT ARE THE ALTERNATIVES?

4.1 Response Alternatives

There are numerous possible responses by government, industry and the public to the issues of atmospheric emissions. Since air quality concerns range in scale from local to global, and it is likely that problem-specific responses will be required, this section discusses the various alternatives within the full spectrum of possible responses.

4.1.1 Business-as-Usual Response

One course of action for Alberta is to maintain current practices. Existing environmental standards would continue to be enforced and there would be no efforts to control air emissions further. Table 4-1 provides a forecast of Alberta's emissions, assuming there are no new emission reduction initiatives.

Table 4-1. Forecast of Alberta emissions

Type of Emission	1990 (in kilotonnes)	2000 (in kilotonnes)	Percentage Increase
SO_2	590	713	21%
NO_X	475	532	12%
VOCs	176	170	-3%
CO_2	129 000	172 000	33%
CH_4	——Adequate data is not available——		

Source: Alberta Energy, 1991.

This forecast assumes no implementation of proposed control measures such as the *NO_X/VOC Management Plan*, a sulphur dioxide cap (either nationally or for the Western provinces), or a carbon dioxide target such as stabilization. Reductions in emissions of NO_X and VOCs, expected as a result of discussion on the national *Management Plan for NO_X and VOCs*, are addressed in Section 3.0.

While business-as-usual is a possible alternative, public and industry input to the Clean Air Strategy indicate some form of action is required. Further, while there is debate about the extent and magnitude of environmental damage from current emissions in Alberta, there are indicators that point toward future problems if emissions continue to increase. For example, transportation-related emissions now produce ozone levels in Edmonton and Calgary that exceed standards several days a year — and transportation fuel use is growing. In Northeastern and Northwestern Alberta, there are some localized areas of high SO_2 levels that are causing public concern.

The business-as-usual case serves as a baseline for measuring the impact of any future action that might be taken. In that sense, it is important to know the current level of emissions and to estimate expected growth patterns within the economy.

4.1.2 Reducing the Uncertainties

A large degree of uncertainty surrounds the potential timing and magnitude of global warming and its impacts. Although much is known about the causes and effects of acid deposition and smog, some details required to develop and choose cost-effective actions to reduce problems are unknown. Thus, a reasonable course of action is to try to reduce the uncertainties surrounding these issues, while at the same time monitoring changes in the composition of the atmosphere and the environment.

The uncertainties surrounding the issues of acid deposition, global warming and smog can be grouped under the following:

- ▲ chemical constituents of air and air chemistry processes;
- ▲ effects on health, ecosystems and property of the various chemical constituents, both separately and in combination;
- ▲ status, consequences and risks of changing air quality;
- ▲ technology and management practices for reducing emissions and improving air quality; and
- ▲ economic costs and benefits associated with improving air quality and definition of least-cost options for meeting specific environmental objectives.

The more these uncertainties are reduced, the more confidently cost-effective actions can be defined and chosen. Appropriate monitoring of the atmosphere and environment can improve understanding of the issues, and would provide the basis for corrective actions as knowledge increases.

4.1.3 Adaptation Response

Another response is to adapt both environmentally and economically to increasing emissions. This is particularly relevant to possible climate change from man-made greenhouse gases, but could also apply to acid deposition.

Adaptation to climate change has consequences for forest management, which could see a northward shift in forest ecosystems and a change in native species. While Alberta has a diverse forest ecosystem, it takes decades to implement changes in forest species. Similarly, agriculture may undergo a northward shift as a result of global warming, although this shift may be limited by soil capability. Southern agricultural regions may become unsuitable for certain crops, but new crops could possibly be grown there. Thus, there may be some agricultural benefits to Alberta. Biological diversity may come under stress as ecosystems struggle to adapt.

Some of the same ecosystems might serve as sinks for emissions; however, the role of forests has not yet been fully assessed. In addition, agriculture and forestry have the potential to generate significant biomass as an alternative to fossil fuels. Adaptation to climate change could mean learning to maximize the benefits and minimize the negative effects of global warming.

Of all the potential responses, adaptation is the most complicated and the least understood. The environmental effects resulting from changes in air quality and climate on ecosystems are not clear. Further, if past emissions have already ensured the occurrence of future global warming, some degree of adaptation may already be necessary. However, it should be realized that adaptation already occurs to a certain degree, as humans respond to the variations that are part of the normal climate.

Planning and research are needed to better understand the role of adaptation responses to a changing environment. Because of the many uncertainties, however, it is not practical to assume that adaptation alone will provide adequate responses to increasing atmospheric emissions. For example, adaptation will be of little assistance in resolving local problems such as urban smog.

4.1.4 Reducing Emissions

Within Alberta

Much of the discussion and analysis in the Clean Air Strategy for Alberta has focused on managing and, where needed, reducing emissions in Alberta. Participants at the Regional Sessions and the individuals and organizations who provided written submissions have indicated that local air quality problems must be addressed as a priority. In addition, there are other reasons to look for opportunities to reduce emissions within Alberta. Oil and gas development and Alberta's coal-fired thermal power generation contribute to relatively high carbon dioxide, sulphur dioxide and nitrogen oxide emissions when compared to other provinces. Consequently, Alberta is seen by many to have a responsibility to reduce its emissions.

Outside Alberta

To help address regional and global atmospheric issues, Alberta could consider helping other governments to reduce emissions outside the province. This approach to reducing emissions, particularly carbon dioxide, could provide Alberta with more cost-effective emission reduction opportunities than those available within the province. Alberta, as an exporter of energy and as a centre for energy technology has much to offer other regions in Canada and other countries to help them reduce emissions.

Regionally, there are opportunities for Alberta to work with the Western provinces and two territories through the recently-signed Western Accord on Environmental Cooperation. On issues such as acid deposition, there may be opportunities for joint environmental activities between provinces, although there is concern that such activities could be delayed due to jurisdictional considerations.

Energy produced for export is responsible for generating about 30 per cent of Alberta's carbon dioxide and a similar percentage of nitrogen oxides. Other provinces could adopt emission reduction measures such as fuel switching from coal or gasoline to Alberta natural gas. This reduces their end-use emissions but, because of emissions associated with the production and processing of the gas, increases Alberta's share. It is important for the provinces to agree on the allocation of the emissions which result from increased hydrocarbon production, or conversely which province should receive credit for end-use reductions. It again raises the question, as to where emissions can best be controlled and what the implications are.

Similarly, on an international scale, Canadian technologies and financial resources might be best applied to emission control in other countries. Developing countries have been asking for change in the rules for the transfer of environmental technology from developed nations. They suggest that pollution control and energy technologies be made available at "non-commercial" or preferential rates. Some Western nations, notably the United States, the United Kingdom and France, have resisted, citing the need to protect intellectual property in order to encourage further technological development. It is therefore important to determine how one nation's emissions could be effectively reduced with the help of another and how the sponsoring nation could receive credit for the resulting emission reductions.

There are many issues associated with interprovincial and international emission reduction efforts. Before any reduction activities could be implemented, extensive discussions, negotiations and research would be required. International agreements could be an important option to achieve significant emission reductions.

4.2 Mechanisms for Reducing Emissions

An effective Clean Air Strategy for Alberta will require cooperative action from all sectors. The range of mechanisms available to these groups to reduce emissions include the following:

- ▲ regulatory instruments;
- ▲ economic instruments;
- ▲ scientific research, technology development and transfer; and
- ▲ information, persuasion and education.

4.2.1 Regulatory Instruments

Regulatory instruments include permits/licences and performance standards.

Regulatory instruments, also known as "command and control" mechanisms, are legislative and administrative rules established by government to provide clear directives concerning behaviour to industry or individuals operating within its jurisdiction. Regulations establish the obligations, responsibilities and rights that are attached to the licence of an operator. Regulatory instruments are particularly effective when there is a localized problem with emissions from one or a small number of isolated facilities. Using the regulatory approach, the government has the option to force a desired action or to penalize or shut down the offending plants. Regulations must be enforced to be effective. However, ambient air quality standards are impossible to enforce all the time because it is difficult and expensive to monitor all the point sources. Results from the Issues and Options Workshop and the Regional Sessions indicate there is a commonly held view that the province does not adequately enforce its environmental standards.

Permits/Licences

In general, Alberta requires companies wishing to construct, modify and/or operate an industrial plant to obtain a permit to construct (or modify) and a licence to operate the plant. The permit to construct (or modify) will specify location, capacity, equipment to be included, technological processes to be used, and other terms and conditions of operating such as source and ambient monitoring and reporting requirements. If the construction is not in accordance with the terms and conditions of the permit, a stop-work order can be issued and fines can be levied. The licence to operate will generally be granted for a specific time period and will specify performance standards or guidelines such as allowable stack emission rates (see below). Upon renewal of the licence to operate, terms and conditions can be renegotiated.

Alberta's ambient air quality objectives identify maximum allowable concentrations of certain contaminants over specified periods of time. The province sets "point source" or "stack" emission limits for each industrial plant emitting any of those contaminants. It is intended that the total emissions of all plants into a particular area or zone, plus the contaminants imported by the wind from outside the zone and the expected emissions from all non-industrial sources, will not exceed the ambient air quality objectives.

Alberta's stack emission limits are based on the best available technology that is economically achievable at the time of construction. Consequently, as technology improves, more stringent limits are applied to new plants. This reflects a fundamental premise of environmental legislation in Alberta that a plant must comply only with the point-source emission limit established for it either at the time of construction or most recent modification or expansion.

Performance Standards

Various Alberta and Canadian laws specify performance or product standards or guidelines that supplement terms or conditions in permits or licences. One example of such a law is the Alberta Clean Air Act, which specifies maximum permissible concentrations of some air contaminants in Alberta. Performance and product (or equipment) standards can be established for many diverse types of technologies, from sulphur recovery equipment at natural gas plants to energy efficiency provisions in building codes, to standards for consumer goods like automobiles and appliances.

A number of provincial governments in Canada have energy efficiency legislation. This type of legislation regulates the efficiency levels of products that are produced and/or marketed within the province. The Canadian Standards Association has developed a number of efficiency performance standards based on input from major stakeholders, including all provincial governments. The Canadian Gas Association has developed efficiency criteria within some standards and is considering more emphasis in this area. In provinces with appropriate legislation, penalties can be levied for non-compliance with these standards.

Until recently, provincial building codes focused primarily on safety. While safety remains the major aspect of building codes, some jurisdictions include, or are considering including, energy efficiency/performance standards.

There is debate over the benefits from improved performance standards. A good example is a fuel efficiency standard for vehicles. Manufacturers of automobiles are guided by the Canadian government's Corporate Average Fuel Consumption guidelines (CAFC). Some groups propose that an effective way to improve the fuel economy of vehicles is to lobby for tighter CAFC standards. According to the Friends of the Earth, "improving auto fuel economy is the single largest action Canada can take to reduce CO_2 contribution to global warming." Others, such as General Motors and Ford, argue that efficiency standards are not effective without the support of high gasoline prices. In a submission to the Alberta government, General Motors said: "the present CAFC program pressures manufacturers to build more fuel efficient vehicles without creating any incentive for consumers to buy them." The position of the Ford Motor Company is that because regulations "apply only to new cars, they do not affect driving costs, and higher fuel economy encourages people to drive more miles." The Alberta Motor Association indicates that a third of the province's vehicle stock is responsible for the majority of harmful emissions, and "the elimination of one pre-1971 automobile is the equivalent of removing twenty-six 1990 models." Thus, the AMA advocates that, as an immediate step toward reducing emissions, Alberta should follow the lead of British Columbia, Quebec and Ontario and establish mandatory vehicle emission testing as a way of ensuring a minimum emission standard is met for all vehicles.

Performance standards could ensure that only new equipment, appliances and buildings that meet the minimum standard enter the market. Such standards can also be used effectively to cause owners to retrofit or remove the least efficient equipment, appliances and buildings from use.

4.2.2 Economic Instruments

Regulations and standards provide a uniform level of control but can be an inflexible way to achieve ambient air quality targets. They do not provide any incentive to reduce emissions below the mandated level. Regulatory controls such as licences often apply uniform standards to different sources of emissions, with little consideration for the different costs of meeting these standards. As well, current Alberta regulations tend to focus on specific industrial point sources of emissions, rather than addressing all emissions on a zone, provincial or regional provincial basis. Economic instruments could help to address these deficiencies. Economic instruments could also be used to encourage the reduction of gaseous emissions.

Economic instruments support the principle that the costs of pollution prevention and control should be reflected in the cost of goods. Ordinarily, the market forces of supply and demand identify all the costs of producing a good or service. These costs could be included in the price charged to the consumers. However, as stated in the February 1990 issue *Energy Economist*, "the principal problem for conventional economics in dealing with environmental issues is that the environment has largely been seen as a free good." Costs associated with the environment are external, in that they are not paid by producers or consumers. Much of the literature reviewed for preparation of the Full Cost Accounting paper (contained in Attachment A — *Background Project Reports*) indicates that prices do not generally reflect the ecological costs in terms of damage to the environment resulting from their production, use and/or disposal.

Economic instruments can be used to compensate for market imperfections as well as encourage more efficient forms of emissions control. They attempt to identify some of the external costs associated with a transaction, so that the party responsible for the cost will be accountable. This is a complex process since it is never possible to identify all the costs of a transaction. As suggested by the Organization for Economic Cooperation and Development's (OECD) Environment Directorate, economic instruments can improve "the allocation and efficient use of natural and environmental resources . . . to better reflect the social cost of using these resources."

Economic instruments include taxes and fees, subsidies and incentives, and tradeable permits.

Taxes and Fees

Traditionally there are three types of taxes or fees used to address environmental problems: effluent fees, user charges and product charges. Although the taxes vary in terms of who and what is taxed; they are functionally identical. All three force producers and consumers to account for the marginal environmental costs associated with the provision of the good or service.

There are advantages to a tax or fee. First, such charges create an economic incentive for industry or consumers to reduce emissions. This encourages the reduction of emissions in an efficient manner, since firms or individuals want to minimize cost by reducing emissions as much as possible and at the lowest cost. Taxes and fees also create an incentive for industry to develop pollution-reduction technology to reduce future tax payments. This encourages emission reductions because firms and individuals would seek to minimize the total cost of emitting (i.e. they would likely implement any emission reduction options available that cost less per unit emitted than the tax or fee). Another advantage of a tax or fee is that it generates revenue. Some resulting revenues could be applied to environmental objectives. As tax collection infrastructures exist, a pollution tax could be implemented almost immediately and at relatively low cost.

Taxes and fees also have significant disadvantages. The primary difficulty is the determination of the rate. Too low a rate would be ineffective because it would fail to provide sufficient incentive to reduce emissions to the desired level. Too high a rate could force industry out of business or drastically alter individual income, and risk damaging the economy. Even if a rate could be determined, the problem of identifying the proper object to tax would remain. For example, to encourage energy conservation, Ontario recently raised its sales tax rate on fuel-inefficient vehicles. However, a tax targeted directly at fuel use might be more effective because it is closer to the item the government wishes to discourage (i.e. emissions). Another disadvantage of taxes and fees is that total emissions may rise despite the extra cost. For example, as an industry expands the number of polluting agents increase and the total amount of effluent or emission may increase despite the tax.

Subsidies and Incentives

Subsidies and incentives are forms of financial assistance that governments use to encourage the use of certain energy sources, technologies or procedures. Subsidies and incentives often take the form of tax rebates, grants or loans.

Subsidies and incentives have the advantage that they may succeed where other forms of economic instruments are inapplicable. For example, some industries may be unable to pay the costs of compliance imposed by other schemes such as taxes. It may be more efficient from society's point of view to encourage the industry to alter its pollution habits by using financial incentives rather than suffering the economic repercussions of shutting down the industry.

An obvious disadvantage of subsidies and incentives is that they require public funding. Another disadvantage is that they may treat some firms unfairly. For example, some industries could be disadvantaged if required to comply with costly emission-reduction programs while their competitors' emission reductions are subsidized. Another concern is that subsidies and incentives could actually increase emissions in the long run. If the subsidy or incentive is too high, it may make the industry profitable enough to encourage new entrants. As more companies enter the industry, total industry emissions would increase.

Tradeable Permits

Under a tradeable permit system, government fixes the total amount of a pollutant that can be emitted within a region. The government then issues permits for the total allowable emissions for that region. The specified permits can be bought, sold or traded by existing or new industries.

Tradeable permits offer several advantages. The primary advantage is that, like taxes, tradeable permits encourage emission reductions at a lower cost to society than subsidies or regulations. Because permits can be sold, holders of permits will attempt to find ways to reduce emissions so they can sell their permits at a profit. This ensures that both present and future emission-reduction costs are minimized. A unique advantage of tradeable permits, is that they ensure target levels of total emissions are attained. While the emissions of any firm are variable because of trading, the total amount of pollutant emitted in the region is fixed at the capped level.

Establishing a reasonable cap requires consideration of a number of factors, as does setting ambient air quality objectives for regulatory instruments. Different regions may have different sensitivities and therefore may require different emission caps. However, if caps are set for regions with very few emitters, then a tradeable permit system is not as likely to be effective because of the limited number of potential buyers and sellers.

Tradeable permits have other potential disadvantages. There must be a sufficient number of firms emitting a contaminant to sustain a competitive permit market. An uncompetitive market could allow some firms to dominate the emission-trading market. Moreover, since tradeable permits have not been used in Canada, it would be necessary to establish an infrastructure to administer the scheme.

In summary, economic instruments that act to channel market forces can be a powerful means of tapping the creativity of the private sector to achieve environmental objectives in cost-effective way. The closer an economic instrument is to the environmental concern it seeks to affect, the more efficient the program can be. While market instruments offer many advantages, they are not necessarily the most effective policy instrument in all situations. Much depends on the nature of the environmental problem and administrative considerations. In some cases, regulations could be the most appropriate or cost-effective approach. In others, economic instruments could achieve the environmental goal in a more cost-effective manner, and therefore are appropriate substitutes.

4.2.3 Research, Technology Development and Transfer

The impact of increased concentrations in the atmosphere of gases such as carbon dioxide, sulphur dioxide and methane, range from relative certainty (e.g. acid deposition on buildings) to uncertainty (e.g. global warming). Reducing the uncertainties through research would allow more appropriate environmental objectives to be defined and more cost-effective actions to be prescribed to achieve such objectives.

Emissions of greenhouse, acid and smog-forming gases could initially be reduced most effectively and inexpensively through energy conservation and efficiency. Renewable energy sources and fuel switching could yield further reductions in these gases. However, the goal recommended by the Toronto conference to reduce emissions of carbon dioxide by 20 per cent from 1988 levels by 2005 can be achieved at reasonable cost only in some countries. The development and implementation of new technology may be essential for meeting environmental goals in those jurisdictions.

It is important to determine who should pay for such research and technology development. Opinions on who should bear this burden range from polluters to consumers to taxpayers. Regardless of who pays, there has been a strong indication from the public that ongoing research, technology development and transfer should be an essential part of the Clean Air Strategy for Alberta. Many who participated in the Clean Air Strategy for Alberta consultation process pointed to the need to appropriately prioritize and coordinate research and technology development activities, in order to ensure maximum returns on development investments.

Scientific Research

There are numerous knowledge gaps with respect to the science of air quality issues that, if filled, would aid decision-makers at all levels in setting directions to manage air quality.

To many, the focus of the Clean Air Strategy for Alberta should be on how the quality of air affects health and what has to change in the areas of energy production and use to maintain and improve human health. There is a need to identify, quantify and monitor the presence and effects of substances that may be a factor in human and environmental health.

The Alberta government/industry Acid Deposition Research Program (ADRP) showed that regional air quality in Alberta is highly variable, and that point source and urban air quality monitoring alone is not adequate to protect the atmosphere in Alberta. There is a need to characterize and quantify the air quality chemistry and the meteorological, industrial and chemical processes that produce that air quality chemistry in the different regions of Alberta. This includes defining, quantifying and monitoring all sources and sinks of relevant chemicals. A comprehensive monitoring system, which includes rigorous quality-control procedures, is required. Research into cause-and-effect relationships of gaseous emissions on human health and ecosystems, as well as the life-cycle impacts of such gases (particularly when combined with other chemicals) is in its infancy and needs to be accelerated.

The environment is composed of many components that are interrelated and in a constant state of flux. These components and their effects need to be integrated to develop an overall assessment of air quality and of the impacts of changes in air quality. This integration requires ready access to comprehensive data bases and tools for integrating and assessing such data.

Socio-Economic Research

A frequent theme in Clean Air Strategy for Alberta discussions was that economic aspects must be considered in developing a strategy. This means that measures adopted to meet environmental objectives must be cost-effective and Canada's and Alberta's competitive position in the world economy must not be damaged. There is a need to quantify the risks, as well as the environmental, societal and economic costs and benefits, of both action and inaction to meet environmental objectives. There is also a requirement to develop tools to help choose the most cost-effective course of action, and to estimate the effect, both benefits and costs, on society, our economy and our position within the global economy. Mechanisms for choosing positions on issues such as "how big a risk is acceptable" or "who should bear the costs" are also required. Such techniques, tools and mechanisms are developed through socio-economic research.

Socio-economic research can be complex, requiring the use of sophisticated mathematical models. At present, there is a lack of consensus regarding what variables and data should be used in models, and how the data should be manipulated by the model. Further research aimed at resolving these and other issues would be necessary to refine socio-economic instruments.

Technology Development

Research would provide insight into the problems facing the environment today, while technology would provide guidance toward solutions. Technology is of two general types: hard and soft.

Hard technology refers to physical innovations developed to solve specific problems. In the context of gaseous emissions, hard technology could include devices that reduce the amount of emissions from a particular source. For example, the fuel injector helps reduce gaseous emissions from automobiles.

