SUBMISSION

TO THE

ONTARIO ROYAL COMMISSION

ON

ELECTRIC POWER PLANNING

BY

FISHERIES AND ENVIRONMENT CANADA

October 8, 1976

STATEMENT TO THE COMMISSION

The Department of Fisheries and the Environment welcomes the opportunity to present to the Ontario Royal Commission on Electric Power Planning a number of considerations relating to the environmental management and pollution control aspects of long-range planning for the electric power system in the province. The establishment of a Royal Commission by Ontario is recognized by the Department as a positive indicator of the Province's concern for the socio-economic and environmental implications of electric power production and consumption. The Department concurs with and lauds this initiative to examine in a most fundamental way this important area of human activity.

Fisheries and the Environment Canada would like to express its appreciation to the Commission for the invitation to make a presentation outlining our mutual concerns on the environmental implications of long-range electric power planning.

R.W. Slater
Chairman
Ontario Regional Board
Department of Fisheries and
the Environment

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1. DEPARTMENTAL MANDATE AND INTEREST IN ENERGY PRODUCTION AND USE

1.1 Introduction

International events in recent years have heightened concern over a continued scarce supply of energy at a reasonable price to Canadians, a concern recognized in the recent federal energy strategy document which advocates greater national self reliance in energy through programs of improved demand management and the development of energy supply alternatives.(1) At the same time there has been strong and increasing interest in the protection and enhancement of the natural environment coupled with a growing awareness that energy production and distribution systems generate environmental costs. It is the role of Fisheries and Environment Canada to inform decision makers about the nature of environmental costs and to recommend ways in which energy policy can be shaped to minimize them. Both the general interest of the Department in environmental quality and its particular interest in energy production and consumption are reflected in a number of the Department's programs, the more relevant of which will be outlined in this Submission. The Department's interests are also reflected in an emerging approach to energy/environment relationships.

This initial section of the Submission presents a preliminary statement of the Department's general approach to the effective management of environmental resources. It also outlines the legislative mandate of the Department in general and more particularly with respect to the management of the environment in Ontario, as well as discussing selected programs which are administered in discharging those responsibilities. Section 2 discusses briefly the Ontario energy situation in order to put the Department's concerns regarding the environmental impacts of specific energy supply options into perspective.

Section 3 presents a discussion of the problems involved in assessing the environmental impacts of energy developments themselves as well as the indirect effect current proposals may have on environmental quality in the future through their impact upon the direction of development of technology and of economic activity. Sections 4 and 5 document the Department's specific interest in energy and environment as it relates to long-range electric power planning in Ontario.

This Submission addresses a wide range of concerns that relate to the Department's broad concepts of the relationship between human activity and the environment. It concentrates on presenting a review of relevant information and knowledge drawn from both departmental and external sources. In doing so, the Submission attempts a broad view of the subject of electric power from an environmental perspective. It should be stressed that in this Submission, Fisheries and Environment Canada is not necessarily expounding federal government policy. Rather, it is conveying to the Commission the concerns the Department has for the environmental implications of electric power production and consumption and some overall perspectives the Commission may find useful to consider in the course of its deliberations.

This Submission concentrates on the environmental impacts of planned electricity generating systems. This does not mean that the Department is ignoring alternative energy sources. Indeed, the Department has a vital interest in promoting such efforts as evidenced by its involvement with the ARK project in Prince Edward Island and in the Forest Biomass program. (2), (3) Therefore, while this Submission concentrates on environmental impacts of traditional energy sources, the Department will be happy to supply the Commission with details of its involvement in alternate energy sources at a future date, on request.

1.2 Energy/Environment Positions

Before discussing specific energy developments and departmental programs, it is clearly desirable to outline a coherent and comprehensive framework for approaching energy/environment issues.

(a) Fisheries and Environment Canada cannot have a position "for" or "against" energy development, production, or use as such, but must promote policies that lead to a long-term balance between the needs for energy and the benefits of its use on one hand; and the availability of energy and the net environmental, social, and economic costs of its supply and use on the other.

(b) The overall environmental effects of the supply and use of energy, in both the short and longer-term, are integral parts of the costs and benefits of energy, and must be included from the beginning in energy-related decisions and policies. In this context:

(i) The environmental impacts of energy policy and energy development decisions must be examined with respect to the consequences of all activities connected with the energy activity -- exploration, development, processing, distribution and marketing, consumption, residuals, and waste -- in space and time.