Soft technology pertains to management systems. While hard technology reduces emissions by changing what society uses, soft technology is the way that society uses what it has. A hard technology solution to automobile emissions may be the development of an engine that emits fewer pollutants. A soft technology solution to the same problem might be the promotion to induce people to drive less.

Energy conservation and efficiency can be reflected in cost-effective ways to reduce emissions. Development of new technology (either hard to increase energy efficiency or soft to increase energy conservation) would help. Conservation and efficiency alone are insufficient to meet some emission-reduction goals being discussed, and they may not be cost-effective in some cases. Renewable energy sources and other non-fossil fuels could provide further emission reductions. New technology could also increase supplies of such energy resources and their cost-effectiveness. Success in meeting some longer-term environmental objectives appears to depend upon the development of new technologies for capturing, removing, disposing and using carbon dioxide and other greenhouse gases such as methane. New technologies could also assist society in adapting to climate change.

The prevention of global warming is not just a potential burden, it is also an opportunity. The Federal Republic of Germany made a commitment to reduce carbon dioxide emissions by 25 per cent by the year 2010, based on the report of its Ministry of Economics, which declared that this would be the vehicle to ensure German ascendancy in international trade and exports in high technology for the next 20 years.

Technology Transfer

While acid deposition and smog are problems that can be corrected through actions undertaken in Alberta, the emission of man-made greenhouse gases is a global problem that requires global solutions. Comparisons of inventories of greenhouse gas emissions from human sources suggest that Canada's net contribution from all sources currently stands at about 1.6 per cent of total global values. This suggests that actions taken by Canada alone to control the emission of such gases will be relatively insignificant in solving the global warming problem. Therefore, the question arises as to how Canada can encourage cooperative action among nations to provide a global solution.

One approach Canada could take is to develop technology that will help solve the problem. The new technology could be made available to other nations, in particular developing countries which do not have the resources to develop such technologies themselves. This approach may be the most cost-effective way to contribute to solving the global warming problem. It would also allow Canadian industry to turn a problem into an opportunity by developing products for, and markets in, developing countries.

4.2.4 Information, Persuasion and Education

The results of the Clean Air Strategy for Alberta Regional Sessions indicate that few Albertans understand the risks associated with energy-related emissions and how their personal actions contribute to the problem. For Albertans to be effective stewards for future generations, it is vital that well-informed decisions be made.

Learning is a lifelong process. It involves synthesizing experiences to develop values, beliefs and understanding. For some individuals or businesses, it may be enough to provide them the relevant information at the appropriate time and know that it will result in a better-informed decision. In some cases, the party may be well informed but may require encouragement to actually make the decision. This is often accomplished by providing a non-monetary reward (such as recognition) or penalty. In other situations, the undesirable behaviour may be a deeply ingrained part of our culture that would require a long-term investment in education to yield a change in the succeeding generation.

Information

Information can increase the awareness level and knowledge of decision-makers. Providers of information hope that when this information is made available better decisions will result. For example, the U.S. Office of Technology Assessment observes in *Changing by Degrees — Steps to Reduce Greenhouse Gases*: "Lack of information and uncertainty have been identified as key barriers to greater investment in energy conservation. The large number of highly cost-effective investments that are not chosen by consumers indicates that price alone does not stimulate optimal investment decisions."

The following are commonly used examples of information programs:

- publications;
- hotlines;
- exhibits and displays;
- demand-side management programs (informs electrical utility customers of opportunities to save money if they alter their pattern of electrical usage);
- environmental audits;
- energy audits (provide building owners/occupants with information on their energy use and opportunities for saving on energy bills);
- labelling and rating systems (provide consumers with information about energy use and operating costs at the time of purchase);
- benchmark information (such as annual state of the environment reports);
- public access to environmental data (on air quality monitoring data as recommended by Imperial Oil, the Canadian Petroleum Association, the cities of Edmonton and Fort McMurray in their submissions to the Clean Air Strategy for Alberta); and
- funding special events and non-governmental environment groups (encourage Albertans to get together to seek and discuss environmental information).

Many people at the Regional Sessions indicated they felt inundated by the volume of, and confused by the conflicting messages in, environmental information they were receiving. To be effective, information programs must have a clear factual message delivered in a way that is of interest to the target audience. The information should be balanced and, where there is scientific consensus or disagreement, it should be clearly explained. Discussing and exploring various points of view can aid in understanding an issue. Problems should be presented in a manner that leads to solutions. Any environmental information programs resulting from the Clean Air Strategy should be coordinated and designed so they are recognized as coming from a credible source.

Persuasion

Persuasion is the active encouragement of someone to perform a desired action. Such encouragement can range from promotion and publicity to explicit, non-monetary rewards. Persuasion programs can take many forms including:

- promotional campaigns (e.g. *Participaction* and Calgary's Air Improvement Resolution (AIR) program);
- recognition programs (e.g. Alberta's Environment Awards and a voluntary vehicle emissions testing program being considered by Calgary); and
- consumer sanctions (e.g. boycott of fast-food restaurants over-packaging materials).

Such programs can be effective in changing the behaviour of some people. As TransAlta pointed out in its submission to the Green Plan, "*Participaction* changed the way many Canadians feel towards health and physical fitness. With the backing of government and business, a similar national promotion program could be developed to increase public awareness of environmental concerns and outline ways . . . in which individuals can make significant contributions to the environment."

Education

Education is the process of imparting both the factual knowledge and the decision-making tools necessary to use that knowledge. Education must, therefore, lead to the development of knowledge, skills and positive attitudes that will enable the individual to be self-confident, capable and committed to setting goals, making informed decisions and acting in a manner that improves their life and the life of their community. There can be immediate benefits from education, but the most profound effects tend to be long term.

An education program could provide learners with the knowledge and capacity necessary for a critical perspective on the issues and phenomena facing them. It should equip them to develop their own values and opinions by integrating information about science, technology, economic impacts and opposing viewpoints. The outcome of an educational program of this nature is that it could produce a citizens who are willing to make informed and responsible decisions.

The development of an educational program related to the Clean Air Strategy could involve the following components:

- setting clear objectives and specific goals;
- designing the methods for reaching the target audience (including how to integrate the message into existing school curricula);
- developing appropriate resource and information materials;
- pilot programs;
- implementing programs; and
- program evaluation and revision.

An essential element for developing a Clean Air Strategy for Alberta would be the education of Albertans of all ages regarding air quality issues. To have informed and educated citizens, it is imperative to have a program that integrates information, persuasion and education programs into the overall strategy. Few measures would meet success until Albertans understand the need for each action and change their behaviour. Coordinated, integrated programs (e.g. AADAC and Designated Driver) have been found to be effective in changing public attitudes and behaviour.

There are many organizations in Alberta with experience and interest in air quality information, persuasion and education programs. Examples include SEEDS (Society, Environment and Energy Development Studies); Friends of Environmental Education Society of Alberta; TransAlta Utilities; Alberta Environment's Education Branch; Alberta Energy's Energy Efficiency Branch; Energy Resources Conservation Board; Environmental Resource Centre; and the Pembina Institute for Appropriate Development.

4.3 Emission Reduction Opportunities

Notwithstanding questions of scientific and cost uncertainty, the potential environmental consequences of specific, uncontrolled emissions can justify adopting measures that are socially and economically viable now (or in the near term). Additional measures can be adopted in the long term if they are warranted.

The most attractive measures are those that are cost-effective, serve multiple social, economic and environmental purposes, are flexible and phased in (so that they can easily be modified in the light of new information), are compatible with economic growth and are administratively practical.

4.3.1 Technology Areas for Emission Reduction

There is no single, quick-fix technological solution for reducing emissions from energy production and use. Rather, a comprehensive strategy is required that takes advantage of behavioural and operational changes to encourage the development, implementation and penetration of a variety of desirable options. Technology options that can help reduce energy-related emissions can be categorized as follows:

- energy end-use reduction measures;
- energy efficiency measures;
- fuel substitution measures;
- renewable energy measures; and
- emission capture and recovery measures.

Energy End-Use Reduction Measures

Energy end-use reduction measures are those that reduce demand for energy at the point of use, primarily by changing behaviour so less energy is consumed. Simple examples are turning down thermostats or using public rather than private transport. For individuals, this often means lifestyle changes. For business and industry, it often affects operational practices and, occasionally, technological processes.

Examples of such measures are in Table 4-2. The table also provides an estimate of the current viability of the reduction measures. These measures are classified as either short-term (available within five years) or long-term (requires further development and will only be available only after more than five years).

Energy Efficiency Measures

Energy efficiency measures are those that achieve the same amount of output with less energy input. Many efficiency measures appear to be practical now, and would have the effect of reducing individual expenditures and increasing industries' competitiveness. Even though numerous efficiency opportunities exist, there are economic (e.g. the requirement for capital investment) and infrastructure barriers, which must be addressed if these opportunities are to be explored to their full potential. Examples are in Table 4-3.

Fuel Substitution Measures

Fuel substitution generally refers to the replacement of energy sources which produce high levels of emissions with those with lower or no emissions. There are strong technological linkages between emissions of various pollutants, so fuels which restrict the emission of one type of gas often reduce the emissions of other gases. When considering carbon dioxide, fuel switching or substitution generally means replacing high carbon-emitting fuels, such as coal, with lower or no carbon-emitting fuels, such as natural gas or non-fossil fuels. This opportunity is of particular interest to Alberta's electric utilities, which have access to significant coal and natural gas supplies. Opportunities exist to use cleaner coal technology or switch to alternative fuels for new facilities. Examples of fuel substitution measures are in Table 4-4.

Renewable Energy Measures

For the purposes of this discussion, renewable energy sources include hydroelectric, wind, biomass, solar and geothermal. Alberta has significant potential resources of renewable energy. Promising opportunities include:

- liquid fuels from biomass;
- biomass energy use in the forestry sector;
- wind-generated electricity, both grid-connected and off-grid;
- small-scale hydro; and
- solar for space heating and electricity generation (e.g. photovoltaic cells).

These technologies are fairly well developed but face economic and infrastructure barriers. Work needs to be done to encourage the development of the renewable industry in the province if it is seen as a preferred long-term option to meet future energy supply requirements. Examples of renewable energy measures that can reduce emissions of concern are in Table 4-5.

Emission Capture and Recovery Measures

Emission capture and recovery have been successful in some instances, such as the recovery of sulphur from the emissions of sour gas processing plants. Revenue from the recovered sulphur has become an important factor in the economics of such plants. Methane recovery from landfill, coal and oil field operations also has environmental and economic potential.

Some effort has been devoted to capturing and using or disposing of carbon dioxide (e.g. carbon dioxide injection for enhanced oil recovery). The physical properties of carbon dioxide make it difficult to store. Its reactivity is limited, so numerous end uses are not apparent, even if the price of carbon dioxide were reduced to zero. Considerable technology development is required before such measures will be viable.

Measures that relate to the capture, recovery, use and disposal of gases that are emitted through the production and use of energy are listed in Table 4-6.

4.3.2 Constraints

Tables 4-2 to 4-6 provide examples of technological options within each broad category defined above, along with their possible application in the short or long term. The examples are intended only to represent the range of options available. They are not intended to be all-encompassing or to single out a particular sector. The technical, economic and market potential of technological options vary. The technical potential of an energy technology is its capacity to reduce emissions and is largely a function of technical feasibility. Economic potential refers to whether the application is economically efficient and cost-effective, and may be dependent upon such factors as capital cost, relative price of fuels and lack of infrastructure. Market potential refers to whether the consumer or user is likely to adopt the option and may be dependent upon such factors as awareness, attitudes to risk, and presence of non-monetary costs.

It should be noted that the experience gained by Alberta Energy in operating energy audit programs for 10 years has shown that cost-effective measures having a short payback period are not necessarily implemented. Thus, cost-effective measures that make sense in their own right may have low market penetration without some external forces such as regulations or incentives to encourage their implementation. Some constraints that limit the penetration of technologies are also presented in the following tables.

Table 4-2. Examples of energy end-use reduction measures

Energy Sector	Measure	Availability*	Constraint
Buildings	Increase energy conservation in buildings (lights off, thermostat down)	short	requires operational change
	Encourage use of advanced electronic energy management control systems	short	requires new technology
	Improve building design and urban planning	short	requires operational change, new technology
Transportation	Discourage auto use, encourage use of public transport, car pooling, bicycling	short	requires lifestyle changes
	Better urban traffic management	short	requires new technology
Industry (including electricity generation)	Increase recycling and reuse	short	requires operational change
	Encourage conservation through audits	short	requires implementation incentives for good penetration
	Improve operation and maintenance	short	requires operational change
	Increase use of less energy-intensive materials	long	materials need to be developed, made economical and implemented
	Reduce flaring in oilfield operations	long	high cost and requires legislative changes

* Available in the short term means that the technology can be made available for general use within five years. Long term means that it will not be available in five years, but will be later on.

Table 4-3. Examples of energy efficiency measures

Energy Sector	Measure	Availability*	Constraint
Building	Improve efficiency in buildings (energy management programs, energy audit service, improved building construction and appliance standards)	short	high cost and requires new regulation and operational change
	Improve energy storage systems	long	requires new technology
	New food storage systems that eliminate refrigeration requirements	long	requires new technology
	Improve heating, cooling, lighting equipment	short	requires capital investment
	Improve operation and maintenance	short	requires operational change
Transportation	Improve efficiency in transportation (fleet audits, vehicle fuel efficiency standards)	short	requires investment in new vehicles
	Improve technology development in public transport (high-speed inter-city trains, modal shift)	short	requires capital investment
	Improve driver behaviour, traffic management, vehicle maintenance	short	requires lifestyle/behaviour changes
Industry (including electricity generation)	Develop opportunities for co-generation	long	requires new structure
	Alter electricity pricing structures to encourage efficiency	short	review of pricing policy required
	Generate electricity more efficiently	short	new equipment required
	Advanced technologies for storage of intermittent energy	long	new technology required
	Increase heat recovery/district heating and cooling	short	structural changes required
	Improve efficiency in energy production, processing and transportation	short	requires capital investment
	Improve efficiency in non-energy industry, including petrochemical and manufacturing	short	requires capital investment
	Increase the generation of energy from waste	short	requires capital investment
	Improve efficiency standards for electric motors	short	requires legislation

* Available in the short term means that the technology can be made available for general use within five years. Long term means that it will not be available in five years.

Table 4-4. Examples of fuel substitution measures

Energy Sector	Measure	Availability*	Constraint
Building	Improve storage systems for natural gas	long	requires new technology, capital investment
Transportation	Use natural gas or propane instead of gasoline for motor vehicles	short	requires conversion of existing vehicles, new design for new vehicles, new infrastructure, capital investment
	Use synthetic motor oil	short	requires awareness
	Introduce electrical and hybrid vehicles	long	requires development of new technology and new infrastructure
	Use reformulated gasoline	short	high capital and product costs
	Develop hydrogen as a transportation fuel	long	new technology required
Industry (includes electricity generation)	Substitute natural gas in place of coal for electricity generation	short	requires structural changes and a significant increase in operating costs
	Use nuclear energy instead of fossil fuels for electricity generation	long	requires new structures, large capital investment and improved methods for radioactive waste disposal
	Use fuel cell technology	long	requires new technology
	Improve fuel upgrading; upgrade H/C ratio	long	requires new technology, capital investment
	Improved storage systems for natural gas	long	requires new technology and equipment

* Available in the short term means that the technology can be made available for general use within five years. Long term means that it will not be available in five years.

Table 4-5. Examples of renewable energy measures

Energy Sector	Measure	Availability*	Constraint
Building	Increase solar for low grade thermal or space heating	short	not currently economic, lack of public awareness
	Substitute biomass for heating	short	not currently economical; requires new infrastructure, equipment
	Develop geothermal energy for heating	long	geothermal energy sources need to be discovered and used; capital investment required; may not be economic
Transportation	Introduce flexible fuel and alcohol fuel vehicles	short	requires capital investment, new infrastructure
	Develop high-yield processes to convert ligno-cellulosic biomass into alcohol fuels	long	requires new technology
Industry (including electricity generation)	Increase use of renewable electricity generation (including small hydro, wind, biomass and solar)	short	economics and reliability must be demonstrated
	Use wood waste from forestry industry	short	requires infrastructure
	Establish level economic playing field for renewable energy sources	short	requires change in policy
	Solar or geothermal for heating	short	not currently economic
	Improve storage and combustion systems for hydrogen	long	new technology required

* Available in the short term means that the technology can be made available for general use within five years. Long term means that it will not be available in five years.

Table 4-6. Examples of emission capture and recovery measures

Energy Sector	Measure	Availability*	Constraint
Buildings	N/A		
Transportation	Improve emission standards including vehicle exhaust	short	requires regulation, capital investment and new infrastructure
Industry (including electricity generation)	Capture and separate carbon dioxide	long	high cost; needs technology development and mechanism for disposing of carbon dioxide
	Capture and separate sulphur dioxide from flue gas	short	high capital cost
	Provide emission reduction technologies to other countries	short	high cost
	Encourage development of clean coal technology (e.g. Integrated Gasification Combined Cycle)	long	requires technology development and capital investment
	Increase monitoring of emissions and expand to include methane and toxics	short	requires capital investment
	Collect, recycle and destroy chlorofluorocarbons	long	requires new technology, new policy and new infrastructure
	Recover methane from landfills, coal and oil fields	short	requires capital investment and infrastructure

* Available in the short term means that the technology can be made available for general use within five years. Long term means that it will not be available in five years.

5.0 NEW CHALLENGES

Alberta's existing air quality management system, developed in the 1960s and 1970s, was to maintain local air quality by controlling local industrial emissions. Ambient objectives and "end of stack" standards were established in order to control air pollution at acceptable levels. In the 1980s, new challenges arose through issues like acid deposition, global warming, smog and stratospheric ozone depletion. Notwithstanding that the science for some issues may be uncertain, the public is demanding action from their elected representatives. Governments have responded with pledges and commitments as illustrated in Chapter 2.0, Table 2-2.

5.1 Existing Air Quality Management System

Alberta's current air pollution control program has four main premises:

- ▲ emissions from each industrial source must be controlled using the best available demonstrated technology that is economically achievable;
- ▲ residual emissions must be dispersed through a stack designed to keep ambient concentrations below the Alberta ambient air quality objectives;
- ▲ industrial operators must monitor emissions and the resulting air quality around their facilities and report the measurements to the government;
- ▲ cumulative emissions from industrial sources are considered with respect to ambient objectives and regional air pollutant deposition.

Alberta regulations specify maximum permissible concentrations in ambient air for six different contaminants (see Appendix 1). The best available demonstrated technology (BADT) for various industry categories is generally determined by joint government-industry task forces. The recommended emission rates and implementation schedules are formalized as regulations, guidelines and policies, Energy Resources Conservation Board's Informational Letters and other government publications, and are used to set individual licence limits. Based on the "polluter pay" principle, the cost of monitoring is borne by the industry. The government restricts its activities to data quality assurance and spot checks. Licences issued by the government to industrial operations contain a variety of conditions and specify equipment, operations, maximum emission rates, stack limits, source testing, ambient monitoring and data reporting. A tiered enforcement procedure is also in place to ensure compliance with licence conditions. The system achieves two goals:

- ▲ emissions from individual industries are minimized using BADT; and
- ▲ air quality in the vicinity of industrial operations meets Alberta objectives.

5.2 Problems and Opportunities

To address the emerging challenges, it is essential that the scientific, economic, social and political linkages are considered in developing a clean air strategy. Participants at the Clean Air Strategy Issues and Options Workshop, at the Regional Sessions and through written submissions, identified problems and opportunities that need to be addressed for an effective strategy. While a broad discussion of the scientific information has been outlined in the previous sections, the following areas are considered priorities for Alberta.

5.2.1 Comprehensive Air Quality Management

There is a need for a more comprehensive system for managing air quality in the Province of Alberta.

The current system of monitoring and regulations addresses gaseous emissions of sulphur dioxide, hydrogen sulphide, nitrogen dioxide, carbon monoxide, ozone and particulate.

It is important to review whether the right data is being gathered, how it is being collected and whether it could be better used.

There are a number of other emissions from a variety of sources which may be of concern and are not part of the current provincial air quality management system. These include greenhouse gases, air toxics and odour-causing emissions other than hydrogen sulphide. To obtain a more accurate picture of air quality in the province, ambient air quality levels need to be monitored and environmental and human health indicators need to established so that the public and industry can better understand the effects emissions have on humans and the environment.

Currently, specific emissions are dealt with through separate standards and agreements or protocols. It is now evident that measures taken to control one emission often affect other emissions. For example, measures to decrease emissions of sulphur dioxide or nitrogen oxides may result in increases in carbon dioxide emissions.

Furthermore, health and environmental effects of many emissions and their synergistic effects are not well understood. Systems need to be in place to both involve and inform the public and industry about the health and environmental effects of gaseous emissions, or to effectively research and respond to public concerns regarding air quality.

5.2.2 Local Air Quality

Local air quality issues and problems need to be addressed as a priority.

Participants at the Regional Sessions and several of the written submissions identified specific local air quality issues and problems. These include acid-forming emissions from oil sands plants in Northeastern Alberta, localized impacts from flaring and venting at oil and gas facilities, impacts from coal burning at thermal-power generating stations, air toxics resulting from pulp and paper facilities as well as incinerators, and episodic smog in Edmonton and Calgary. Whatever the source of the emissions, the Regional Sessions showed that the Alberta public appears to be more concerned with these local issues than with national or global issues. As is indicated in the Moderator's Report on the Regional Sessions, "Unless local problems are resolved, national and international commitments will lack credibility in the eyes of the public."

5.2.3 Zone/Regional Air Quality

The air quality management system needs to address cumulative regional emissions and impacts from those emissions.

At present, emission monitoring and control are focused on industrial point sources, rather than airsheds or larger regional zones. This emphasis creates the potential for increases in emissions despite compliance with regulations by individual facilities. At present, the number of sources in a given geographic area and the total mass are minor considerations. An improved means of achieving environmentally sustainable loadings of pollutants of concern, both within and outside of provincial boundaries, must be established. This requires an environmental impact focus which relates total loadings to environmental effects.

5.2.4 Provincial Position on National and International Initiatives

Alberta needs to develop a position which responds to current and anticipated commitments by the federal government to reduce air emissions.

The federal government has made international commitments to stabilize greenhouse gases and nitrogen dioxide emissions in Canada, and will likely make more commitments in the future. Past commitments have been made without adequate consultation. To develop national strategies that make sense, full consultation with interested and affected parties is essential. All commitments have significant implications for Alberta and require provincial government response.

Global warming is one of the important environmental issues facing decision-makers in the world today. The total amount of greenhouse gases from Canada represents only 2 per cent of the global total. However, on a per capita basis Canada and Alberta are large contributors of carbon dioxide. There is an expectation nationally and internationally that jurisdictions in developed countries should move to reduce their emissions of greenhouse gases.

5.2.5 Cost-Effectiveness and Flexibility

There needs to be a strong commitment to include cost-effectiveness and flexibility in the operating principles.

While there are penalties for not complying with standards, there is little incentive for reducing emissions below the standard, or for the adoption of other emission control options. This discourages industrial creativity and innovation to develop processes that further reduce emissions. However, there is opportunity for improved economic/environmental efficiency — the greatest environmental benefit for the resources expended — which will enable more progress in mitigating air quality concerns and problems. This requires a system that sets efficient and effective priorities, and establishes goals, objectives and actions to address specific problems.

5.2.6 Scientific and Economic Uncertainty

Scientific and economic uncertainties need to be addressed for improved decision-making.

Considerable scientific uncertainty and information gaps exist in the areas of air quality, climate modelling, rate of change impacts due to temperature or precipitation changes, and assessment of effects of emissions on human health and the environment. Time, as well as financial and human resources, would be required to enable the information gaps to be filled. However, if actions are delayed until all the scientific uncertainty about effects is resolved, it may be too late to avoid major global environmental impacts and human suffering.

Concerning acid-forming emissions that cause acid deposition, although Alberta has done significant work through the Acid Deposition Research Program and is a world leader in developing emission-reduction technology, there is still much to be done. For example, there is a need to refine appropriate target loadings (ambient acid deposition standards) and to develop reliable methodology for measuring dry deposition.

With respect to greenhouse gases, atmospheric concentrations, rates of increase, and projected changes are now available. There is less certainty about the chemical, meteorological, physical and biological processes that lead to these concentrations or the processes which lead to an impact on climate due to increases in the concentrations of these gases. Thus, the resulting rate of climate change cannot yet be predicted with any reliability, especially at the regional or local level. Furthermore, the reliability of predictions of climate change and its impacts on the environment may not improve substantially over the next few years.

In addition to scientific uncertainty, there is considerable debate about the economic impacts of reducing emissions on Alberta's and Canada's industries. Some suggest that measures taken in isolation to reduce energy-related emissions will increase product costs for the resource or industrial sectors in Alberta — or Canada — relative to other countries, thereby putting Alberta industry at a competitive disadvantage. This could have negative effects on the economy of Alberta. On the other hand, others share the view that if Alberta industry is required to cope with leading-edge environmental policies, it will develop the capacity and innovation required to respond and provide Alberta and Canada's industries with a competitive advantage.

5.2.7 Role of the Public

The greatest challenge to implementing a Clean Air Strategy is to ensure Albertans understand the required commitment and are willing to make the necessary changes.

The results of the Regional Sessions indicate that the public wants action, but generally Albertans are unaware of their part in either directly causing emissions or in creating the demand to which industry responds. They also do not see themselves as having to make lifestyle changes as part of solving these problems. On the other hand, Albertans appear to be deeply concerned about potential health risks associated with local air quality problems. Participants also suggested the need for industry to reduce energy use and increase efficiency as a way of reducing air quality problems.

National public opinion research tends to verify these attitudes. Research indicates the public wants to know that air quality issues are being satisfactorily addressed, but the research also indicates the public sees industry and government as responsible for both the problem and the clean-up. It is not clear how much cost and lifestyle change the public is willing to bear to address national and global air quality issues. There is a need for substantial public education to show how individual actions and choices affect air quality, and what options individuals have for contributing to improved air quality. In other words, Albertans should be informed about the environmental consequences of their lifestyle and consumer behaviour. They should be encouraged to use environmental impacts as an important criteria in resource consumption and purchasing decisions as well as in their broader lifestyle choices.

6.0 STRATEGIC FRAMEWORK

The previous section outlines the air quality challenges facing Alberta, and indicates that there is an incomplete knowledge base on which to make decisions. Given the problems and opportunities facing the province, the Clean Air Strategy for Alberta has chosen an approach that outlines a prudent yet practical framework for decision making, rather than attempting to resolve the issues. The framework provides a vision of the desired attributes of clean air, and includes a mission statement and the principles on which future plans could be based. All of these are founded on the beliefs and values held by Albertans. The following diagram (Figure 6) describes the relationship of the components.

6.1 Overall Vision

This vision of clean air is the guiding star. It is fundamental to the development of an effective air quality management strategy for Alberta.

The air will be odourless, tasteless, look clear and have no measurable short- or long-term adverse effects on people, animals and the environment.

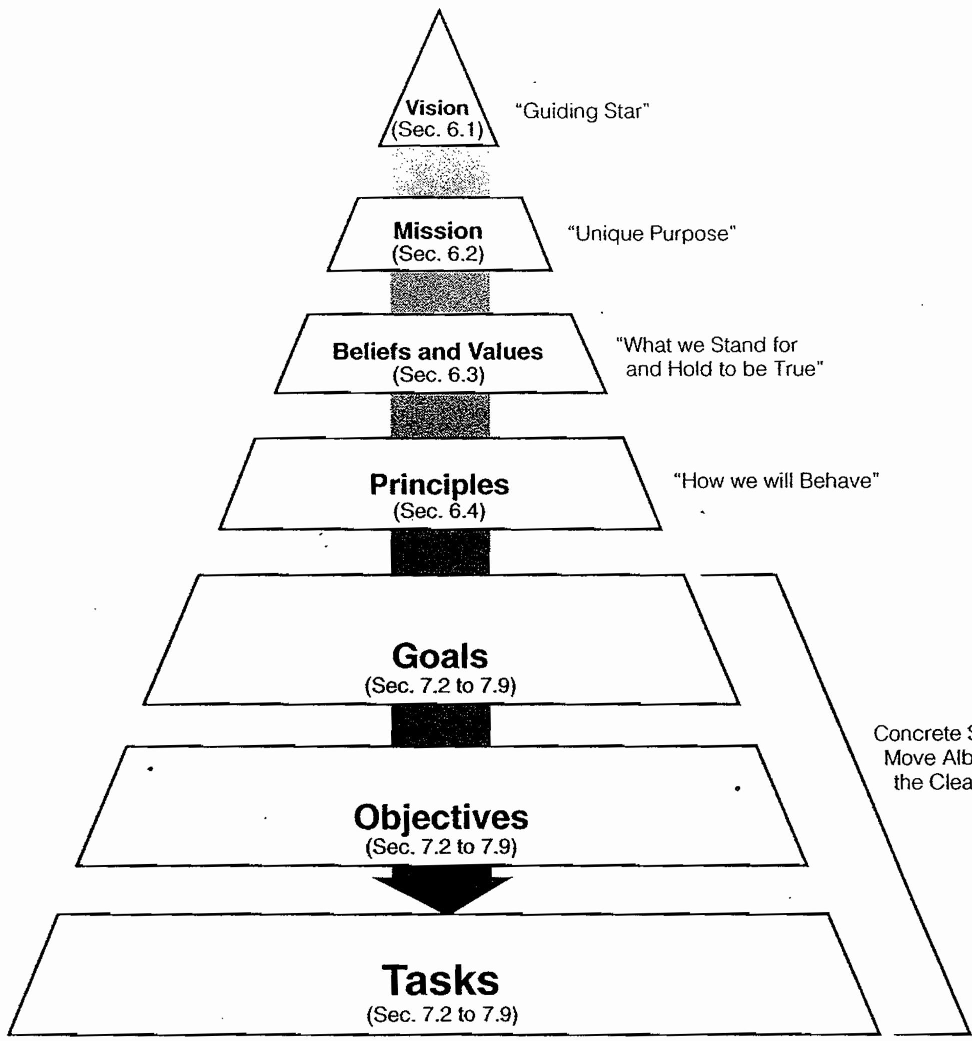


Figure 6. Components of the recommended strategy

6.2 Mission Statement

The vision provides the basis for the development of a mission statement which is as follows:

Alberta's Clean Air Strategy is to provide guidelines for the management of emissions from human activity and encourage appropriate life-styles so as to protect human health and ecological integrity within a provincial, national and international context.

The strategy will be comprehensive but flexible and, through an ongoing consultative process, will employ a wide range of mechanisms available for implementing the strategy, including public education, market-based approaches, legislation, regulation, and research and development.

6.3 Guiding Beliefs and Values

Commonly held beliefs and values, what Albertans stand for and hold to be true, are the basis upon which the strategy is built. These concepts reflect the views of Albertans presented through the Clean Air Strategy for Alberta public consultation process. They are fundamental to the development of an effective air quality management system for the province. At the same time, however, it is important to recognize that solutions to air quality problems must be governed by the availability of financial and human resources. The challenge for Alberta will be to find innovative solutions that are cost-effective (maximum emission reduction for minimum cost), and which are developed on a focused and prioritized basis. The following beliefs and values have been identified through the Clean Air Strategy for Alberta process (see Appendix 3 for explanatory notes on these beliefs and values).

Health, Quality of Life and Education

- ▲ Human health and ecological integrity within the province must be protected.
- ▲ Albertans have an obligation to their children and future generations to pass to them a healthy environment.
- ▲ Human health, environmental quality and the economy are interdependent and inseparable.
- ▲ Air quality management and decision-making must strive to use cooperative and constructive processes rather than adversarial approaches.
- ▲ An educated and motivated public, which is able to make sound life-style choices, is essential to the development and implementation of a successful clean air strategy.
- ▲ Full public access to information and involvement in decision-making for air quality is essential.

Equity

- ▲ Fairness in recommendations and actions is essential.
- ▲ All consumers should share fairly in the costs and benefits of reducing emissions.
- ▲ All suppliers of energy resources or services should be given an equal opportunity to contribute to a healthy environment and a sound economy.

Coordination and Interrelationships

- ▲ Addressing local and regional air quality problems is a priority.
- ▲ Albertans must work to alleviate their share of national and international air quality problems.
- ▲ Albertans have a leadership role to play in solving air quality problems.
- ▲ The various levels of government share responsibility for air quality management and must coordinate their efforts to avoid duplication of efforts.
- ▲ Encouraging wise use of energy use and striving to optimize energy conservation and efficiency are essential.

Science and Research and Development

- ▲ Alberta's strengths in technology, new technology development and services can be used to help resolve air quality problems and to diversify and strengthen the economy.
- ▲ Air quality should be managed on the basis of sound scientific information and appropriate risk management.

6.4 Principles

Building on the beliefs and values developed through the Clean Air Strategy for Alberta, a number of principles were established that will be used to guide planning and actions. The following principles are guidelines that will help to translate the beliefs and values into decisions and behaviours:

Health, Quality of Life and Education

- ▲ The protection of human health and ecological integrity are fundamental considerations.
- ▲ Important consideration must be given to economic well-being and quality of life.
- ▲ The public must be informed about air quality in the province and aware of their individual roles in both the problems and solutions.

Equity

- ▲ Alberta's environmental, economic and social interests relative to other jurisdictions must not be jeopardized in implementing actions.
- ▲ The costs and benefits of implementing measures must be shared fairly among all sectors, including consumers.
- ▲ The potential impacts of clean air policies and programs on low income Albertans must be addressed.
- ▲ The management of air quality must be approached on the basis of a full assessment of direct and indirect environmental, social and economic costs and benefits.

Coordination and Interrelationships

- ▲ Cooperation with the federal government and other provinces must be ensured in setting and, where appropriate, in harmonizing air quality objectives without compromising provincial standards.
- ▲ It must be recognized that air quality issues at point sources within zones, regions, nationally and internationally are interrelated and must be addressed as such.
- ▲ Where appropriate, provincial expertise in technology and services must be shared with others (especially less-developed countries).

Science and Research and Development

- ▲ Sound, scientific information about emissions and their environmental and health impacts must be used to form the basis of air quality management decisions and strategies.
- ▲ Scientific and economic factors, and other uncertainties are to be addressed using sound management principles and risk assessment.
- ▲ Scientific understanding of air chemistry and transport must be enhanced in order to build better practical models and improve theoretical understanding.
- ▲ Research and technology development must be encouraged in order to fill knowledge gaps and to develop new ways to prevent, reduce or eliminate undesired emissions and/or increase efficiencies.
- ▲ Development of cleaner energy sources must be fostered.

Key Thrusts

- ▲ Full consultation with affected and interested Albertans must be an integral component of air quality management and decision-making.
- ▲ The most cost-effective measures which achieve the greatest human health and ecological benefits must be implemented.
- ▲ The most appropriate approaches to prevent or reduce emissions must be selected from among the range of mechanisms, including public education, market-based approaches and regulations/standards.
- ▲ Cost-effective energy efficiency must be maximized and energy conservation must be promoted as a priority.
- ▲ Local and regional air quality problems are to be addressed as priorities.
- ▲ Encouraging individuals to take actions that contribute to cleaner air must be a priority.
- ▲ Emission reduction and energy efficiency technologies and services must be pursued as potential opportunities for economic development and export.

7.0 RECOMMENDED STRATEGY

A comprehensive system to respond to present and emerging air quality issues is presented. It is built on the strategic framework developed by the Clean Air Strategy for Alberta (discussed in Section 6.0). General goals and specific objectives are also recommended. Tasks in support of specific goals are proposed for improving air quality management.

It is noteworthy that several criteria were considered in designing the recommended strategy. The criteria provide a logical and orderly approach to decision making. The criteria were employed in a qualitative manner and applied by the Advisory Group and Summary Workshop participants to the recommendations from the Issues and Options Workshop, to the information gathered from the Regional Sessions and to written submissions. The criteria are:

Criteria Used for Developing the Strategy

▲ It is recognized that considerable time will be required to achieve many of the goals and objectives. The resources required to achieve the goals will need to be balanced with other claims on provincial resources.

▲ Cost-effectiveness is essential. Changes in consumer behaviour, and in the energy industry and other sectors, will require significant investments over time. Recognizing the potential economic benefits associated with energy conservation and efficiency, investments to reduce emissions are likely to be large enough to affect the economy in various ways. Therefore, it is sensible to seek reductions at the lowest cost.

▲ A least-cost strategy by itself is not a satisfactory criterion. Flexibility in the approaches used to achieve goals is critical, especially if objectives to achieve the goals are to be economically viable. Innovative approaches need to be part of the strategy.

▲ Agreed-upon problem definition and priority setting are also considered essential. The problem definition criterion used by the Clean Air Strategy for Alberta is "significance to Alberta." The priority setting criteria employed are a mix of "ease of implementation" and "significance to Alberta."

▲ The term management, as defined by the Clean Air Strategy for Alberta, means to identify, monitor, assess and where required, respond, reduce and follow-up.

Energy efficiency and conservation can be regarded as means to enhance air quality. Due to their important potential to reduce energy-related emissions, they are given special emphasis as separate goals. Many energy efficiency and conservation measures have significant potential to reduce energy-related emissions with a net savings, or at low net cost, but have not been implemented because of established social and behavioural habits, lack of awareness, uncertainty regarding the economic impacts, policy and legislative obstacles and market penetration barriers. Note: net savings means there would be a net return on the expenditure, rather than that no expenditure is required to implement.

Seven types of goals have been identified. These are:

▲ comprehensive air quality management system (Section 7.1, Goal A)

▲ energy efficiency, conservation and renewables (Section 7.2, Goals B, C and D);

▲ point source (Section 7.3, Goals E and F);

▲ zone (Section 7.4, Goals G and H);

▲ regional (Western Canada in Section 7.5, Goal I);

▲ national/international (Section 7.6, Goal J); and,

▲ general (Section 7.7, Goals K, L and M).

Many objectives may apply to more than one goal, but the objectives are listed only once. The recommended goals for the Clean Air Strategy for Alberta are listed below.

Clean Air Strategy for Alberta Strategic Goals

Comprehensive Air Quality Management System

Goal A
Implement a comprehensive air quality management system in Alberta that allows for identification of problems, prioritization of issues, allocation of resources, development of action plans and is based on full multi-stakeholder involvement.

Energy Efficiency and Conservation

Goal B
Identify, evaluate and implement legislative and regulatory opportunities for energy efficiency and conservation.

Goal C
Identify, evaluate and implement cost-effective energy conservation and efficiency opportunities.

Goal D
Identify, promote and implement cost-effective energy developments that contribute to clean air.

Point-Source

Goal E
Strengthen the management approach for all point-source emissions in Alberta in order to avoid adverse effects on human health and the environment.

Goal F
Identify and evaluate a range of options available for managing point-source emissions to encourage greater innovation, improved environmental protection and cost-effectiveness.

Zone

Goal G
Develop and implement a zone approach to managing air quality within specific airsheds.

Goal H
Develop innovative and targeted solutions to better manage cumulative emissions in and around urban areas.

Regional

Goal I
Manage emissions within Western Canada to address regional air quality problems.

National/International

Goal J
Encourage collaboration between the provinces and the federal government to pursue actions that are cost-effective and ensure maximum flexibility in addressing national and international air quality issues.

General

Goal K
Improve the gathering, sharing, integration and application of scientific, technical knowledge and research regarding atmospheric processes and effects on health and ecosystems.

Goal L
Improve public awareness of air quality and enhance the public's capability of making choices and commitment to change through environmental education.

Goal M
Integrate clean air goals into the provincial economic development strategy.

There is broad-based support for improving the way air quality is managed in the province in order to better address present and emerging challenges. To meet these challenges the Clean Air Strategy for Alberta recommends that Goals B through M and their objectives and tasks be addressed using the air quality management system in Section 7.1. There is strong belief that a number of objectives and tasks particularly related to energy efficiency, environmental education and Alberta's position on greenhouse gases should be considered for immediate implementation. Decisions on and implementation of these recommendations, that are marked with a star (★), should be undertaken as soon as possible.

7.1 Comprehensive Air Quality Management System

Goal A

Implement a comprehensive air quality management system in Alberta that allows for identification of problems, prioritization of issues, allocation of resources, development of action plans and is based on full multi-stakeholder involvement.

★

Objective A-1

An expanded multi-stakeholder Clean Air Advisory Committee should be established, with a secretariat, and a mandate to:

- ▲ guide the implementation of the comprehensive air quality management system; monitor its effectiveness toward meeting approved goals and objectives; and consider additional management options; and
- ▲ address other air quality issues integral to clean air such as air toxics, indoor air and other issues arising out of the agriculture, forestry and other sectors. Please see Appendix 4 for a discussion on air toxics and emissions from non energy sources

The organizational structure in Figure 7 illustrates the inter-relationships.

This objective is proposed with the understanding that air quality issues are dynamic in nature and that to effectively resolve them, it is necessary to obtain the expertise and commitment of a broad range of interested or affected parties.

Public input is essential for four important reasons:

- ▲ to bring the benefits of diverse knowledge and experience to the process;
- ▲ to ensure public commitment to plans and actions;
- ▲ to ensure the most efficient and effective solution is identified and applied to a specific issue or problem; and
- ▲ to implement democratic principles and ensure that citizens and industry have the opportunity to influence decisions which will affect them.

Potential parties associated with air quality management would include representatives from the public, industry and government. Their involvement should occur at every step of the air quality management system.