(ii) The environmental impacts of energy activities must be examined from the point of view of both routine and controllable impacts, and non-routine or accidental impacts (spills, sabotage, fabrication fault, etc.). Where uncertainty exists, cost-benefit analysis may be an inadequate evaluative technique.

(c) Energy and power developments must be assessed and reviewed as part of integrated and cumulative energy systems and industrial systems, not as single developments on a one-by-one basis. Similarly, all energy supply and distribution activities and proposals must be assessed with respect to environmental impacts, in the context of the spectrum of possible alternative energy supply and distribution systems, including possible conservation measures, and in relation to the environmental consequences of not developing and distributing the energy. These assessments must be consistent for all types of energy activities, and between energy activities and other industrial and social activities.

(d) The environmental impacts of energy development must be reviewed in the context of:

(i) The effect that the particular development will have on the distribution and pattern of industrial growth, investment, and population growth, with the consequent demands on the environment from those factors; and

(ii) The effect that the energy development will have on the increased or decreased dependency of industrial, economic, and social activities on complex and sophisticated energy systems, with resultant vulnerability to interruption or malfunction, and the tendency to rely on technical safeguards and standby systems.

(e) The only long-term solution to accelerating energy problems is a reduction in use of energy to a level which can be supplied on a continuing basis from natural processes. Thus the underlying thrust of the Department's long-term energy program must be to:

(i) help reduce the demand for energy, by

(a) increasing the efficiency of energy use, and

(b) finding ways of achieving the same social ends without using as much energy as at present; and

(ii) help develop practical and quantitatively useful ways of meeting man's needs for energy from renewable or sustainable sources.

It is within this framework that sections dealing with specific options for electricity production are designed to fit. The framework highlights the Department's concern, as a national agency, for assessing all the impacts associated with any option whether they actually occur in Ontario or not. The following section will outline the Department's legal basis for involvement in energy related activities.

1.3 Departmental Mandate

1.3.1 Federal Authority

The federal role in environmental management and pollution control is an evolving one, due to the necessity of controlling pollution and preserving a high quality of the natural environment within the political and legal context of a dynamic federal state. Accordingly, the federal role and, more specifically, the Department's role in pollution control and environmental management is based upon the division of power between Parliament and the provincial legislatures, as well as on proprietary rights over natural resources as stipulated in the British North America Act of 1867.

1.3.2 Legislation

Parliament has passed a number of pieces of legislation to carry out federal responsibilities encompassing environmental management and pollution control.

The Government Organization Act of 1970 (R.S.C. 1970 Chapter 42) established the Department of the Environment, (now the Department of Fisheries and the Environment). The scope of responsibilities assigned the Department under this Act are stated as follows:

- The duties, powers and functions of the Minister of the Environment extent to and include all matters over which the Parliament of Canada has jurisdiction, not by law assigned to any other department, branch or agency of the Government of Canada, relating to

  (a) sea coast and inland fisheries;

  (b) renewable resources, including
    (i) the forest resources of Canada,
    (ii) migratory birds, and
    (iii) other non-domestic flora and fauna;

(c) water;

(d) meteorology;

(e) the protection and enhancement of the quality of the natural environment, including water, air and soil quality;

(f) technical surveys within the meaning of the Resources and Technical Surveys Act relating to any matter described in paragraphs (a) to (e); and

(g) notwithstanding paragraph (f) of Section 5 of the Department of National Health and Welfare Act, the enforcement of any rules or regulations made by the International Joint Commission, promulgated pursuant to the treaty between the United States of America and His Majesty, King Edward VII, relating to boundary waters and questions arising between the United States of America and Canada, so far as the same relate to pollution control.

- The Minister of the Environment, in exercising his powers and carrying out his duties and functions under Section 5, shall

(a) initiate, recommend and undertake programs and coordinate programs of the Government of Canada, that are designed to promote the establishment or adoption of objectives or standards relating to environmental quality, or to control pollution; and

(b) promote and encourage the institution of practices and conduct leading to the better protection and enhancement of environmental quality, and cooperate with provincial governments or agencies thereof, or any bodies, organizations or persons, in any programs having similar objects.