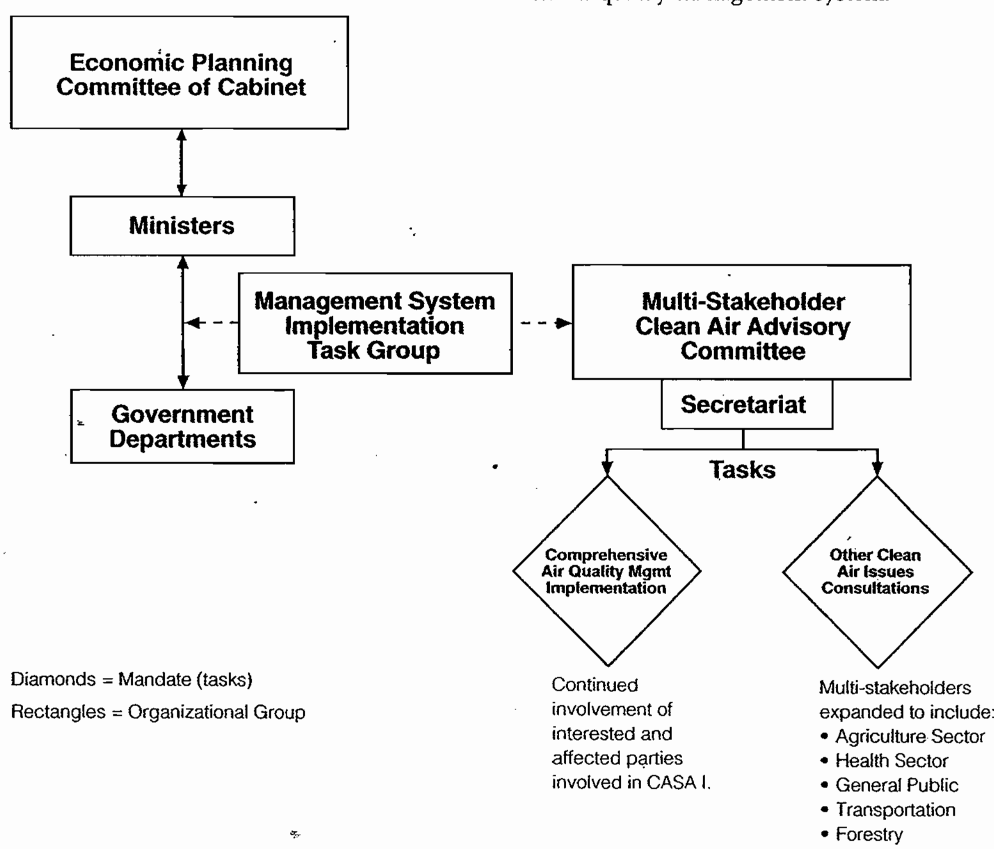
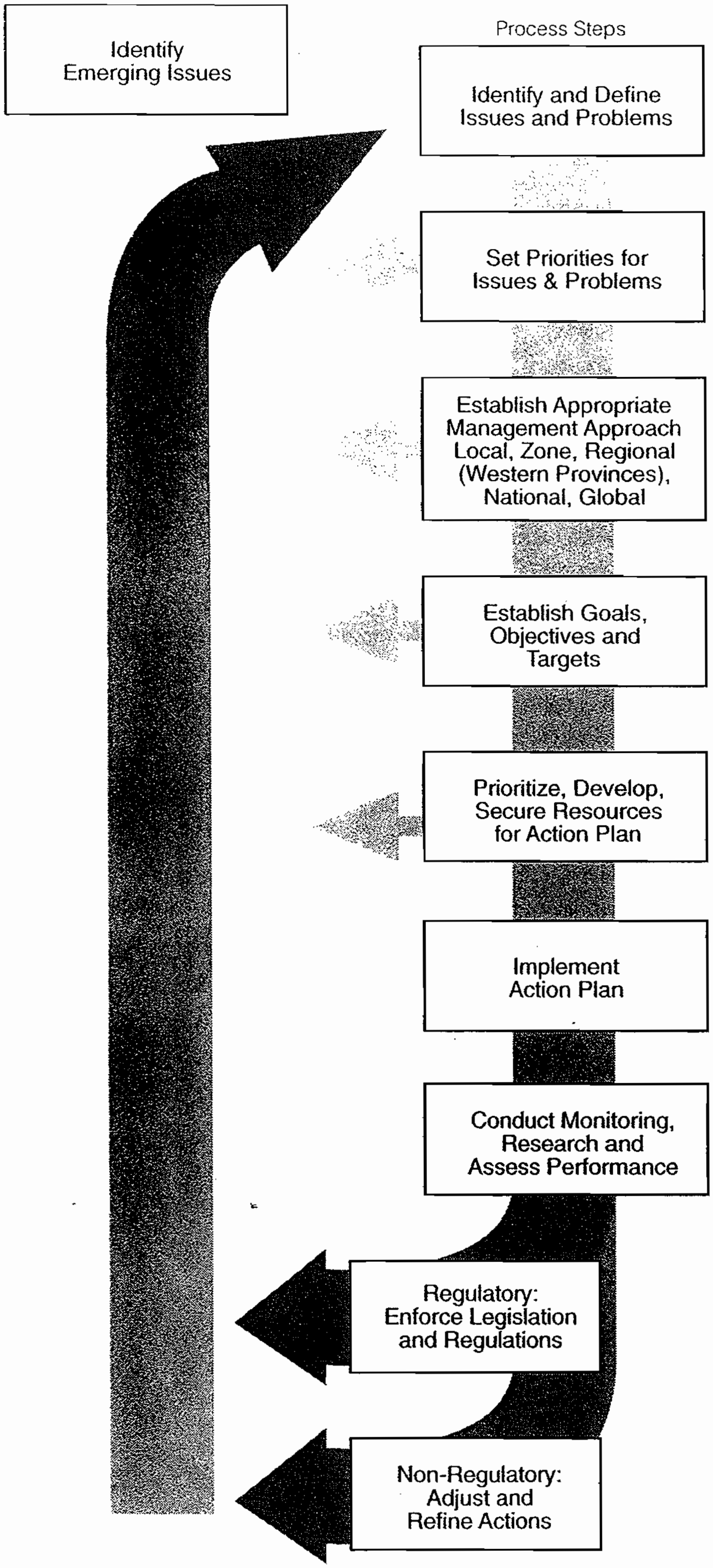


Figure 7. Clean Air Strategy for Alberta implementation organizational structure



A multi-stakeholder committee is established. Current and future problems are identified and defined. The probability and significance of impacts on human health, the environment and the economy are assessed. (Section 7.1.1)

Priorities are established to ensure optimum use of available resources (human, financial, natural). Priorities are reviewed and revised to reflect new knowledge. (Section 7.1.2)

A management approach is adopted which will ensure that plans and actions are targeted to the specific problem of concern (i.e. local solutions are used to resolve local problems, regional solutions are used to resolve regional problems). (Section 7.1.3)

Specific goals and objectives are established which recognize human health, environmental and economic considerations. (Section 7.1.4)

Action plans are developed which ensure the desired objectives are achieved in an optimum manner (economic efficiency, cost-effectiveness) and reflect public priorities. Alternate instruments (regulations, economic instruments) and actions are identified and assessed. Resources are re-allocated or directed to fund the action plan. (Section 7.1.5)

Actions and programs are undertaken in accordance with the activities and timing outlined in the Action Plan. (Section 7.1.6)

Information is gathered to assess the effectiveness of actions and to resolve uncertainties associated with problems and their solutions. (Section 7.1.7)

An enforcement process is applied which creates incentives for performance beyond minimum requirements and levies penalties for performance which is below expectations. (Section 7.1.8)

Based on monitoring activities and performance measures, adjust action plans or expectations. (Section 7.1.9)

Figure 8. A comprehensive air quality management system

★
Objective A-2

Establish a task group to develop and implement the processes needed for the comprehensive air quality management system as described in Sections 7.1.1 through 7.1.9.

Description of the Comprehensive Air Quality Management System

The recommended air quality management system is made up of the process steps shown in Figure 8. While the steps identified are seldom separate and distinct, they do describe the process and range of activities to be considered in developing a solution-oriented approach to air quality management. The proposed process would help anticipate and prevent issues from becoming problems that might be difficult to manage. As well, it can provide the tools to manage significant air quality issues in Alberta in an effective, efficient and timely manner.

The concepts described in the first five steps have been used to develop the Clean Air Strategy for Alberta. Once the comprehensive air quality management system is further developed, this process can be applied with varying rigor and complexity to local, zone, regional and national/international issues or problems.

7.1.1 Identify and Define Issues and Problems

The first step to providing effective management of air quality is to have the interested and affected parties (the stakeholders) clearly identify the specific air quality issues or problems (current or anticipated), and the nature and significance of their environmental and/or health effects. The identification and definition of air quality issues or problems, should:

- ▲ describe emission types, amounts, and dispersion characteristics;
- ▲ assess or predict effects of emissions; and
- ▲ assess the probability and significance of the effects of emissions on health, socio-economics and the biophysical environment.

Applying this step would ensure that air quality issues are identified in a pro-active manner, and that plans and actions would be directed towards resolving a specific air quality issue(s) based on the best available knowledge.

The public also has a major role to play in the preliminary identification of potential problems and in bringing them to the attention of those responsible for the management system. Sufficient resources should be made available to examine perceived or reported problems and assess emission levels and health or ecological impacts. The system should ensure that concerns are acted upon promptly.

7.1.2 Set Priorities for Issues and Problems

After current and potential air quality issues have been identified and defined, priorities should be set to ensure available resources (human, financial, institutional and natural resources) are used efficiently and effectively.

Because stakeholders would be directly affected by choices, and should be committed to the actions, they need to be involved in identifying and defining problems and establishing priorities. It is important that priorities are objectively established using mutually agreed- upon criteria and the best available information. Suggested criteria could include:

- ▲ human health effects;
- ▲ biophysical impacts;
- ▲ economic impacts;
- ▲ urgency; and
- ▲ regulatory compliance.

The setting of priorities should be an ongoing process which responds to the changing nature of factors which influence the management of air quality. Priorities should be reviewed periodically, in response to new knowledge or as progress is made.

7.1.3 Establish Appropriate Management Approach

Stakeholders should focus planning and actions on addressing spatially defined, pollutant-specific air quality issues/problems. The management approach for a specific problem may be local, zone, regional (i.e. Western Canada) or national/international in nature depending on its characteristics. Adopting an appropriate management approach would ensure that plans and actions are targeted to the specific issue or problem. This would ensure that resources are applied effectively and commitment is obtained from affected stakeholders.

For example, the Clean Air Strategy for Alberta supports the use of zone-targeting as a new approach to managing area-specific air quality issues. Zone management would complement, not replace, a system of province-wide minimum ambient standards and minimum recovery guidelines. This would enable the province to establish an air quality management zone(s) that includes sources and areas affected on a defined basis to facilitate management of specific existing or potential air quality problems. For example, a zone could be established to define an urban area where urban smog/ground-level ozone may be a problem. Plans and actions would be targeted within the zone to ensure the problem is appropriately managed. Plans and actions should be developed with involvement of stakeholders within the zone as well as other interested and affected parties. This approach is not possible with the current regulatory system.

7.1.4 Establish Goals, Objectives and Targets

After stakeholders have set priorities for air quality issues and have established an optimum management approach, they should determine goals, objectives or targets for the emissions of concern using the following factors:

- environmental and social effects;
- effects on human health; and
- costs.

7.1.5 Prioritize, Develop and Secure Resources for Action Plan

Action plans would be developed which ensure objectives are achieved in an optimum manner (economic efficiency, cost-effectiveness) and reflect public priorities. Alternate instruments (regulations, economic instruments) and actions would be identified and assessed. Resources would be re-allocated or directed to fund the action plan.

7.1.6 Implement Action Plan

Solutions applied to address specific problems should encourage innovation and cost effectiveness. This would require that alternative approaches to current regulations, such as various economic instruments (i.e. tradeable permits, taxes/fees etc.) be available as options. This would ensure that for any problem the province has the capability to apply the most effective instrument to achieve the desired effect.

7.1.7 Conduct Monitoring, Research and Assess Performance

Experience with implemented actions should be closely monitored and research efforts enhanced throughout the province to support the management of air quality. Periodic assessment of progress should be built into the system. Current efforts are focused primarily on compliance testing which is valid and important but does not allow for timely assessment and analysis of air quality trends (i.e. progress towards achieving established goals/targets and support for decision-making). This would require improved data management, as credibility of the data and analysis is crucial. Thus, the public should be involved in the design of the ambient air quality monitoring system and in its operation. As well, data and reports should be presented in a straight-forward, comprehensible manner and prompt public access to all information should be ensured.

7.1.8 Enforce Legislation and Regulations

Enforcement is important to ensuring progress on achieving established goals/targets. The enforcement process should create incentives for those who perform beyond requirements, and should establish significant penalties for those who do not perform up to requirements.

7.1.9 Adjust and Refine Actions

For programs not needing regulations, it is also important to ensure progress is made. All programs should adapt to new information and performance measures.

The Clean Air Strategy for Alberta recommends that Goals B through M and their objectives and tasks be addressed using the air quality management system in Section 7.1. There is strong belief that a number of objectives and tasks particularly related to energy efficiency, environmental education and Alberta's position on greenhouse gases should be considered for immediate implementation. Decisions on and implementation of these recommendations (i.e. marked with a star) should be undertaken as soon as possible.

7.2 Energy Efficiency and Conservation

Goal B.

Identify, evaluate and implement legislative and regulatory opportunities for energy efficiency and conservation.

★

Objective B-1

Incorporate appropriate energy efficiency performance requirements, consistent with other leading jurisdictions, into the Alberta Building Code for houses and buildings.

Task

Using the proposed management system, Alberta Energy and Alberta Labour should undertake a review of options for incorporating energy efficiency requirements into the Alberta Building Code. The review would include an assessment of the relevant legislation and identification of required amendments. The review would also focus on required changes in the membership of the Building Standards Council to provide appropriate balance.

The interdepartmental review should start in 1992 and the code amended by 1993.

★

Objective B-2

Develop and enact an energy efficiency act for Alberta which specifies minimum efficiency standards for both gas and electric appliances, furnaces, heaters, and for lighting, motors and other suitable equipment.

Task

Alberta Energy should undertake a comprehensive review of energy efficiency acts in other jurisdictions. Using the proposed management system, Alberta Energy would draft an Energy Efficiency Act for Alberta which specifies minimum efficiency standards for both gas and electric appliances, furnaces, heaters, and for lighting, motors and other suitable equipment.

The survey work and Energy Efficiency Act should be completed in 1992 and tabled in spring of 1993. A schedule for developing regulations would accompany the act.

★
Objective B-3

Review and, where necessary, revise the utility regulatory process to remove barriers and create incentives which would ensure that a wide range of energy efficiency programs could be pursued by the utilities and their consumers. This should include changes which promote a more cooperative process of approving demand-reduction programs by the Public Utility Board.

Task

Using the proposed management system, Alberta Energy should coordinate a comprehensive review of utility regulatory policy used in other jurisdictions which encourage cost-effective energy efficiency choices by consumers. Barriers to cost-effective energy efficiency choices in Alberta should also be identified.

This review should be completed in spring of 1992. Institutional responses considered appropriate for Alberta should be developed and tabled by the end of 1992.

Goal C

Identify, evaluate and implement cost-effective energy conservation and efficiency opportunities.

★
Objective C-1

Develop and implement comprehensive energy management planning and programs for provincially-funded facilities.

Task

Alberta Public Works, Supply and Services should extend the Energywise program to a government-wide effort to plan and implement energy management in government facilities and facilities receiving government funding. Government should be a leader in adopting the most up-to-date energy saving techniques and technology and should encourage corporations and municipal governments within the province to voluntarily adopt similar techniques and technologies.

Program should be announced early in 1992.

★
Objective C-2

Establish provincial government fleet fuel efficiency standards. These would be strengthened as vehicle efficiencies improve. Work with municipalities and the corporate sector to establish similar programs.

Task

Incorporate fleet fuel efficiency standards into objectives for provincial government fleet management and purchase programs. Establish a mechanism to encourage corporate and municipal vehicle fleets to voluntarily adopt the objectives.

Program should be announced early in 1992.

Objective C-3

Develop and implement a revenue-neutral gas-guzzler fee and gas-sipper rebate program for purchase of new vehicles in Alberta that will encourage consumers to select the most fuel-efficient vehicles.

Task

Evaluate similar programs in other jurisdictions and develop options to implement a revenue-neutral gas-guzzler fee and gas-sipper rebate program in Alberta which would encourage consumers to select the most fuel-efficient vehicles available.

Research should begin in 1992.

★
Objective C-4

Evaluate, develop and implement aggressive and comprehensive provincial programs to encourage energy efficiency and conservation. The programs should reach all sectors and include all the stakeholder groups in the provincial delivery system. Programs also should include energy audits and appropriate incentive mechanisms.

Task

Using the proposed management system, Alberta Energy should coordinate an evaluation of the scope, coverage, coordination and effectiveness of energy conservation and efficiency awareness, information and education services in Alberta. Concepts for programs would be prepared to expand these services, resulting in a comprehensive slate of services affecting all energy consuming sectors. Incentives to encourage the implementation of measures and funding for utility company-sponsored programs and non-governmental groups would be included in the review. A means of coordinating all complementary services would be recommended.

Concepts for programs should be prepared starting in 1992.

★
Objective C-5

Develop and implement educational and incentive programs to encourage consumers to select high-efficiency appliances, furnaces, motors, lighting and other equipment.

Task

Using the proposed management system, Alberta Energy should coordinate development and implementation of educational and incentive programs to encourage consumers to select high-efficiency appliances, furnaces, motors, lighting and other equipment.

This should be completed in 1992.

Objective C-6

Develop and implement innovative programs to encourage upgrading and retrofitting of existing housing and commercial buildings to achieve higher energy efficiency performance.

Task

Within the proposed management system, Alberta Energy should coordinate development of innovative programs for improving energy efficiency in existing houses and buildings (e.g. market-based incentive programs).

Recommended programs should be implemented by mid-1993.

Objective C-7

Assess and encourage the offering of upgrading and certification programs for building trades and building design professionals to increase their capability to incorporate energy conservation practices and technologies into construction.

Task

Alberta Energy and Alberta Advanced Education, in collaboration with the appropriate educational institutions, Alberta Career Development and Employment, apprenticeship programs and interested stakeholder groups should review opportunities for improving energy efficiency construction practices and technologies in Alberta (i.e. development of curriculum, delivery of information or education programs and identification of new technologies). Recommendations for changes and implementation of programs that would permit the affected stakeholders to keep pace with energy-efficient building codes, construction practices and technologies and developments elsewhere should be included as amendments to the Alberta Building Code.

Education and information programs should be implemented in 1993.

Goal D

Identify, promote and implement cost-effective energy developments that contribute to clean air.

Objective D-1

Identify the levels of provincial support for, and royalties and taxes from, various energy sources (e.g. fossil fuel developments, utility projects, clean energy technologies systems, renewable energy development and conservation and efficiency measures). This information should then be used to help ensure that future provincial subsidies and incentives encourage energy developments that contribute to clean air.

Task

Within the proposed management system, Alberta Energy should coordinate compiling information on the levels of provincial support (subsidies, incentives, economic-development assistance, research and development support, government loans) for, and taxes and royalties from, the various energy sectors within the province. The impact on clean air should be highlighted and this information should be made available to the public. The information should be used to adjust provincial energy development subsidies and incentive programs where appropriate.

The survey should be done in 1992.

Objective D-2

Investigate and consider how to implement full-cost analysis to take into account environmental and socio-economic implications of various energy sources for energy projects in government decision making.

Task

Within the proposed management system, the Energy Resources Conservation Board should coordinate development of criteria for full-cost analysis to be applied in the evaluation of energy projects. All options should be considered. This analysis should be tested and reviewed. Any new system also would need to be applied to non-energy projects through the Natural Resources Conservation Board.

Full cost analysis should be piloted in 1994.

★

Objective D-3

Revise government policy to allow for flexibility in the sources of energy used for generation of electricity and to encourage conservation. This includes developing fair mechanisms to allow for environmentally-sound commercial projects and utility-entrepreneur joint projects that contribute to cleaner air.

Task

Within the proposed management system, Alberta Energy should identify the range of available mechanisms to achieve flexibility in the sources of energy used for generation of electricity and make recommendations for legislative, policy and program changes if required. A priority area of focus should be on those cost-effective projects which lead to an overall reduction in air emissions for Alberta but are faced with access and rate issues which affect their viability within the Alberta interconnected system.

The work is to commence in 1992 with recommendations to be developed by the end of 1993.

7.3 Point Source

Goal E

Strengthen the management approach for all point-source emissions in Alberta in order to avoid adverse effects on human health and the environment.

Objective E-1

Develop new approaches for managing all point-source emissions to avoid adverse effects on human health and the environment. This should include the following components:

- developing a more effective monitoring system structured to enhance public credibility;
- developing better provincial inventories of point-source emissions such as methane, volatile organic compounds, and air toxics;
- defining, prioritizing and implementing a management system to include a broader range of emissions and sources that are monitored and regulated;
- identifying substances that may be a factor in human health including substances from non-energy-related emissions and air toxics;
- developing standards (regulations or other management mechanisms) for the broader range of emissions;
- developing and implementing a revised enforcement policy; and
- improving the system for exchanging information with the public, particularly regarding health concerns.

Task

Within the proposed management system, Alberta Environment should coordinate development of a new approach for managing all point-source emissions.

Work toward revising the management of point-source emissions to begin in 1992.

Objective E-2

Conduct a comprehensive review of gas-flaring practices, guidelines and regulations and make recommendations regarding opportunities for improving air quality.

Task

This review should be coordinated by Alberta Environment within the proposed management system.

Recommendations would be made in time to be incorporated into the new regulations of the Alberta Environmental Protection and Enhancement Act.

Objective E-3

Encourage research and technological development to develop new ways to eliminate, reduce, recapture and dispose of emissions.

Task

Within the proposed management system, an Alberta Environment task group should be established to coordinate ongoing and anticipated research.

The program should start in 1993.

Goal F

Identify and evaluate a range of options available for managing point-source emissions to encourage greater innovation, improved environmental protection and cost-effectiveness.

Objective F-1

Review and prioritize the options available to manage point-source emissions and build consensus for those that are most appropriate for controlling specific sources or combinations of sources and ensure the regulatory system allows for flexibility in management approaches.

Task

Within the proposed management system, the Energy Resources Conservation Board and Natural Resources Conservation Board should jointly review management options (e.g. standards, incentives, tradeable emissions permits, emission charges/taxes) and the existing regulatory framework. Recommendations should be coordinated with the development of new regulations for the Alberta Environmental Protection and Enhancement Act. (Note: this task should be closely coordinated with Goal E and the associated objectives and tasks.)

The review should begin in early 1992.

7.4 Zone

Goal G

Develop and implement a zone approach to managing air quality within specific airsheds.