Accordingly, the Department, in carrying out its pollution control and environmental management functions, administers a number of pieces of legislation. A list of Departmental Acts and Regulations is presented in Appendix 1. From the point of view of the environmental implications of energy planning in Ontario, the more significant of these Acts include:

The Fisheries Act
The Canada Water Act
The Clean Air Act
The Environmental Contaminants Act
The Canada Wildlife Act
The Migratory Birds Convention Act
The Forestry Development and Research Act

Since energy production and distribution systems are a major source of environmental impact, the legislative base established by the Department's acts and regulations effectively gives it an interest in energy planning and development in Canada.

1.3.3 Environmental Assessment and Review Process

The Department is responsible for administering the Environmental Assessment and Review Process. Under this Process, all those projects involving federal funds or lands, considered to have significant environmental consequences, are submitted for review. Appendix 2 describes the process in more detail.

1.3.4 International Obligations

Many of the Department's activities stem from obligations arising out of treaties and international agreements. Those agreements which are more relevant to Ontario include:

The Boundary Waters Treaty
The Niagara Treaty
The Great Lakes Water Quality Agreement
The Great Lakes Fisheries Convention
The Migratory Birds Convention

In addition, under the Boundary Waters Treaty, a number of Boards of Control were established to regulate the levels and flows of the Great Lakes system. Although the main thrust of the Treaty deals with the diversion of water and its effect on water levels, it also states that "the waters herein defined as boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other". This provision forms an important basis for the 1972 Canada-U.S. Great Lakes Water Quality Agreement. (Submitted under separate cover)

1.3.5 Federal-Provincial Agreements

Many of the Department's programs stem from federal-provincial agreements which are the principal mechanisms through which required coordinated and cooperative action is achieved with the province to carry out essential pollution control and resource management functions. In Ontario, the primary agreement between the federal and provincial governments for matters relating to environmental protection is the Canada-Ontario Accord for the Enhancement and Protection of the Environment (see Appendix 3).

The Canada-Ontario Great Lakes Water Quality Agreement (submitted under separate cover) was signed by Canada and Ontario specifically to expedite the signing and implementation of the Canada-United States Great Lakes Water Quality Agreement. The Canada-Ontario Agreement provides for the development of coordinated programs by Canada and Ontario to implement the International Agreement by the arrangement of shared costs for research in developing regulatory programs as well as carrying out water quality surveillance activities.

Basically, this federal-provincial agreement ensures that each government will take the required action to implement the International Agreement within its jurisdiction. Specific programs under this Agreement are discussed in Section 1.5.

1.4 Organization of the Department

1.4.1 Overall Departmental Structure

The Department of Fisheries and the Environment is one of the largest departments of the federal government in terms of staff. It has approximately 12,210 employees and a budget of about $515 million. To carry out its role, the Department is organized into operational units, each concerned with a broad element of the natural environment (the atmosphere, the oceans, fisheries, the forests, etc.), or with a common problem of managing human activities (e.g., the Environmental Protection Service). Each of these units has a distinct operational and management program.

To begin this brief outline, it will be useful to refer to Figure 1, which shows that, in addition to a Planning and Finance Service, the Department has two main components: The Environmental Services and the Fisheries and Marine Service.

a) The Environmental Services:

This major arm of the Department administers three components responsible for Environmental Management, Environmental Protection, and Atmospheric Environment. These components are described below:

(i) Environmental Management Service

This Service is responsible for operational and research activities pertaining to renewable resources under its Inland Waters Directorate, Lands Directorate, Forestry Service, and Wildlife Service. Its Policy and Program Development Directorate provides the overall policy planning and program development and review capability. Five Regional Directorates (the Pacific and Yukon, Western and Northern, Ontario, Quebec, and Atlantic) direct the work of the Service on a geographically decentralized basis.

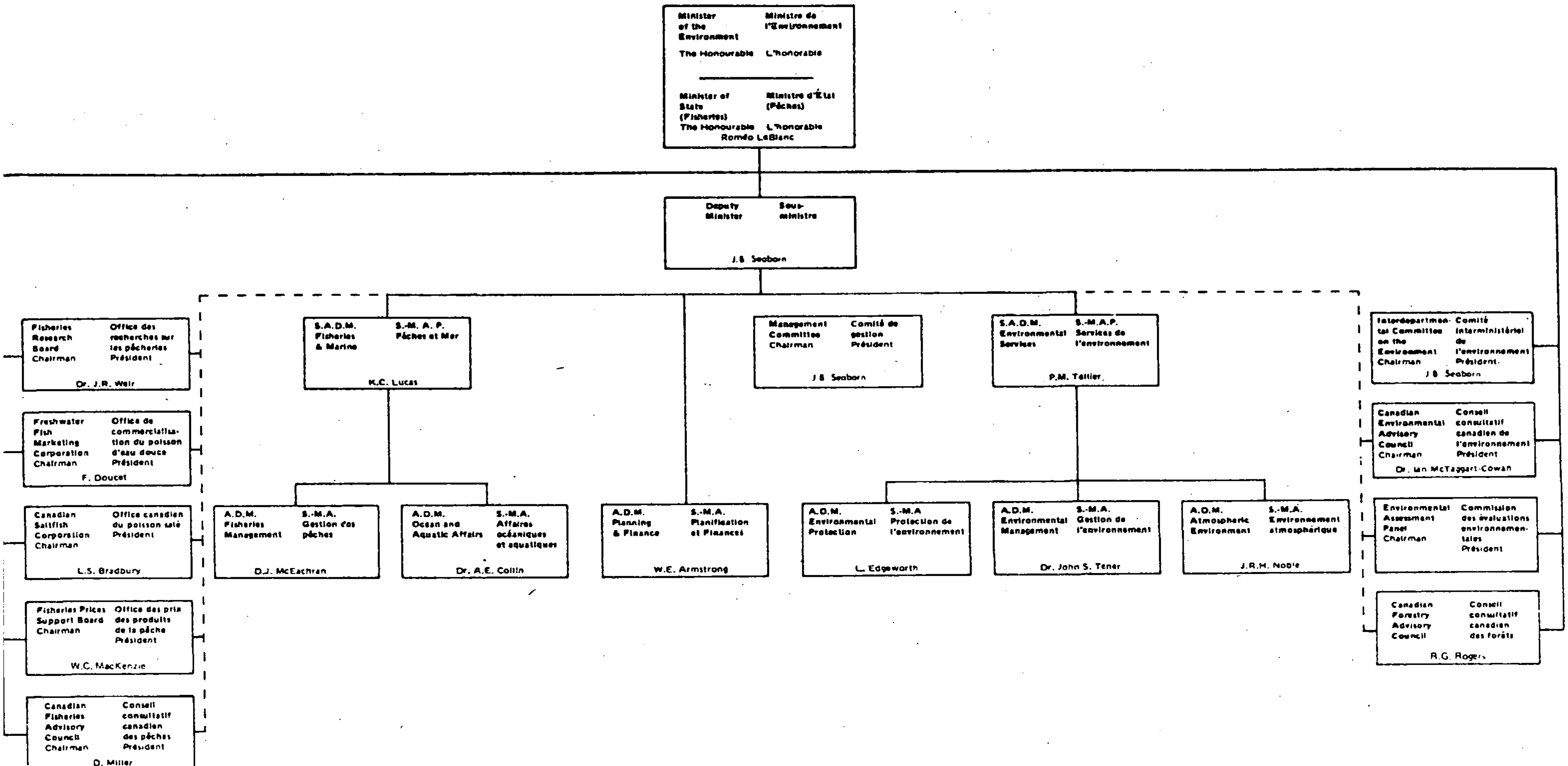


Figure 1

S.A.D.M. Senior Assistant Deputy Minister
S.-M.A.P. Sous-ministre adjoint principal
A.D.M. Assistant Deputy Minister
S.-M.A. Sous-ministre adjoint

July 20, 1976 — Juil 20, 1976

Organization, Department of the Environment
Organisation Ministère de l'Environnement

(ii) Environmental Protection Service

This Service is responsible for developing and enforcing environmental protection regulations, codes, protocols, and other protection and control instruments used to implement federal environmental legislation. It is also the source of information for other federal departments administering legislation within which environmental regulations are developed. It has developed regulations under the Fisheries Act concerning the characteristics of specific industrial wastes which degrade the water and make it deleterious to fish. Also, it administers phosphorus concentration control regulations under the Canada Water Act and deals with environmental protection matters associated with the facilities and activities of federal agencies. EPS also administers the Clean Air Act and the Environmental Contaminants Act.