Objective G-1

Establish a new approach for dealing with identified air quality problems in specific zones throughout Alberta. The definition of a zone would be based on the following criteria:

- emission sources and volumes
- emission dispersion characteristics
- impacts of emissions
- administrative considerations

The new approach should include:

- managing emissions, from both point and non-point sources, within specific zones to meet existing standards;
- improving existing air quality standards within specific zones where necessary;
- ensuring ecological integrity within zones;
- managing the combined effects of a concentrated number of point sources;
- establishing zones within Alberta and Western Canada based on need, nature of emissions and problems and what it is anticipated will be accomplished;
- establishing a decision-making mechanism for determining when an air quality problem is appropriate and significant enough for a zone approach (e.g. smog in Calgary or Edmonton, sulphur emissions in northeastern Alberta or the Caroline area);
- creating a mechanism for defining and officially recognizing a zone;
- determining the roles of government, industry, the public and regulatory bodies (ERCB, NRCB) in problem solving (i.e. advisory or decision making) and defining appropriate mechanisms for accommodating those roles (e.g. multi-stakeholder regional air quality committee; regulatory hearings);
- ensuring that decision-making procedures adequately consider total emissions, cumulative effects and ecological integrity;
- ensuring that zone management is integrated with point-source emission management; and
- ensuring that zone management is integrated with provincial and national emission management.

Task

Within the proposed management system, this review should be coordinated with the review of point-source emissions (Section 7.3, Goals E and F) to develop a complementary and comprehensive approach to the management of air quality for zones within the province.

Recommendations should be made by the end of 1993.

Goal H

Develop innovative and targeted solutions to better manage cumulative emissions in and around urban areas.

Objective H-1

Develop and implement innovative solutions to air quality problems arising from urban transportation.

Task

Within the proposed management system, a task group should be formed to develop new approaches to better manage urban transportation. For example, the group could assess measures including innovative urban planning, greater support for mass transit and funding for municipal bicycle trails, parking and bicycle-carrying equipment on transit vehicles. Tasks would involve identifying mechanisms, roles and responsibilities, adjustments to institutional or policy arrangements and assessment of costs and benefits.

The task group should be formed in early 1992 and recommendations should be tabled by the end of that year.

★
Objective H-2

Design and implement a mandatory vehicle-emissions testing program for urban centres in Alberta.

Task

Using the proposed management process, Alberta Environment, Alberta Energy and the Solicitor General should coordinate a survey of vehicle-emissions testing programs in other jurisdictions as well as financial incentive programs for purchasing and/or operating fuel-efficient vehicles and disincentives for inefficient vehicles. The cost-effectiveness and social impacts of these programs also would be evaluated, including investigating means to reduce economic impacts on low-income groups.

A program would be designed for Alberta as well as a discussion of costs and benefits by the end of 1992.

7.5 Regional

Goal I

Manage emissions within Western Canada to address regional air quality problems.

Objective I-1

Develop a decision-making system for managing regional air quality problems. This should include:

- meeting existing provincial standards;
- supporting and strengthening ties among the western provinces and territories including the Western Provincial/Territorial Air Quality Issues Coordinating Committee (a committee with representatives from departments of Energy and Environment in four western provinces and two territories);
- establishing mechanisms for industry and public consultation on specific regional air quality issues (e.g. bilateral agreements between provinces and with federal government);
- ensuring that the position the Alberta government takes to the Committee is consistent with public input on provincial issues (e.g. consistent with the principles of the Clean Air Strategy for Alberta);

▲ focusing on the distinctive characteristics of air quality issues in Western Canada (e.g. the predominance of energy-related emissions);

▲ integrating economic and environmental considerations in solving regional air quality problems;

▲ identifying, monitoring and managing the import and export of point-source emissions;

▲ developing appropriate decision-making mechanisms to manage regional problems on an ongoing basis; and

▲ deciding who makes what decisions within the Western Canada region.

Task

Alberta should encourage the Western Provincial/Territorial Deputy Ministers and Air Quality Issues Coordinating Committee to develop a comprehensive strategic plan. The plan should consider the strategies developed by the participating jurisdictions and incorporate the needs of stakeholder groups. This effort should be coordinated with actions taken to reform the ambient air monitoring system.

The plan should be developed by the end of 1993.

7.6 National/International

Goal J

Encourage collaboration between the provinces and the federal government to pursue actions that are cost-effective and ensure maximum flexibility in addressing national and international air quality issues.

★
Objective J-1

Alberta should endorse the recommended Alberta position statement regarding greenhouse gases on page 60.

Objective J-2

Identify a cooperative and integrated range of options to reduce emissions at the national and international level in order to better position Alberta and Canada in international discussions.

Objective J-3

Initiate a multi-stakeholder task force to develop capture and recovery strategies for greenhouse gases, with methane as the first priority.

Objective J-4

Work with the federal government to develop an economic development strategy that encourages the export of energy efficiency, renewable energy, clean fossil fuel combustion and pollution-control technologies and services.

Objective J-5

Encourage the federal government to pursue mandatory vehicle-efficiency standards to ensure automakers offer vehicles to consumers which are increasingly fuel efficient.

★
Objective J-6

Work with the federal and other provincial governments to obtain reliable national inventories of greenhouse gases.

Task

Alberta Environment and Alberta Energy should work with the federal and provincial governments directly and through the Canadian Council of Ministers of Environment and the Energy Ministers to bring forward Alberta's position and to establish inventories. Both ministries should continue to encourage stakeholder involvement in the development of a comprehensive national strategy.

Objective J-7

Investigate sulphur-recovery requirements for all industries within the context of the Canadian sulphur dioxide cap.

Task

Initiate a multi-stakeholder task group which, using the proposed management system, will review and assess sulphur dioxide emissions, their impacts and recovery strategies.

7.7 General

Goal K

Improve the gathering, sharing, integration and application of scientific, technical knowledge and research regarding atmospheric processes and effects on health and ecosystems.

Objective K-1

Identify more consistent and readily detectable adverse effects on ecosystems, human and animal health and physiological adaptation resulting from changes in ambient air quality. Correlate these effects with levels of exposure and thresholds of effect. Priority should be given to the most sensitive receptors and its largest sources.

Task

Within the proposed management system, Alberta Environment and Alberta Health should coordinate an integrated, comprehensive research program to address these issues as they pertain to Alberta. It is essential that this initiative be coordinated with other national and international efforts.

Programs should start in 1993.

Recommended Alberta Position Regarding Greenhouse Gases

The increasing concentration of man-made greenhouse gases is of global concern. At present, the federal position regarding greenhouse gases, as identified in the federal Green Plan, is to stabilize emissions of carbon dioxide and other greenhouse gases not covered by the Montreal Protocol at 1990 levels by the year 2000. Albertans want to ensure that the Canadian response regarding greenhouse gases is comprehensive and integrated as an international strategy which actively encourages global actions which:

- strengthens appropriate domestic emission controls and efficiency measures;
- encourages the use of science to reduce uncertainty;
- transfers Canadian pollution control technologies and environmental expertise;
- addresses all sources and responses; and
- assesses adaptation responses.

Alberta believes that, as a first step, Canada should rigorously apply cost-effective energy efficiency and conservation measures that make sense in their own right. This step also will contribute to Canada's improved competitiveness and movement toward broader sustainable development goals. Thus, as an interim step, Canada should apply energy conservation and efficiency measures at consumer, industrial and government levels.

As part of international efforts to reduce greenhouse gas emissions, Canada should encourage the international community to develop mechanisms to permit emission reductions through the most cost-effective options by both domestic actions and international initiatives. For example, to meet its international commitments, emission reduction credits should be given for Canada to reduce domestic emissions as well as for assisting less developed countries to reduce their emissions.

As part of the global solution and domestic actions, Alberta is committed to moving toward reduction of greenhouse gas emissions from current levels. Alberta and Canada should initiate immediate actions to clarify understanding of the timing, cost and benefits of a full range of reduction goals and measures. A federal-provincial multi-stakeholder process should be established to conduct this evaluation and to assess progress on a regular basis.

As a parallel activity, Alberta will develop more reliable provincial inventories of greenhouse gases, develop cumulative effects methodology, undertake detailed modelling using a mix of various measures and options, as well as developing effective and meaningful reporting mechanisms. This additional work will better define what provincial goals should be for the mix of energy-related emissions, the range of feasible options and the full costs and benefits of achieving these agreed-upon goals.

Finally, Albertans want to ensure that the responsibility for greenhouse gases created as a by-product of fuels or products produced for use in other parts of the country and internationally is shared by the users of those fuels or products. Albertans believe that the contribution of both personal consumption and human population growth to global warming must be included in the development of strategies to manage greenhouse gases.

Objective K-2

Review and develop a series of environmental indicators that are representative and indicative of human and environmental health and which are understandable for reporting on air quality management progress.

Task

Within the proposed management system, Alberta Environment and Alberta Health should convene a task group to develop a set of agreed-upon indicators. The group would coordinate its efforts with similar efforts underway at the national level.

The task group should be convened in early 1992 with recommendations for a preliminary set of indicators by the beginning of 1994.

Objective K-3

Undertake research and technology development activities in support of clean air goals.

Goal L

Improve public awareness of air quality and enhance the public's capability of making choices and commitment to change through environmental education.

★

Objective L-1

Coordinate and support the development and expansion of environmental education and public awareness programs within Alberta.

Task

A multi-stakeholder task group should be established to evaluate current environmental education and information efforts as to their scope, coverage, coordination and effectiveness. Appropriate providers of information, delivery infrastructure, audience and evaluation criteria should be considered. Concepts for programs should be prepared to expand services where appropriate. (Note: task group would need to coordinate efforts with the group focusing on energy conservation and efficiency education programs.)

Task group should convene in 1992 with recommendations prepared by 1993.

Goal M

Integrate clean air goals into the provincial economic development strategy.

Objective M-1

Develop specific components of a provincial economic development strategy to support commercialization and export of energy efficiency and renewable energy technologies and services and state-of-the-art clean fossil fuel combustion technologies and services.

Tasks

Alberta Economic Development and Trade should convene an additional special session of *Toward 2000 Together* to deal specifically with environment and economy issues.

Alberta Economic Development and Trade should establish a business development program geared to developing business opportunities for the private sector in the fields of energy efficiency and clean coal technology, including commercialization and export assistance.

A data base on products and services and a directory of firms should be established starting in late 1992. Business development incentives should be in place in 1993.

7.8 Summary Tables

The following tables are an abbreviated form of the text in Section 7.0. The headings (categories of goals) relate to the section numbers in the text (e.g. 7.3 Point Source). The 13 goals are listed from A to M.

The objectives are numbered for each goal (e.g. A-1, A-2, A-3, etc.).

Table 7-1. Summary tables

Goals	Objectives	Tasks	Priority
7.1 Comprehensive Air Quality Management System			
A. Implement a comprehensive air quality management system in Alberta that allows for identification of problems, prioritization of issues, allocation of resources, development of action plans and is based on full multi-stakeholder involvement.	A-1 An expanded multi-stakeholder Clean Air Advisory Committee should be established, with a secretariat, and a mandate to: • guide the implementation of the comprehensive air quality management system; monitor its effectiveness toward meeting approved goals and objectives; and consider additional management options; and • address other air quality issues integral to clean air such as air toxics, indoor air and other issues arising out of the agriculture, forestry and other sectors. Please see Appendix 4 for a discussion on air toxics and emissions from non-energy sources.		★
	A-2 Establish a task group to develop and implement the processes needed for the comprehensive air quality management system as described in Section 7.1.1 through 7.1.9 of the text.		★
7.2 Energy Efficiency and Conservation			
B. Identify, evaluate and implement legislative and regulatory opportunities for energy efficiency and conservation.	B-1 Incorporate appropriate energy efficiency performance requirements, consistent with other leading jurisdictions, into the Alberta Building Code for houses and buildings.	Using the proposed management system, Alberta Energy and Alberta Labour should undertake a review of options for incorporating energy efficiency requirements into the Alberta Building Code. The review would include an assessment of the relevant legislation and identification of required amendments. The review would also focus on required changes in the membership of the Building Standards Council to provide appropriate balance. The interdepartmental review should start in 1992 and the code amended by 1993.	★
	B-2 Develop and enact an energy efficiency act for Alberta which specifies minimum efficiency standards for both gas and electric appliances, furnaces, heaters, and for lighting, motors and other suitable equipment.	Alberta Energy should undertake a comprehensive review of energy efficiency acts in other jurisdictions. Using the proposed management system, Alberta Energy would draft an Energy Efficiency Act for Alberta which specifies minimum efficiency standards for both gas and electric appliances, furnaces, heaters, and for lighting, motors and other suitable equipment. The survey work and Energy Efficiency Act should be completed in 1992 and tabled in spring of 1993. A schedule for developing regulations would accompany the act.	★

★ in the priority column indicates objectives and tasks which should be considered for immediate implementation

Table 7-1. Summary tables, continued

Goals	Objectives	Tasks	Priority
	B-3 Review and, where necessary, revise the utility regulatory process to remove barriers and create incentives which would ensure that a wide range of energy efficiency programs could be pursued by the utilities and their consumers. This should include changes which promote a more cooperative process of approving demand-reduction programs by the Public Utility Board.	Using the proposed management system, Alberta Energy should coordinate a comprehensive review of utility regulatory policy used in other jurisdictions which encourage cost-effective energy efficiency choices by consumers. Barriers to cost-effective energy efficiency choices in Alberta should also be identified. This review should be completed in spring of 1992. Institutional responses considered appropriate for Alberta should be developed and tabled by the end of 1992.	★
C. Identify, evaluate and implement cost-effective energy conservation and efficiency opportunities.	C-1 Develop and implement comprehensive energy management planning and programs for provincially-funded facilities.	Alberta Public Works, Supply and Services should extend the Energywise program to a government-wide effort to plan and implement energy management in government facilities and facilities receiving government funding. Government should be a leader in adopting the most up-to-date energy saving techniques and technology and should encourage corporations and municipal governments within the province to voluntarily adopt similar techniques and technologies. Program should be announced early in 1992.	★
	C-2 Establish provincial government fleet fuel efficiency standards. These would be strengthened as vehicle efficiencies improve. Work with municipalities and the corporate sector to establish similar programs.	Incorporate fleet fuel efficiency standards into objectives for provincial government fleet management and purchase programs. Establish a mechanism to encourage corporate and municipal vehicle fleets to voluntarily adopt the objectives. Program should be announced early in 1992.	★
	C-3 Develop and implement a revenue-neutral gas-guzzler fee and gas-sipper rebate program for purchase of new vehicles in Alberta that will encourage consumers to select the most fuel-efficient vehicles.	Evaluate similar programs in other jurisdictions and develop options to implement a revenue-neutral gas-guzzler fee and gas-sipper rebate program in Alberta which will encourage consumers to select the most fuel-efficient vehicles available. Research should begin in 1992.	

★ in the priority column indicates objectives and tasks which should be considered for immediate implementation

Table 7-1. Summary tables, continued

Goals	Objectives	Tasks	Priority
	C-4 Evaluate, develop and implement aggressive and comprehensive provincial programs to encourage energy efficiency and conservation. The programs should reach all sectors and include all the stakeholder groups in the provincial delivery system. Programs also should include energy audits and appropriate incentive mechanisms.	Using the proposed management system, Alberta Energy should coordinate an evaluation of the scope, coverage, coordination and effectiveness of energy conservation and efficiency awareness, information and education services in Alberta. Concepts for programs would be prepared to expand these services, resulting in a comprehensive slate of services affecting all energy consuming sectors. Incentives to encourage the implementation of measures and funding for utility company-sponsored programs and non-governmental groups would be included in the review. A means of coordinating all complementary services would be recommended. Concepts for programs should be prepared starting in 1992.	★
	C-5 Develop and implement educational and incentive programs to encourage consumers to select high-efficiency appliances, furnaces, motors, lighting and other equipment.	Using the proposed management system, Alberta Energy should coordinate development and implementation of educational and incentive programs to encourage consumers to select high-efficiency appliances, furnaces, motors, lighting and other equipment. This should be completed in 1992.	★
	C-6 Develop and implement innovative programs to encourage upgrading and retrofitting of existing housing and commercial buildings to achieve higher energy efficiency performance.	Within the proposed management system, Alberta Energy should coordinate development of innovative programs for improving energy efficiency in existing houses and buildings (e.g. market-based incentive programs). Recommended programs should be implemented by mid-1993.	
	C-7 Assess and encourage the offering of upgrading and certification programs for building trades and building design professionals to increase their capability to incorporate energy conservation practices and technologies into construction.	Alberta Energy and Alberta Advanced Education, in collaboration with the appropriate educational institutions, Alberta Career Development and Employment, apprenticeship programs and interested stakeholder groups should review opportunities for improving energy efficiency construction practices and technologies in Alberta (i.e. development of curriculum, delivery of information or education programs and identification of new technologies). Recommendations for changes and implementation of programs that would permit the affected stakeholders to keep pace with energy-efficient building codes, construction practices and technologies and developments elsewhere should be included as amendments to the Alberta Building Code. Education and information programs should be implemented in 1993.	

★ in the priority column indicates objectives and tasks which should be considered for immediate implementation

Table 7-1. Summary tables, continued

Goals	Objectives	Tasks	Priority
D. Identify, promote and implement cost-effective energy developments that contribute to clean air.	D-1 Identify the levels of provincial support for, and royalties and taxes from, various energy sources (e.g. fossil fuel developments, utility projects, clean energy technologies systems, renewable energy development and conservation and efficiency measures). This information should then be used to help ensure that future provincial subsidies and incentives encourage energy developments that contribute to clean air.	Within the proposed management system, Alberta Energy should coordinate compiling information on the levels of provincial support (subsidies, incentives, economic-development assistance, research and development support, government loans) for, and taxes and royalties from, the various energy sectors within the province. The impact on clean air should be highlighted and this information should be made available to the public. The information should be used to adjust provincial energy development subsidies and incentive programs where appropriate. The survey should be done in 1992.	
	D-2 Investigate and consider how to implement full-cost analysis to take into account environmental and socio-economic implications of various energy sources for energy projects in government decision making.	Within the proposed management system, the Energy Resources Conservation Board should coordinate development of criteria for full-cost analysis to be applied in the evaluation of energy projects. All options should be considered. This analysis should be tested and reviewed. Any new system also would need to be applied to non-energy projects through the Natural Resources Conservation Board. Full cost analysis should be piloted in 1994.	
	D-3 Revise government policy to allow for flexibility in the sources of energy used for generation of electricity and to encourage conservation. This includes developing fair mechanisms to allow for environmentally-sound commercial projects and utility-entrepreneur joint projects that contribute to cleaner air.	Within the proposed management system, Alberta Energy should identify the range of available mechanisms to achieve flexibility in the sources of energy used for generation of electricity and make recommendations for legislative, policy and program changes if required. A priority area of focus should be on those cost-effective projects which lead to an overall reduction in air emissions for Alberta but are faced with access and rate issues which affect their viability within the Alberta interconnected system. The work is to commence in 1992 with recommendations to be developed by the end of 1993.	★

★ in the priority column indicates objectives and tasks which should be considered for immediate implementation

Table 7-1. Summary tables, continued

Goals	Objectives	Tasks	Priority
7.3 Point Source			
E. Strengthen the management approach for all point-source emissions in Alberta in order to avoid adverse effects on human health and the environment.	E-1 Develop new approaches for managing all point-source emissions to avoid adverse effects on human health and the environment. This should include the following components: • developing a more effective monitoring system structured to enhance public credibility; • developing better provincial inventories of point-source emissions such as methane, volatile organic compounds, and air toxics; • defining, prioritizing and implementing a management system to include a broader range of emissions and sources that are monitored and regulated; • identifying substances that may be a factor in human health including substances from non-energy-related emissions and air toxics; • developing standards (regulations or other management mechanisms) for the broader range of emissions; • developing and implementing a revised enforcement policy; and • improving the system for exchanging information with the public, particularly regarding health concerns.	Within the proposed management system, Alberta Environment should coordinate development of a new approach for managing all point-source emissions. Work toward revising the management of point-source emissions to begin in 1992.	
	E-2 Conduct a comprehensive review of gas-flaring practices, guidelines and regulations and make recommendations regarding opportunities for improving air quality.	This review should be coordinated by Alberta Environment within the proposed management system. Recommendations would be made in time to be incorporated into the new regulations of the Alberta Environmental Protection and Enhancement Act.	
	E-3 Encourage research and technological development to develop new ways to eliminate, reduce, recapture and dispose of emissions.	Within the proposed management system, an Alberta Environment task group should be established to coordinate ongoing and anticipated research. The program should start in 1993.	
F. Identify and evaluate a range of options available for managing point-source emissions to encourage greater innovation, improved environmental protection and cost-effectiveness.	F-1 Review and prioritize the options available to manage point-source emissions and build consensus for those that are most appropriate for controlling specific sources or combinations of sources and ensure the regulatory system allows for flexibility in management approaches.	Within the proposed management system, the Energy Resources Conservation Board and Natural Resources Conservation Board should jointly review management options (e.g. standards, incentives, tradeable emissions permits, emission charges/taxes) and the existing regulatory framework. Recommendations should be coordinated with the development of new regulations for the Alberta Environmental Protection and Enhancement Act. (Note: this task should be closely coordinated with Goal E and the associated objectives and tasks.) The review should begin in early 1992.	

★ in the priority column indicates objectives and tasks which should be considered for immediate implementation

Table 7-1. Summary tables, continued

Goals	Objectives	Tasks	Priority
7.4 Zone			
G. Develop and implement a zone approach to managing air quality within specific airsheds.	G-1 Establish a new approach for dealing with identified air quality problems in specific zones throughout Alberta. The definition of a zone would be based on the following criteria: • emission sources and volumes • emission dispersion characteristics • impacts of emissions • administrative considerations The new approach should include: • managing emissions, from both point and non-point sources, within specific zones to meet existing standards; • improving existing air quality standards within specific zones where necessary; • ensuring ecological integrity within zones; • managing the combined effects of a concentrated number of point sources; • establishing zones within Alberta and Western Canada based on need, nature of emissions and problems and what it is anticipated will be accomplished; • establishing a decision-making mechanism for determining when an air quality problem is appropriate and significant enough for a zone approach (e.g. smog in Calgary or Edmonton, sulphur emissions in northeastern Alberta or the Caroline area); • creating a mechanism for defining and officially recognizing a zone; • determining the roles of government, industry, the public and regulatory bodies (ERCB, NRCB) in problem solving (i.e. advisory or decision making) and defining appropriate mechanisms for accommodating those roles (e.g. multi-stakeholder regional air quality committee; regulatory hearings); • ensuring that decision-making procedures adequately consider total emissions, cumulative effects and ecological integrity; • ensuring that zone management is integrated with point-source emission management; and • ensuring that zone management is integrated with provincial and national emission management.	Within the proposed management system, this review should be coordinated with the review of point-source emissions (Section 7.3, Goal E and F) to develop a complementary and comprehensive approach to the management of air quality for zones within the province. Recommendations should be made by the end of 1993.	

★ in the priority column indicates objectives and tasks which should be considered for immediate implementation

Table 7-1. Summary tables, continued

Goals	Objectives	Tasks	Priority
H. Develop innovative and targeted solutions to better manage cumulative emissions in and around urban areas.	H-1 Develop and implement innovative solutions to air quality problems arising from urban transportation.	Within the proposed management system, a task group should be formed to develop new approaches to better manage urban transportation. For example, the group could assess measures including innovative urban planning, greater support for mass transit and funding for municipal bicycle trails, parking and bicycle-carrying equipment on transit vehicles. Tasks would involve identifying mechanisms, roles and responsibilities, adjustments to institutional or policy arrangements and assessment of costs and benefits. The task group should be formed in early 1992 and recommendations should be tabled by the end of that year.	
	H-2 Design and implement a mandatory vehicle-emissions testing program for urban centres in Alberta.	Using the proposed management process, Alberta Environment, Alberta Energy and the Solicitor General should coordinate a survey of vehicle-emissions testing programs in other jurisdictions as well as financial incentive programs for purchasing and/or operating fuel-efficient vehicles and disincentives for inefficient vehicles. The cost-effectiveness and social impacts of these programs also would be evaluated, including investigating means to reduce economic impacts on low-income groups. A program would be designed for Alberta as well as a discussion of costs and benefits by the end of 1992.	★
7.5 Regional			
I. Manage emissions within Western Canada to address regional air quality problems.	I-1 Develop a decision-making system for managing regional air quality problems. This should include: • meeting existing provincial standards; • supporting and strengthening ties among the western provinces and territories including the Western Provincial/Territorial Air Quality Issues Coordinating Committee (a committee with representatives from departments of Energy and Environment in four western provinces and two territories); • establishing mechanisms for industry and public consultation on specific regional air quality issues (e.g. bilateral agreements between provinces and with federal government); • ensuring that the position the Alberta government takes to the Committee is consistent with public input on provincial issues (e.g. consistent with the principles of the Clean Air Strategy for Alberta);	Alberta should encourage the Western Provincial/Territorial Deputy Ministers and Air Quality Issues Coordinating Committee to develop a comprehensive strategic plan. The plan should consider the strategies developed by the participating jurisdictions and incorporate the needs of stakeholder groups. This effort should be coordinated with actions taken to reform the ambient air monitoring system. The plan should be developed by the end of 1993.	

★ in the priority column indicates objectives and tasks which should be considered for immediate implementation

Table 7-1. Summary tables, continued

Goals	Objectives	Tasks	Priority
	• focusing on the distinctive characteristics of air quality issues in Western Canada (e.g. the predominance of energy-related emissions); • integrating economic and environmental considerations in solving regional air quality problems; • identifying, monitoring and managing the import and export of point-source emissions; • developing appropriate decision-making mechanisms to manage regional problems on an ongoing basis; and • deciding who makes what decisions within the Western Canada region.		
7.6 National/International			
J. Encourage collaboration between the provinces and the federal government to pursue actions that are cost-effective and ensure maximum flexibility in addressing national and international air quality issues.	J-1 Alberta should endorse the recommended Alberta position statement regarding greenhouse gases on page 60.		★
	J-2 Identify a cooperative and integrated range of options to reduce emissions at the national and international level in order to better position Alberta and Canada in international discussions.		
	J-3 Initiate a multi-stakeholder task force to develop capture and recovery strategies for greenhouse gases, with methane as the first priority.		
	J-4 Work with the federal government to develop an economic development strategy that encourages the export of energy efficiency, renewable energy, clean fossil fuel combustion and pollution-control technologies and services.		
	J-5 Encourage the federal government to pursue mandatory vehicle-efficiency standards to ensure automakers offer vehicles to consumers which are increasingly fuel efficient.		
	J-6 Work with the federal and other provincial governments to obtain reliable national inventories of greenhouse gases.	Energy should work with the federal and provincial governments directly and through the Canadian Council of Ministers of Environment and the Energy Ministers to bring forward Alberta's position and to establish inventories. Both ministries should continue to encourage stakeholder involvement in the development of a comprehensive national strategy.	★
	J-7 Investigate sulphur-recovery requirements for all industries within the context of the Canadian sulphur dioxide cap.	Initiate a multi-stakeholder task group which, using the proposed management system, will review and assess sulphur dioxide emissions, their impacts and recovery strategies.	

★ in the priority column indicates objectives and tasks which should be considered for immediate implementation

Table 7-1. Summary tables, continued

Goals	Objectives	Tasks	Priority
7.7 General			
K. Improve the gathering, sharing, integration and application of scientific, technical knowledge and research regarding atmospheric processes and effects on health and ecosystems.	K-1 Identify more consistent and readily detectable adverse effects on ecosystems, human and animal health and physiological adaptation resulting from changes in ambient air quality. Correlate these effects with levels of exposure and thresholds of effect. Priority should be given to the most sensitive receptors and its largest sources.	Within the proposed management system, Alberta Environment and Alberta Health should coordinate an integrated, comprehensive research program to address these issues as they pertain to Alberta. It is essential that this initiative be coordinated with other national and international efforts. Programs should start in 1993.	
	K-2 Review and develop a series of environmental indicators that are representative and indicative of human and environmental health and which are understandable for reporting on air quality management progress.	Within the proposed management system, Alberta Environment and Alberta Health should convene a task group to develop a set of agreed-upon indicators. The group would coordinate its efforts with similar efforts underway at the national level. The task group should be convened in early 1992 with recommendations for a preliminary set of indicators by the beginning of 1994.	
	K-3 Undertake research and technology development activities in support of clean air goals.		
L. Improve public awareness of air quality and enhance the public's capability of making choices and commitment to change through environmental education.	L-1 Coordinate and support the development and expansion of environmental education and public awareness programs within Alberta.	A multi-stakeholder task group should be established to evaluate current environmental education and information efforts as to their scope, coverage, coordination and effectiveness. Appropriate providers of information, delivery infrastructure, audience and evaluation criteria should be considered. Concepts for programs should be prepared to expand services where appropriate. (Note: task group would need to coordinate efforts with the group focusing on energy conservation and efficiency education programs.) Task group should convene in 1992 with recommendations prepared by 1993.	★

★ in the priority column indicates objectives and tasks which should be considered for immediate implementation

Table 7-1. Summary tables, continued

Goals	Objectives	Tasks	Priority
M. Integrate clean air goals into the provincial economic development strategy.	M-1 Develop specific components of a provincial economic development strategy to support commercialization and export of energy efficiency and renewable energy technologies and services and state-of-the-art clean fossil fuel combustion technologies and services.	Alberta Economic Development and Trade should convene an additional special session of *Toward 2000 Together* to deal specifically with environment and economy issues. Alberta Economic Development and Trade should establish a business development program geared to developing business opportunities for the private sector in the fields of energy efficiency and clean coal technology, including commercialization and export assistance. A data base on products and services and a directory of firms should be established starting in late 1992. Business development incentives should be in place in 1993.	

★ in the priority column indicates objectives and tasks which should be considered for immediate implementation

8.0 GLOSSARY OF TERMS

Acid
A substance which dissolved in water produces a sharp, sour solution; capable of providing hydrogen ions (H^+); common examples are lemon juice, vinegar and battery acid.

Acid Deposition
The transfer of acids or acid-forming substances from the atmosphere to the earth's surface.

Acidic
Acid-forming; any substance with a pH level of less than 7.

Acidification
A build-up of hydrogen ions above normal levels.

Acidity
A measure of the concentration of hydrogen ions, often on a scale from 1 to 14 where 1 is very acidic, 14 is very basic (alkaline) and 7 is neutral.

Acid Rain
Rain or snow contaminated by acids formed when industrial pollutants, especially sulphur dioxide and nitrogen oxides, undergo chemical changes in the atmosphere.

ADRP
Acid Deposition Research Program. ADRP, an $11 million program jointly funded by the Province and industry, operated from 1983 to 1988. The two major components of the program were the Medical Diagnostic Review (effects of acid pollution on human health) and the Environmental Review (effects of acid deposition on air, soils, waters and crops).

AEN
Alberta Environmental Network. The AEN is an umbrella organization with over 220 member organizations. The purpose of the AEN is to contribute to the enhancement and protection of the environment through the sharing of information and resources.

AEPEA
Alberta Environmental Protection and Enhancement Act (Bill 53). The AEPEA is proposed legislation which will bring Alberta environmental legislation under one umbrella act. The AEPEA was introduced to the Alberta Legislature for first reading in June of 1991, and is expected to be passed in the summer of 1992.

Aerosol
A suspension of fine solid or liquid particles in a gas. Smoke and fog are aerosols.

Airshed
A geographical area containing emission sources and the ecosystems potentially affected by emissions from those sources.

Air Toxics
A substance suspended in the air that has or tends to have a harmful effect on the environment or man.

Alkali
A substance that is soluble in water which neutralizes acid.

Alkaline
Containing an alkali; any substance with a pH level greater than 7.

Ambient Air
Outdoor air; all air that plants and animals breathe except the air.

APIGEC
Alberta Petroleum Industry/Government Environmental Committee.

Atmosphere
The air surrounding the earth, consisting mainly of nitrogen and oxygen. More than 75 per cent of the total mass of the earth's atmosphere is within 10 km of the earth's surface.

BADT
Best available demonstrated technology.

BATEA
Best available technology which is economically achievable.

Biomass, Plant
Wood, peat and other vegetation.

Bromine (Br)
A toxic, highly corrosive gas of the same chemical group as fluorine and chlorine.

Carbon Dioxide (CO_2)
A colourless odourless, non toxic gas essential to plant and animal life and is considered the major greenhouse gas.

Carbon Monoxide (CO)
A colourless, odourless, poisonous gas formed when carbon burns with an insufficient supply of oxygen. Part of the exhaust gases of automobile engines.

CASA
Clean Air Strategy for Alberta

CCME
Canadian Council of Ministers of the Environment. The CCME is a joint council whose members include the provincial and federal Ministers of Environment. The purpose of the CCME is to jointly address environmental issues which cross provincial jurisdictional boundaries.

CH_4
See Methane.

Chloride
Any of a group of chemical compounds consisting of chlorine and another element.

Chlorine (Cl_2)
A greenish-yellow poisonous, corrosive gas used in making drugs, dyes, explosives and plastics, and in bleaching and disinfecting.

Chlorofluorocarbons (CFCs)
Man-made chemical compounds containing chlorine, fluorine, and carbon.

Climate Change
Upward or downward trends in average conditions or in the incidence of weather extremes.

COH
coefficient of haze.

CO_2
See Carbon Dioxide.

CO
See Carbon Monoxide.

CPA
Canadian Petroleum Association.

Critical or Threshold Loading
The maximum level of atmospheric deposition an ecosystem can take without being damaged.

Deforestation
The loss of forests, either by tree harvesting or clearing, or through disruption of the natural balance from changes in rain, moisture, drainage or nutrient supply.

Desertification
The growth of existing deserts or the development of new deserts or desert-like areas.

Dioxide
An oxygen compound having two atoms of oxygen per molecule.

Dry Deposition
The transfer of acids and acid-forming substances to the earth's surface by all means that do not involve some form of precipitation; includes absorption, impaction, sedimentation, and chemical reaction.

Ecosystem
The interaction of organisms and their physical surroundings.

EIA
environmental impact assessment.

ENGOs
Environmental non-government organizations. ENGO's are typically organizations whose members are concerned with, and interested in, environmental issues. ENGO's are usually not for profit organizations which rely heavily on volunteers to accomplish their objectives.

Environment
The components of the earth and includes:

i) air, land and water
ii) all layers of the atmosphere
iii) all organic and inorganic matter and living organisms, and
iv) the interacting natural systems that include the components referred to in i to iii above

EPA
Environmental Protection Agency (United States).

ERCB
Energy Resources Conservation Board.

Fluorocarbons
Man-made chemical compounds containing fluorine and carbon.

Fossil Fuels
The remains or traces of prehistoric plants or animals formed in the geological past and removed from the earth in the form of oil, gas and coal.

GCM
general circulation models. GCMs are numeric computer models that simulate the evolution of large scale weather systems including some form of the interaction between the atmosphere and the ocean.

Global Warming
Increase in the earth's lower atmospheric temperature, possibly the result of the greenhouse effect.

Greenhouse Effect
The phenomenon occurring when certain atmospheric gases trap radiated heat in the atmosphere.

Halons
Man-made chemical compounds that contain bromine or iodine.

HC
See Hydrocarbons.

Hydrocarbons (HC)
A series of compounds of hydrogen and carbon formed by the decomposition of plant and animal remains, including the several types of coal, mineral oil, petroleum, paraffin, the fossil resins, and the solid bitumens occurring in rocks.

IPCC
Intergovernmental Panel on Climate Change.

Joule
The base unit of energy.

LRTAP
Long Range Transport of Atmospheric Pollutants (Canada). A program of federal, provincial and territorial governments in western and northern Canada to research, monitor and manage acid deposition and other atmospheric pollutants.

MDR
Medical Diagnostic Review — a component of Alberta's Acid Deposition Research Program.

Megatonne
One million metric tonnes.

Methane (CH_4)
The most simple of the hydrocarbons; the major component of natural gas.

Monoxide
An oxygen compound containing one oxygen atom in each molecule.

Montreal Protocol, The
An international protocol dealing with substances that deplete the earth's ozone layer. Adopted by over 40 countries September 16, 1987 in Montreal, it calls for a 50 per cent reduction in chlorofluorocarbons (CFCs) and halons from the 1986 level by 1999. Canada is committed to an 85 per cent reduction by the year 2000.

NAPAP
National Acid Precipitation Assessment Program (United States). NAPAP was an intensive research effort on the Long Range Transport of Atmospheric Pollutants (LRTAP), carried out in the United States and coordinated with a similar effort in Canada.

Nitrogen (N_2)
A colourless, tasteless, gas that makes up four-fifths of the earth's atmosphere.

Nitrogen Oxides (NO_x)
Formed when nitrogen (N_2) combines with oxygen (0_2) in the burning of fossil fuels and from the natural degradation of vegetation, and from the use of chemical fertilizers. A significant component of acid deposition and photochemical smog.

Nitrous Oxide (N_20)
A colourless, slightly sweet-smelling, non-toxic gas which occurs naturally in the atmosphere. Mad-made nitrous oxide is used as the anaesthetic commonly called "laughing gas."

NMHC
Non-methane hydrocarbons; same as VOC.

NO_x
See Nitrogen Oxides.

OECD
Organization for Economic Cooperation and Development.

Oxidation
Combining or reacting with oxygen.

Oxygen (O_2)
A colourless, tasteless and odourless gas that forms one-fifth of the air and which is combined in water and most mineral and organic substances. The most abundant of the elements, it is essential to plant and animal life.

Ozone (O_3)
A bluish, toxic gas, with a pungent odour, formed of three oxygen atoms rather than the usual two.

Petajoules
An energy measurement. Equals one thousand, million, million or 10^{15} joules.

pH
The pH scale is a means of quantifying acidity.

ppm
Parts per million.

ppmv
Parts per million by volume; 1 ppm is like 1 minute in 1.9 years, 1 inch in 16 miles or 1 ounce in 62,500 pounds.

Renewables
Renewable forms of energy production which include solar and wind energy.

Sinks
Large areas of vegetation or ocean which absorb compounds such as carbon dioxide.

Smog
Air pollution, usually a light brown haze, containing ground-level ozone, nitrogen oxides and other compounds.

SO_2
See Sulphur Dioxide.

Stakeholders
Interested and affected parties, including representatives of the public, industry and government.

Stratosphere
A layer above the earth's atmosphere, between 10 to 50 km (six to 30 miles).

Sulphide
Compounds containing sulphur and some other element.

Sulphur (S)
A non-metallic element, yellow in colour, which occurs abundantly in nature and is a product of sour gas processing.

Sulphur Dioxide (SO_2)
A colourless gas with an irritating odour formed when sulphur burns in air. Dissolves in water to give sulphurous acid.

Sulphur Oxides (SO_x)
Compounds of sulphur and oxygen — the two major ones being sulphur dioxide and sulphur trioxide. They are significant contributors to acid deposition.

Sulphur Trioxide (SO_3)
A colourless gas, formed when sulphur dioxide combines with oxygen in the air. It rapidly combines with water to produce sulphuric acid.

Sulphuric Acid (H_2SO_4)
A strong acid, which is a colourless liquid. When combined with water gives off heat. It is very corrosive, and is used extensively in the dyestuffs and explosive industries and as a drying agent in chemical processes.

Sulphurous Acid (H_2SO_3)
A solution of sulphur dioxide in water.

Sustainable Development
Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Target Loading
The maximum level of atmospheric deposition, based on dose-response and socio-economic analysis, that affords long-term protection from adverse ecological consequences.

THC
Total hydrocarbons.

Tonne
Metric ton, equals 1000 kilograms.

Toronto Conference
The World Conference — Changing Atmosphere: Implications for Global Security was held June 27 to 30, 1988 in Toronto.

Toxic
Having or tending to have a harmful effect on the environment or man.

Tropical Rain Forest
Huge tracts of forest acting as "sinks" for carbon dioxide. Destruction has a dual effect: burning generates carbon dioxide; killing the trees eliminates another means of absorbing carbon dioxide.

Troposphere
The lower part of the earth's atmosphere, up to about 10 km in which the temperature decreases with height.

Ultra-violet Light
Naturally present in sunlight but of a wavelength slightly shorter and thus invisible to the human eye. Its high energy levels cause sunburn.

UN
United Nations

UNCED
United Nations Conference on Environment and Development. (Rio de Janeiro, Brazil, June 1992). Dubbed the "Earth Summit," UNCED will involve 160 heads of state and 30,000 observers. Its objective is to have the heads of state examine ways of achieving sustainable development.

UNECE
United Nations Economic Commission for Europe (also ECE). Established through the UN in 1947, the ECE seeks to generate and improve economic relations among UN members and other countries of the world, and to strengthen inter-governmental cooperation in areas including the environment.

UNEP
United Nations Environment Program. The UN Environment Program, established in 1986, is governed by an international council. The UNEP seeks to promote international cooperation in the environmental field, provide general policy guidance to the UN on environmental issues and review implementation of UN environmental initiatives.

Volatile Organic Compounds (VOCs)
Hydrocarbon chemicals that evaporate easily and play a role in the creation of ground-level ozone.

Wet Deposition
The transport of acids and acid forming substances to the earth's surface by precipitation.

WHO
World Health Organization. The WHO was established through the UN in 1948 and its organizational objective is the attainment by all peoples of the highest possible level of health.

WMO
World Meteorological Organization. The WMO was formed through the UN in 1950, as a successor to the International Meteorological Organization (established in 1873). The WMO was created to facilitate international cooperation in the establishment of networks of stations and centres to provide meteorological services, and to further the application of meteorology to human activity.

APPENDIX 1: ALBERTA EMISSION GUIDELINES AND OBJECTIVES

A 1.1 Source Emission Guidelines

Alberta has published source emission guidelines for SO_2 and NO_X as they relate to several major industries in the province. Sulphur recovery guidelines in Alberta and some other jurisdictions are summarized in Table A1. Emission guidelines for new thermal power generating plants are summarized in Table A2 and Table A3. Industrial facilities receive individualized limits when they are licensed under the Clean Air Act.

Table A1. Sulphur recovery guidelines (%) for the sour gas industry

Sulphur Inlet* (t/d)	Alberta	Texas	U.S.**	New Mexico
> 2 000	99.8	99.8	99.8	98
50-2 000	99.5-99.8	99.8	98-98.5	98
10-50	96.2	96-98.5	93.5-98	90-96
5-10	90	96	93.5	90
1-5	70	80	74	0

* t/d — tonnes per day

** U.S. Environmental Protection Agency guidelines

Table A2. Sulphur dioxide emission guidelines for thermal power plants

Potential Combustion Release (ng/J)*	Alberta	U.S.**
<2 580	258 ng/J	70% SO_2 removal
>2 580	10% of potential up to 516 ng/J	90% SO_2 removal up to maximum 520 ng/J

* ng/J — nanograms per Joule

** U.S. Environmental Protection Agency guidelines

Table A3. Nitrogen oxide (expressed as nitrogen dioxide) emission guidelines for thermal power plants (in nanograms per Joule heat input)

Fuel	Alberta	U.S.**	California	Germany	Japan
Solid	258	300	—	85	125-220
Liquid	129-210	170	86	55	80
Gas	86	86	43	30	35

** U.S. Environmental Protection Agency guidelines

A 1.2 Alberta Air Quality Objectives

Alberta has established ambient objectives as being the maximum permissible concentrations of sulphur dioxide, nitrogen dioxide and ozone. Interim objectives have recently been recommended for acid deposition limits in Alberta. However, air quality objectives have not been established for volatile organic compounds, carbon dioxide, methane and chlorofluorocarbons. Alberta's maximum permissible concentrations are based on the federal air quality objectives which have the following three tiers: (1) the maximum desirable level, which is a long-term goal for air quality, provides protection against degradation of air quality in parts of the country where pristine air quality exist and also provides a basis for continued development of control technology; (2) the maximum acceptable level, which is intended to provide protection against adverse effects of atmospheric pollutants on vegetation, materials, animals, visibility, personal comfort and well-being; and (3) the maximum tolerable level, which specifies the highest concentration level that can be tolerated before public health is threatened.