(iii) Atmospheric Environment Service

In conjunction with its general meteorological activities, this Service gathers data on precipitation, snow cover, evaporation, ice in navigable waters, temperature, radiation, and other factors affecting water resources. The data are used in providing weather forecasts, climatological summaries and analyses, and in conducting research programs. Much of this information is essential in planning water resources projects. AES is also responsible for the formulation of national air quality objectives under the Clean Air Act.

b) Fisheries and Marine Service:

The name of this major arm of the Department suggests its functions, many of which have direct or indirect effects on water resources. It is responsible for fisheries development and fisheries operations on both coasts and in inland waters, and for fisheries research, oceanography, hydrography, and the administration of small craft harbours. Fisheries research extends to all factors affecting the conservation and utilization of marine and freshwater fisheries, flora and fauna, including the relevant aspects of water pollution. Two main components of this Service are:

(i) Fisheries Management

The operational role includes industrial and recreational development of fisheries, maintenance of fish habitat, and conservation as it affects water resource development in a number of ways.

(ii) Ocean and Aquatic Sciences

This program includes physical, chemical, and biological oceanography, marine and aquatic ecosystems research, and hydrographic surveying and charting of all navigable waters; and environmental assessments of activities affecting freshwater and marine life. The Service also oversees and manages the survey-research fleet used by the Department in support of marine and inland water surveys and research.

c) Planning and Finance Service

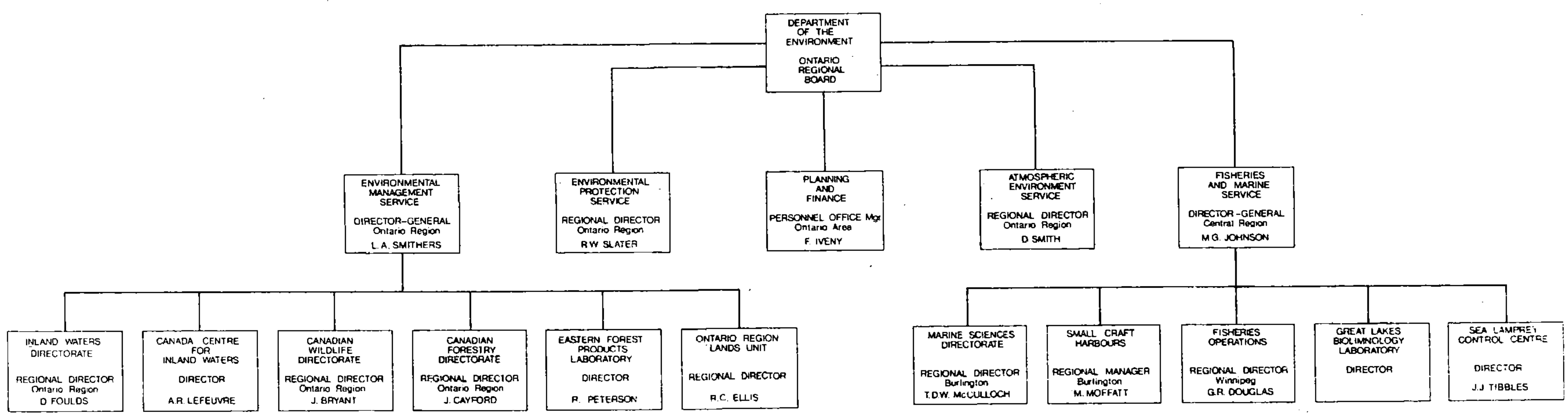
This Service provides staff assistance to the operational arms of the Department. All administration, liaison, as well as policy evaluation and development activities, are carried out by this Service. Through the Office of Science Advisor in this Service, the Department's energy-related program is coordinated with the total federal government energy program which is centered in the Department of Energy, Mines and Resources.

1.4.2 Ontario Regional Structure

In order to carry out its activities in each of the five major regions of Canada (Pacific, Western and Northern, Ontario, Quebec, and Maritimes), the Department has developed a regional structure. Geographically, the Ontario Region boundaries are coterminous with those of the Province of Ontario. Each of the major Services of the Department, which includes the Environmental Management Service, the Environmental Protection Service, the Atmospheric Environment Service, and the Fisheries and Marine Service, has a regional office. Figure 2 outlines these components. To coordinate the overall operation of the regional offices of each Service, there is a Regional Board, composed of the heads of the major components in the region.