Alberta has adopted the federal maximum desirable levels as the maximum permissible concentrations of sulphur dioxide: 0.17 parts per million (ppm) as a 1-hour average, 0.06 ppm as a 24-hour average and 0.01 ppm as an annual average concentration. Figure A1 shows sulphur dioxide objectives in some other jurisdictions throughout North America. Alberta objectives for sulphur dioxide are among the most stringent in North America, with the exception of California which has a slightly lower objective for the 24-hour average sulphur dioxide concentrations. These objectives are set at a level where no known adverse effects are expected to occur to vegetation. Negative effects on human health are not evident at these concentrations of sulphur dioxide.

Objectives for nitrogen dioxide adopted by Alberta conform to the federal maximum acceptable objectives for 1-hour and 24-hour averages, and to the federal maximum desirable level for annual averages. Maximum permissible 1-hour, 24-hour and annual average atmospheric concentrations for nitrogen dioxide are 0.21, 0.11 and 0.03 ppm, respectively. With the exception of 1-hour and 24-hour regulations in Ontario, Alberta has the most rigorous objectives in North America. Nitrogen dioxide objectives are based on adverse effects to humans. Objectives for nitrogen dioxide in some other jurisdictions in North America are presented in Figure A2.

Objectives for maximum permissible ground-level ozone concentrations in Alberta are set at the federal maximum acceptable levels: 0.08 ppm as a 1-hour average and 0.025 ppm as a 24-hour average. An annual average ozone objective has not yet been established for Alberta. Objectives for some other North American jurisdictions are illustrated in Figure A3. Human health effects are the governing factor in the development of objectives for atmospheric ozone concentrations.

In 1983, Canadian provincial and federal environment ministries adopted a wet deposition objective of 20 kilograms per hectare per year for sulphate in precipitation. Alberta's wet sulphate deposition is less than half that (9 kilograms per hectare) but in Western Canada, wet sulphate deposition is not

Figure A1a

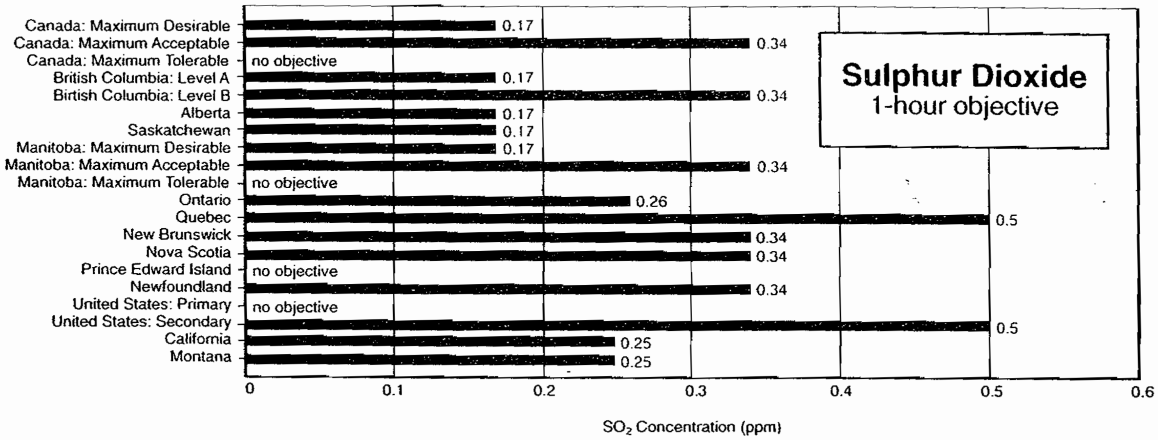


Figure A1b

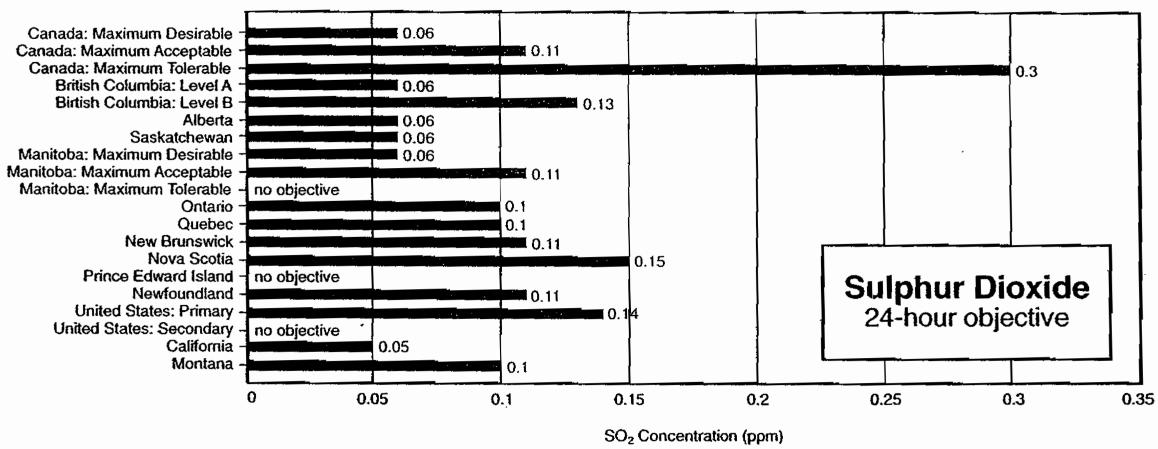


Figure A1c

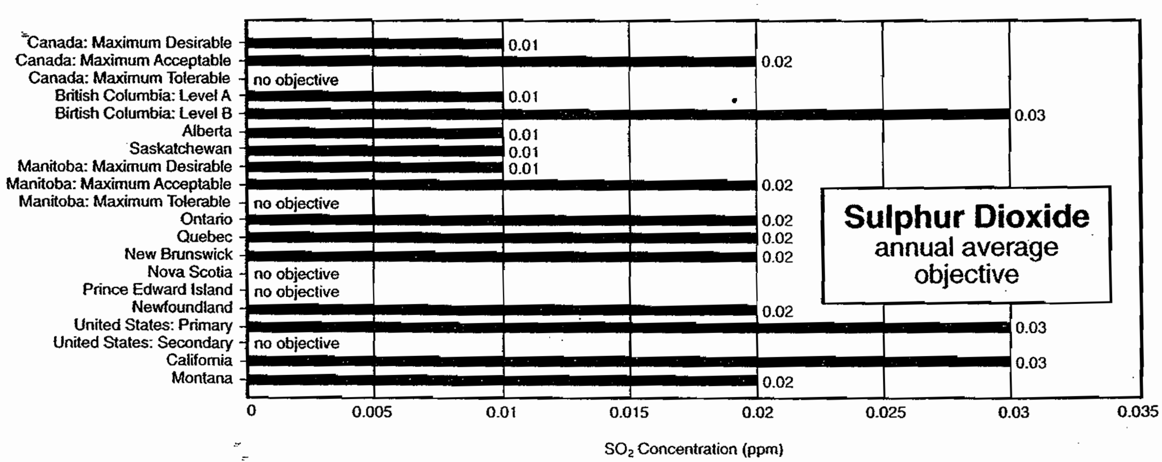


Figure A1. Ambient air quality objectives for sulphur dioxide in Alberta and other jurisdictions

a direct measure of wet acid deposition because alkaline dust and ammonia neutralize the acidity, and sulphate is present in the dust. Dry deposition, which is a greater concern in Western Canada than in Eastern Canada, has not been as extensively studied and objectives to control it have not been set. A 1988 study, supervised by the National Research Council, recommended that interim target loadings (deposition objectives) be developed while further research is conducted. The 1990 report, "Interim Acid Deposition Critical Loadings for Western and Northern Canada," recommended critical loadings for Western and Northern Canada.

Critical loading is defined as the highest loading that will not cause chemical changes leading to long-term harmful effects on the most sensitive ecological systems. These are currently

Figure A2a

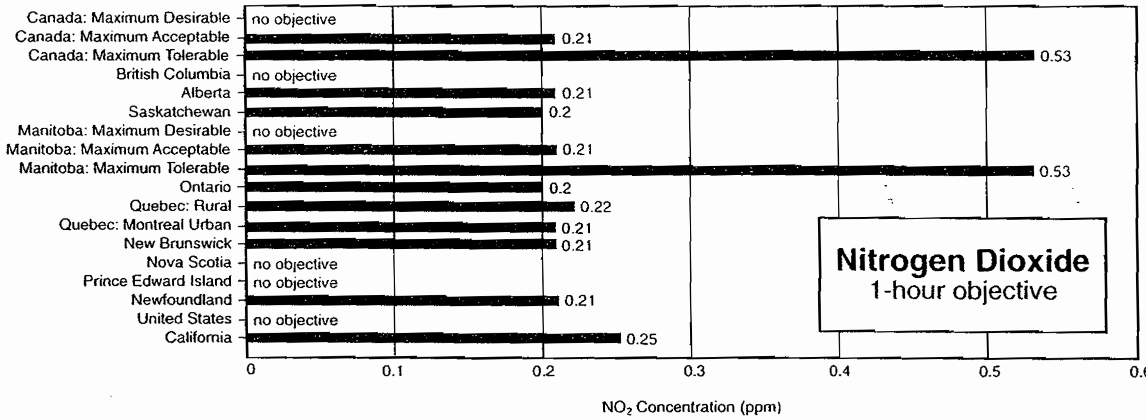


Figure A2b

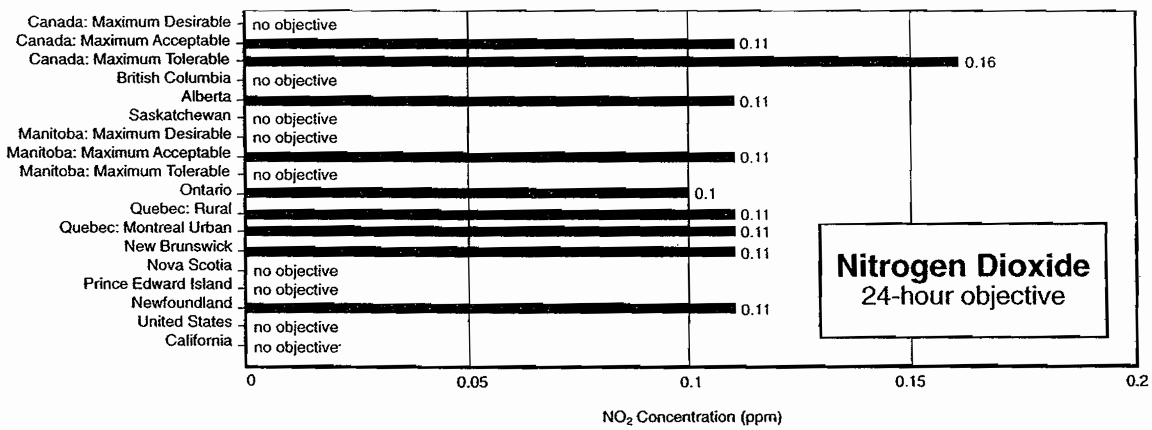


Figure A2c

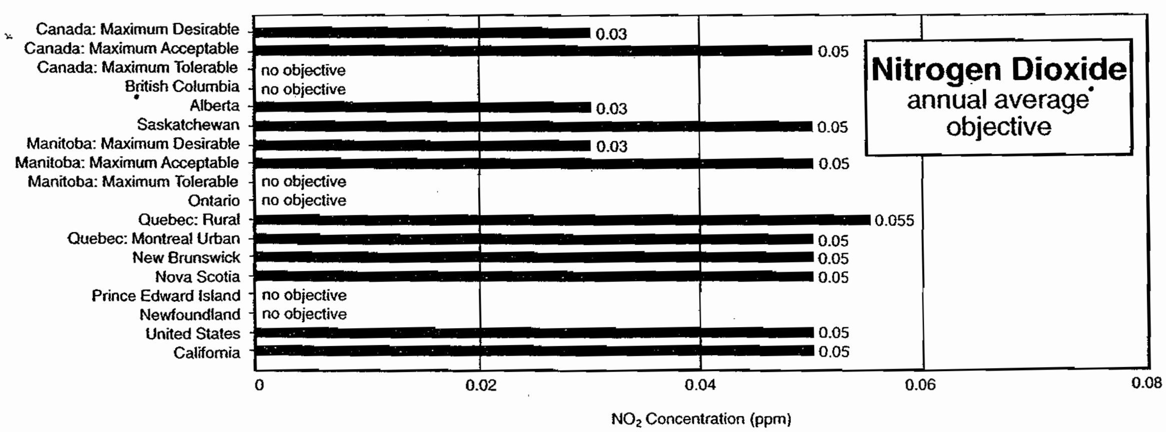


Figure A2. Ambient air quality objectives for nitrogen dioxide in Alberta and other jurisdictions

under consideration by participating agencies. They are expressed in terms of acidifying potential (AP), which is defined as the difference between the concentration of sulphate ions and the sum of calcium and magnesium ions, expressed in hydrogen ion equivalents. A range of interim critical loadings (expressed as AP) of 12 to 31 $meq \cdot m^{-2} \cdot yr^{-1}$ (milli-equivalents per square meter per annum) has been recommended for all areas of Western and Northern Canada. This recommendation is under consideration by the participating agencies.

Figure A3a

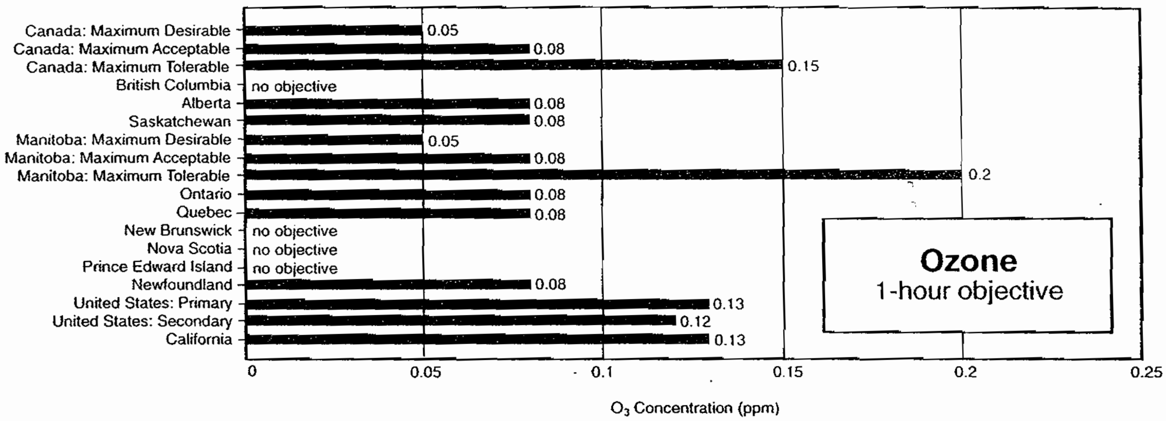


Figure A3b

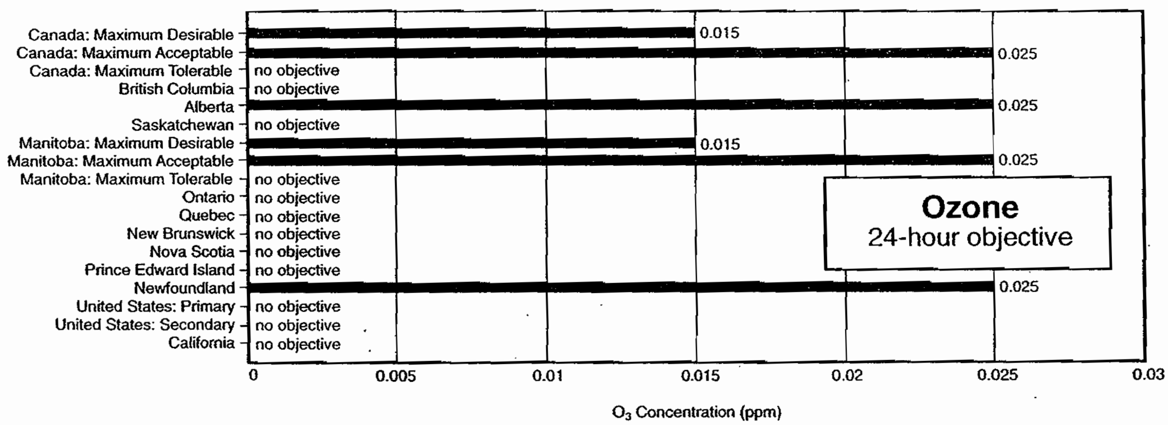


Figure A3c

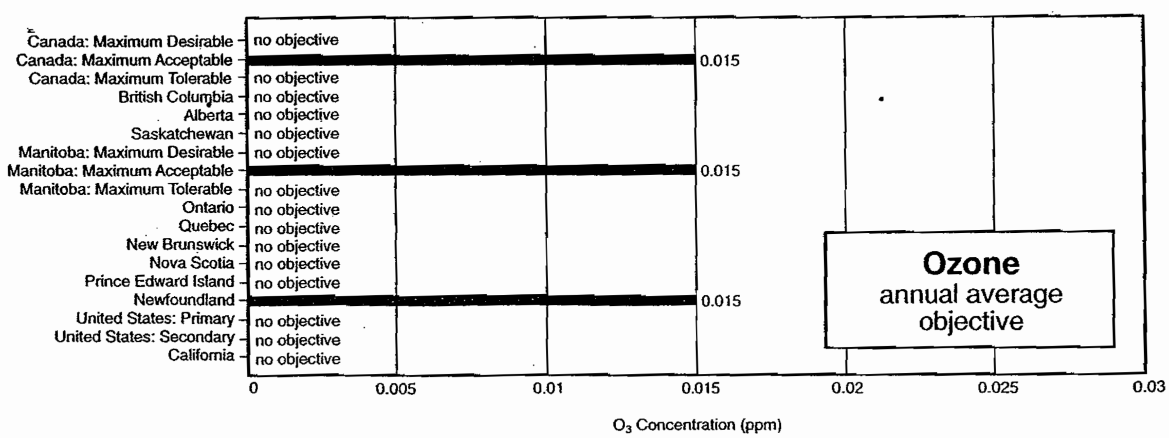


Figure A3. Ambient air quality objectives for ozone in Alberta and other jurisdictions

APPENDIX 2: THE ACID DEPOSITION RESEARCH PROGRAM

The Alberta Petroleum Industry-Government Environment Committee (APIGEC) was formed in 1972 to provide a mechanism for high-level communication between the provincial government and the petroleum industry on matters relating to environmental regulation and emerging environmental concerns. In 1973, a petroleum industry consortium, called the Whitecourt Environmental Study Group, funded a long-term research program to assess the effects of sour gas emissions on forest areas in west-central Alberta. The Alberta Oil Sands Environmental Research Program was initiated in 1975 to address the effects of acid-forming emissions resulting from the energy developments in the oil sands area.

In 1979, an APIGEC-sponsored sour gas workshop reviewed available information from the above studies and recommended that the Canadian Petroleum Association (CPA) and the Alberta Government establish the Steering Committee on Acid Gases in the Environment (SCAGE). The objective was to develop a coordinated research program to determine the consequences, both positive and negative, of acid deposition in Alberta. Over 40 experts from Alberta's industry, government and universities were recruited for three SCAGE technical subcommittees on air, vegetation and human health. The 1981 SCAGE report recommended an integrated, multidisciplinary approach to environmental problem solving. The underlying assumption was that all components of ecosystems are interrelated, and that understanding chemical and biological processes within, between and among ecosystems was essential to assessing the environmental impacts of acid deposition. The SCAGE report recommended the formation of a joint government/industry acid deposition research program (ADRP).

In 1982, a major sour gas well blowout near the town of Lodgepole in west-central Alberta brought to a head more than 25 years of controversy on the environmental and health effects of sour gas emissions in Alberta, particularly in the southwestern region. This event reinforced the fact that no reliable and comprehensive data existed on the effects of sour gas emissions on Alberta's environment, or on the health of local residents or industry. The added sense of urgency caused by the blowout gave impetus to formation of the ADRP.

The ADRP was established in 1983 with the following goals: (1) to provide a comprehensive understanding of the effects and consequences of acid-forming gases (sulphur and nitrogen oxides) and acidic deposition on the environment; (2) to provide a scientific basis for sound, long-term environmental management and regulatory control with respect to acid-forming gases; (3) to disseminate such information among program members, to the public and to government bodies; (4) to undertake any research deemed appropriate; and (5) to encourage and include opportunities for public representation in the ADRP. The ADRP had three components: Biophysical Research, Medical Diagnostic Review (MDR) and the Occupational Health Feasibility Study.

Biophysical Component

The Biophysical Research component addressed two questions. (1) Currently, are there observed or measurable, regional-scale, adverse effects of acidic or acidifying pollutants on Alberta's vegetation, soils and surface waters? (2) If the answer to this question is negative, then where and under what circumstances could such adverse effects occur in Alberta?

To address these two questions, the research program was designed to characterize the air quality of Alberta (background and polluted), and to apply the resulting data the assessment and prediction of the effects that various air pollutant exposure situations could have on sensitive environmental components. This was done in four steps. (1) A world literature review resulted in an 11-volume, 1300-page review which provided information on where, when and under what conditions adverse ecological effects from acid deposition have been observed. These reviews also made initial assessments of how this information related to the environment of Alberta. (2) Background air quality was evaluated over a 24-month period at an air quality monitoring station located at Fortress Mountain west of Calgary. At the same time, air quality was monitored at two similar monitoring trailers located north of Calgary near Crossfield (see to Figure A4). The Crossfield West air quality station sampled air modified by agricultural activities, the city of Calgary, and the general levels of rural human activity. The Crossfield East air quality station had the added influence of a major traffic corridor, a sour gas plant and the towns of Crossfield and Airdrie. (3) An emissions inventory identified 565 sources of sulphur dioxide and a total of 4025 sources of nitrogen oxides. (4) Using the air quality data and the emission inventory, mathematical models were created to predict or simulate the possibility of any regional scale environmental effects on crops, soils and surface waters in Alberta.

Within the province, the Biophysical Component of the Acid Deposition Research Program applied a series of effects models, working from previous models of pollutant dispersion and deposition, to locate any geographic areas and environmental components likely to be affected by present or potential levels of pollutant emissions.

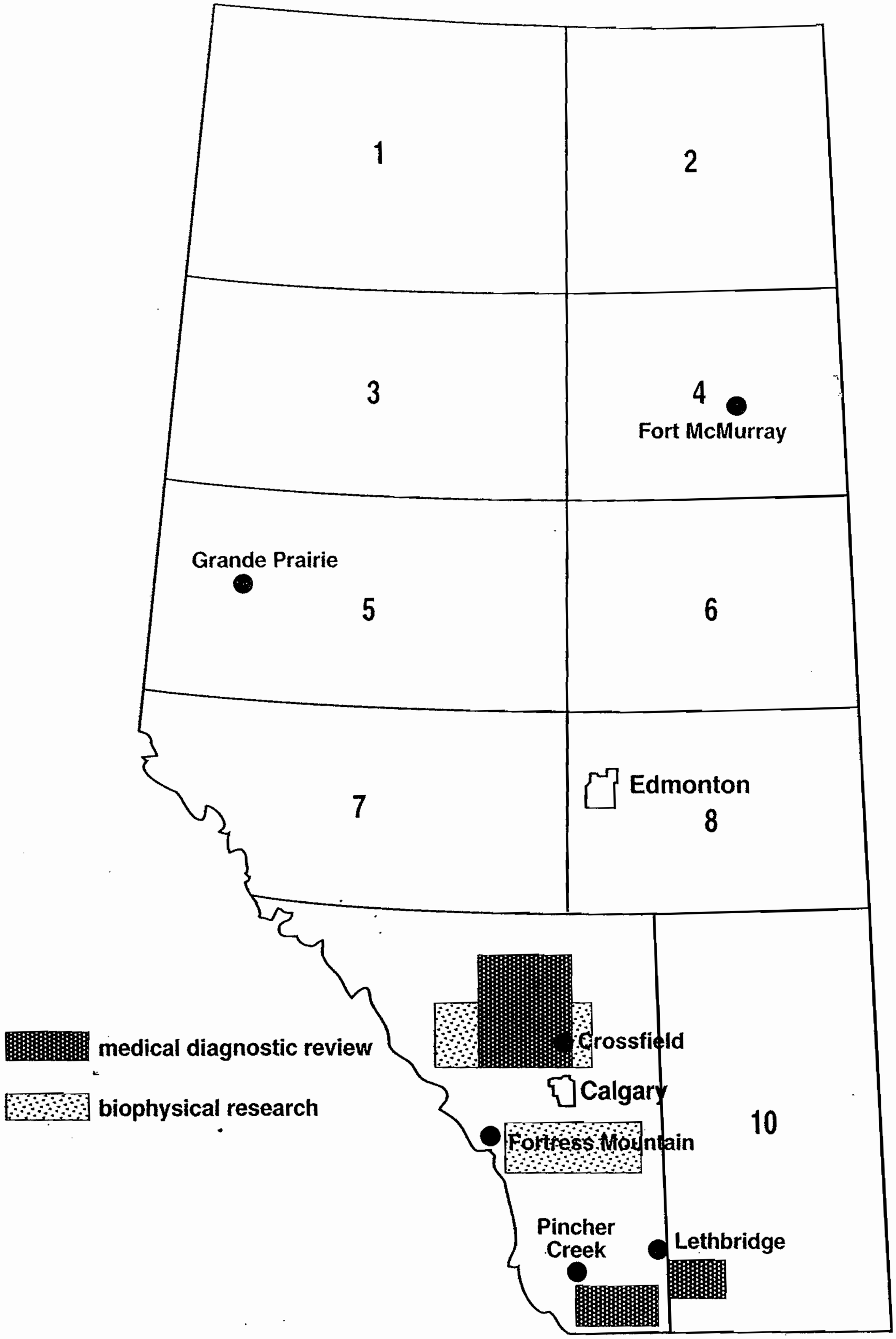


Figure A4. Map of regions and study sites used by the Acid Deposition Research Program

Medical Diagnostic Review

Conducted in 1985 and 1986, the MDR component of ADRP was the largest community health epidemiological survey ever undertaken in the province to address environmental health concerns of air emissions. The study included residents of the southwest Alberta communities of Twin Butte, Hill Spring, Mountain View, Glenwood and Willow Creek — known as the Index Area by the scientists (refer to Figure A4).

Long-standing health concerns, attributed to emissions from a local sour gas plant, had been voiced by some residents of this area for more than 20 years. The main objective of the MDR was to determine whether the residents potentially exposed to emissions from sour gas in the Index Area had a different health status from comparable, unexposed populations within Alberta. A control population (unexposed) was selected from residents in the Stirling/Raymond area, south of Lethbridge. Comparisons between the Index Area and samples from another exposed community, Didsbury/Carstairs/Crossfield/Irricana, north of Calgary, assisted the investigators in the interpretation and corroboration of the contrasts.

Results from ADRP Biophysical Study state:

"The specific crops selected for study were alfalfa, which is widely recognized as being particularly sensitive to sulphur dioxide effects, and wheat, which is generally considered rather tolerant of exposure. The modelling showed no concentrations approaching the levels found to affect the development of wheat crops.

"To predict alfalfa growth, a proven model was employed at three sites: Crossfield, Barrhead, and Cold Lake. This model used meteorological data but made no allowance for the impact of air pollutants. Computed yields were compared with actual reported yields. If reported yields were markedly less than those predicted by the model, it was then assumed that some environmental factor could be operative . . . At both Crossfield and Cold Lake, the forecast yields, particularly those employing the actual daily data, were close to the true field values reported by growers in the area. On the other hand, the figures for Barrhead showed yields to be roughly half of the model values. Accordingly, attention should be centred on the possible effect of environmental sulphur dioxide on alfalfa yields in the Barrhead area . . . The model displayed the known phenomena of growth enhancement as well as growth inhibition; in fact, for the Crossfield locations, it appeared that the low levels of sulphur dioxide may well be more beneficial than detrimental. At Barrhead, however, half of the calculations led to growth inhibition, raising the possibility, although not proving it, that sulphur dioxide exposure is one of the environmental parameters, if not the only parameter, responsible for lower yields found there compared with theoretical expectations . . . The nutritional quality of the crop may also be affected by low-level exposure to sulphur dioxide.

"One of the major concerns in the study of acidic and acidifying deposition has been the impact of the deposited materials on soils. Many agricultural crops such as alfalfa are very sensitive, being harmed by even slight soil acidity. On managed soils, the impact of the usual soil treatments is enormously greater than any effect of acidic or acidifying deposition. Consequently, the effects of acidic deposition on soil manifests itself, so far as any direct economic impact is concerned, in range land and forested areas. Forest soils are almost invariably acidic, predominantly because of the biological recycling of litter, a process that produces organic and inorganic acids . . . A recently developed model of soil acidification using the soil parameters that are tabulated in Alberta soil surveys, was applied. The deposition data are those previously identified as 'mean' and 'maximum' deposition values, the maximum annual deposition values corresponding to the present individual 90th percentile figures, roughly three times as great as the present mean value.

"The soils selected for modelling constitute a cross-section of soils generally characterized as sensitive or moderately sensitive. Modelling was carried out with the assumption that the deposition figures are characteristic of an entire region as defined here, and the soils were subjected to the calculated deposition for the region in which they occur. The five regions (see Figure A4) with the largest sources of acidifying pollutants were considered; i.e. Regions 3, 4, 6, 7, and 9. In addition, a separate calculation was made for the

Comparisons with other samples of Canadian populations were also made.

Occupational Health Feasibility Study

The technical feasibility, practicality and potential usefulness of a major study to examine the health experience of workers in the gas industry, both sweet and sour, and in the thermal power industry was also evaluated. Such a study had been proposed by a panel of scientific advisors convened by the ADRP to establish program priorities. This project involved an extensive literature search, interviews with 40 persons, visits to several field operations and extensive correspondence with appropriate agencies. The final report, submitted to ADRP in 1986, concluded that an occupational health study is feasible using the existing information. The occupational health program team undertook further work on studying potential occupational hazards resulting from the processing of chemicals in the oil and gas industry and has recently published their findings.

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mountainous area common to Regions 7 and 9, using deposition data computed from the monitoring station at Fortress Mountain . . . . The soils of Region 3 are uniformly quite resistant to acidification, whether deposition is assumed to continue at the present rate, or allowed to increase by more than a factor of 2. In contrast, the soils of Region 4 appear more sensitive, although a continuation of present deposition rates would require, in all cases, well over a century before the lowest threshold was passed. In Region 6, the Nestow soil is susceptible to acidification with both deposition scenarios, but the balance of the soils considered were highly resistant, as were the soils of Regions 7 and 9. In the mountains, the Topaz soil, although less acidic today, appears to have less resistance to acidification than the Egypt soil. An important impact of reduced soil pH is a shift in the balance between available nutrient trace and available toxic trace elements. Another is the decreased activity of the microorganisms responsible for litter decomposition and nutrient recycling. Acidification occurs naturally in forests, as previously noted, but it can be accelerated by anthropogenic inputs of acidifying substances, and greatly retarded by the application of soil management practices.

"A final area of concern is the possible acidification of surface waters within the province. Available data were compiled on the present chemistry of nearly 500 lakes and 19 rivers predominantly in the five regions having the highest emissions of sulphur compounds, Regions 3, 4, 6, 7, and 9. In addition, the mountainous portions of Regions 7 and 9 were considered separately and identified as Regions 7b and 9b, respectively . . . The impact of deposition on these waters, first utilizing the present levels of deposition, and then the worst case, in which deposition rises to the level measured at Crossfield East . . . points to Regions 7 and 9 as the areas of concern. However, it must be remembered that a number of the lakes in these regions are located in the mountains, and that this calculation assumes that deposition rates there are similar to those in the more heavily affected foothills and plains of those regions. Correction to deposition rates characteristic of the mountain areas greatly decreases the percentage of lakes threatened by acidification. In all regions, the introduction of major new sources greatly increases the risk of lake acidification. By contrast, the rivers appear quite immune to acidification. It appears that river acidification is not a serious problem in Alberta."

Among the specific conclusions of the Medical Diagnostic Review for southwest Alberta were the following:

"(1) There is no evidence to suggest an excess in the overall incidence of cancer in the Index Area (IA). With the exclusion of non-melanotic skin cancers, the data suggest that residents of this area experience a lower than expected overall incidence of the remaining killing and disabling malignancies; (2) both men and women report slightly higher rates of problems of fertility in the IA compared to the Stirling/Raymond (SR) unexposed control area. The differences do not suggest the existence of a health problem in any area we surveyed; (3) the investigators detected a small excess of some of the symptoms which residents of IA have reported for many years. These are largely the cardinal symptoms. The investigators ascertained heterogeneous complaints which suggest discomfort and sustained distress. The symptoms include burning and watering of eyes, runny nose, itching of the skin, throat irritation, sputum production, tingling and trembling of hands, fatigue, back pain, and leg and hip pain; and (4) the differences in the clinical entities recollected and reported by the participants which are systematically higher in IA as compared to SR are not large enough to contradict or cast doubt upon the major outcome findings. The differences do not constitute an important demonstrated health effect, either good or bad, when the rates of the subjective events are somewhat higher or lower in IA than in the reference populations."

APPENDIX 3: GUIDING BELIEFS AND VALUES

In Section 6.3 commonly held beliefs and values, what we stand for and hold to be true, are presented as the basis upon which the strategy is built. These concepts reflect the views of Albertans presented through the Clean Air Strategy for Alberta process. They are fundamental to the development of an effective air quality management system for the province.

These beliefs and values, with explanatory text, have been developed through the Clean Air Strategy for Alberta.

Health, Quality of Life and Education

- **Human health and ecological integrity within the province must be protected.**

Albertans enjoy and value one of the healthiest environments in the world. To maintain and enhance this environmental quality, the province is committed to effective environmental legislation, regulation and enforcement.

- **Albertans have an obligation to their children and future generations to pass to them a healthy environment.**

This is in keeping with the principles of sustainable development. A good quality of life for the future, including clean air, should not be jeopardized by short-sighted behaviour today. Therefore, decisions about energy policies, programs and projects should consider their full impact on society.

- **Human health, environmental quality and the economy are interdependent and inseparable.**

Health is more than the absence of disease, it is a resource for everyday living; a dynamic balance of physical, social, spiritual, economic and political dimensions which is critical to our individual sense of independence and well-being.

- **Air quality management and decision-making should strive to use cooperative and constructive processes rather than adversarial approaches.**

Multi-stakeholder consultative decision-making processes are needed to review on-going air quality issues. This approach should be used to identify potential conflict, anticipate problems and establish a process to resolve disputes regarding policy development and implementation of programs.

- **An educated and motivated public, which is able to make sound life-style choices, is essential to the development and implementation of a successful clean air strategy.**

Many of the challenges encountered in achieving clean air require individual action and lifestyle change. Therefore, if a clean air strategy is to be successful, it is important that individual Albertans understand how their actions contribute to air quality problems and how they can contribute to solutions. Public information, education and persuasion will be required to help Albertans understand why actions are being taken and the role they can play.

- **Full public access to information and involvement in decision making for air quality is essential.**

The public should have ready access to monitoring data and other relevant air quality information. As well, information should be made available on the various options available for dealing with air quality problems. Using this information, a multi-party consultation approach is needed for establishing air quality goals. This type of approach facilitates public understanding, acceptance and leads to accomplishment of goals.

- **Addressing local and regional air quality problems is a priority.**

Albertans expressed concern about smog in major urban centres, acid deposition in Northeast Alberta, and toxic emissions from pulp mills and waste incinerators. Environmental and community groups also expressed concerns about local air quality associated with flaring and venting from oil and gas facilities. Unless local and regional problems are resolved, national and international commitments will lack credibility.

Equity

- **Fairness in recommendations and actions is essential.**

Fairness is essential. No sectors or regions should bear an excessive part of the burden for reducing emissions. Conversely, there should be equal opportunity and responsibility for all sectors to be part of the solutions to air quality problems. Mechanisms for ensuring fairness include cooperative and consultative approaches to decision-making and consideration of the full cost (including environmental and socio-economic impacts and benefits) of various options.

- **All consumers should share fairly in the costs and benefits of reducing emissions.**

All consumers contribute to air emissions and therefore all should be part of the solutions. Individuals contribute emissions to the atmosphere through the burning of fossil fuels: heating their homes and workplace, operating their vehicles or purchasing and consuming manufactured products.

- **All suppliers of energy resources or services should be given an equal opportunity to contribute to a healthy environment and a sound economy.**

Policy and programs should allow producers of energy and energy-related goods and services the flexibility to choose energy sources and technologies that contribute to clean air.

Coordination and Interrelationships

- **Albertans should work to alleviate their share of national and international air quality problems.**

This commitment should consider the role Alberta wishes to take, the quantity of the emissions relative to national and global amounts, and the potential impact of various measures. It is important that the national and international nature of air quality problems is recognized, as well as the national and international aspects of Alberta's energy industry. Unilateral actions at a provincial or even national level will not contribute significantly to global solutions and may create severe economic pressures on the competitiveness of industry in Alberta and the rest of Canada. However, by showing leadership, Alberta may be able to influence the actions of other countries whose emission levels are greater.

- **Albertans have a leadership role to play in solving air quality problems.**

Alberta has already shown itself to be a world leader in reducing acid-forming emissions from sour gas plants. Not only are there opportunities for Albertans to lead by example in reducing emissions, but also by transferring environmental technology and expertise to other parts of the world. Research and development of new processes and technologies are an important component of this.

- **The various levels of government share responsibility for air quality management and should coordinate their efforts to avoid duplication of efforts.**

Municipal, provincial and federal levels of government in Canada all share responsibility for developing legislation, policy and programs to manage air quality. There is a need to have an integrated approach to define problems, prioritize issues, establish goals and targets that involves all the appropriate levels of government to make best use of limited resources.

- **Encouraging wise use of energy and striving to optimize energy conservation and efficiency are essential.**

Significant emission reductions can be accomplished through measures that would reduce the consumption of energy. As well, measures that increase energy efficiency, for instance stricter vehicle and appliance standards, must be assessed for their potential to reduce energy-related emissions. Some of these measures will require new legislation, while others will require programs that encourage changes in lifestyle.

Science, Research and Development

- **Alberta's strengths in technology, new technology development and services can be used to help resolve air quality problems and to diversify and strengthen the economy.**

Alberta has developed innovative technology to deal with air quality problems. Opportunities exist to transfer and market this technology to other countries. Building on these strengths not only contributes to clean air but also helps to diversify and strengthen Alberta's economy.

- **Air quality should be managed on the basis of sound scientific information and appropriate risk management.**

Accurate and up-to-date scientific information on gaseous emissions and their effects must form the basis of decisions regarding air quality management. Where there are information gaps or uncertainties attempts should be made to reduce these through research. Acting prematurely may result in unnecessary economic losses. On the other hand, delaying action until all information gaps or uncertainties are addressed may result in major environmental damage and human suffering. Therefore, it is important to identify and assess the risks associated with air quality decisions in determining a reasonable course of action.

APPENDIX 4: AIR TOXICS AND EMISSIONS FROM NON-ENERGY SOURCES

The importance of air toxics and emissions from non-energy-related sources was raised throughout the Clean Air Strategy for Alberta process, but these emissions were beyond the terms of reference of the Strategy.

Broaden the Scope of the Strategy

It is critical that any strategy addressing clean air encompass air toxics (including those found in indoor air), regardless of source, as well as other odour-causing gases and non-energy-related sources of those gases addressed by the recent Clean Air Strategy consultations.

Air toxics, regardless of the source or the location of exposure (i.e. indoor air), constitute a threat to human health, ecosystems and the biosphere. Excessive exposure to airborne toxics can have intermediate or long-term adverse effects on the health of human, animal and plant life. In Alberta, many of these toxic substances are associated with the use of motor vehicles and industrial emissions associated with oil production and refining, gas processing, heavy oil extraction and the manufacture of pulp, paper and petrochemicals. Air toxics are also associated with a broad range of building materials, cleaning compounds, pesticides, tobacco and wood smoke, molds and microorganisms.

There are important non-energy-related sources of gases that contribute to smog, acid deposition, global warming and ozone depletion such as the agricultural, chemical, petrochemical and forestry industries. These were not in the original terms of reference for the Clean Air Strategy for Alberta, however, Alberta cannot hope to achieve clean air without addressing these important emission sources.

Some common air toxics include:
hydrogen sulphide;
mercaptans;
volatile organic compounds including benzene;
organochloride;
asbestos;
mercury;
vinyl chloride; and
radio-nuclides.

Expand the Stakeholder Group Advising on Air Quality

The Clean Air Strategy for Alberta recommends, in the Task associated with Objective A-1, that the current Clean Air Strategy Advisory Group be established as an ongoing committee and be expanded to include representation from the health, forestry, transportation and agricultural sectors. The role of the revised Advisory Committee would be, among other things, to guide the consultations addressing air toxics and non-energy-related emissions. It is anticipated that this new committee would have important working-level connections with and support from the provincial departments of Health; Economic Development and Trade; Forestry, Lands and Wildlife; Transportation; Agriculture; and Occupational Health and Safety in addition to Environment and Energy.

The Task associated with Objective A-1 also recommends the Alberta Government consider establishing a permanent secretariat to support Advisory Committee activities during the review and implementation of recommendations from the recent Clean Air Strategy consultations and the proposed follow-on consultations and studies. This secretariat should be funded by the appropriate government departments and include seconded staff from the most interested stakeholder groups.

Scope of the Recommended Follow-on Consultations and Studies

Albertans rely on various standards and regulatory mechanisms to protect them from excessive exposure to airborne toxic substances in cities, homes and the workplace. However, there is no strategy to provide direction, to establish priorities or to effectively pool knowledge and resources to deal with these concerns. Without such a strategy, Alberta's response will be based on uncertain data and, consequently, less focused than would be desired.

Within the Management System proposed in Objective A-2 and its associated Task, there should be a broad consultative process, modelled on the original Clean Air Strategy for Alberta, that:

- identifies and clarifies the most important issues associated with air toxics (including indoor air) as well as non-energy-related emissions of the other gases of concern;
- examines the impact of air toxics on human health and the ecosystem;
- outlines practical and achievable actions that can be taken by consumers and producers to reduce the emission of air toxics; and
- develops policy and program recommendations to present to the Alberta government.

Specific knowledge gaps for air toxics that must be filled in order to adequately address the topic include the need to:

- compile and review current information and standards on air toxics, their sources and effects and design a system to regularly update this information;
- design a system for ready and ongoing access to expertise and data on airborne toxics by the public including communities, local authorities, industry, health professionals and provincial government departments, boards and agencies;
- design a system for responding to specific local concerns regarding air toxics;
- develop practical research goals for the Alberta scientific community including the need to review synergistic effects; and
- identify priority substances for improved monitoring.


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