FIGURE 2

ORGANIZATION CHART: ENVIRONMENT CANADA
ONTARIO REGION



1.5 Selected Energy-Related Programs of the Ontario Region

Under the Canada-United States Great Lakes Water Quality Agreement, the various governments involved in water quality management of the Great Lakes have agreed to set and maintain common water quality objectives. In order to achieve these objectives, both the federal and provincial governments are obligated to carry out many activities. Foremost is to join with their American counterparts under the auspices of the International Joint Commission's Great Lakes Water Quality Board in developing a specific set of water quality objectives based on protecting the most sensitive use of the lake waters in order to ensure the fullest water use potential is achieved.

In the Canadian portion of the Great Lakes Basin, the Agreement serves to focus federal and provincial water pollution research and control activities. This is formalized through the Canada-Ontario Agreement on Great Lakes Water Quality which provides for cost-sharing of research and development activities for storm and combined sewer overflows and disposal of sludge on land. Federal assistance up to 50% of the province's near-shore surveillance program is ensured as well. Further, this sub-agreement specifies that such parties will implement appropriate programs within their jurisdiction to ensure maintenance of the water quality objectives and the development of specific water quality objectives for a number of chemical and physical parameters. (See 1975 Great Lakes Water Quality Board Report submitted under separate cover.)

There are several directed research activities in the Agreement which pertain to the tasks of this Royal Commission.

(i) The Upper Great Lakes Reference Study (report available soon) is to determine the extent of pollution of Lakes Huron and Superior, to ascertain if transboundary pollution is occurring and to recommend remedial measures;

(ii) The pollution from Land Use Activities Reference study (Report due in 1978) is to determine the extent to which various land use activities in the Basin cause pollution of the Great Lakes, and to recommend appropriate remedial measures.

(iii) Great Lakes research studies on waste heat discharges from electric generating stations on the Great Lakes (See Appendix 4).

The Canada-United States Great Lakes Water Quality Agreement establishes one of the critical focal points for environmental management and protection in Ontario. Although the major concern of the Agreement is directed at maintaining and enhancing Great Lakes waters, it is becoming increasingly evident that the various uses to which these waters can be put, and the natural ecosystems which they support, serve as a primary indicator of the environmental quality of Great Lakes Basin.

Air pollution is another significant area of interest of the Department in Ontario. As part of its ongoing concern for air pollution problems and their relation to the Great Lakes, the Ontario Regional Board's Technical Committee on Atmospheric Pollution undertook an extensive survey of this subject. This is discussed in Section 5.2.

1.6 General Departmental Energy-Related Activities

1.6.1 Overview

The Department has actively participated in all of the Federal Government's programs in the energy field: Energy Research and Development, Energy Conservation, and development of "An Energy Strategy for Canada". Other energy-related departmental activities have included federal-provincial arrangements (for example, the Canada-Alberta Agreement on Environmental Research related to the Oil Sands), and international programs (for example, the OECD Energy and Environment Program). In addition, the Department has had a small and expanding program in relation to the assessment, feasibility, and development of environmentally-derived or so-called renewable energy resources (biomass energy, solar energy applications, assessment of tidal power, etc.). Over and above all this, important parts of the activities of all Services (and a substantial part of the activities of the Air Pollution Control Directorate) are directly in response to current uses of energy. Much of the northern activity of the Department as a whole owes its present and planned nature, and priority to energy problems or anticipated energy developments. Thus, a considerable portion of the its budget can be said to be spent on energy-related programs.

The task of fitting the on-going work of the Department into a framework, and then of assessing the work in terms of policy, and the need for policy, is being attempted in the areas of energy R & D and energy conservation.

1.6.2 Selected Examples of Current Energy-Environment Activities

(a) Energy Conservation

(i) The Department took the lead, together with Finance, EMR, MOT and IT&C in recommending actions where energy conserving equipment might qualify for accelerated capital cost allowance on income tax, and for examining areas where tax-based disincentives to the recycling of material would be reviewed.

(ii) Environmental Protection Service has let research contracts for waste heat utilization, waste paper recycling, district heating, and other similar projects.

(iii) EPS is taking the lead in a demonstration program for waste paper recycling in government facilities.

(b) Nuclear Energy

The Department participated in the Federal-Provincial Task Force on Radioactivity in consideration of the environmental aspects of the clean-up of contaminated properties in Port Hope and Uranium City, and in the provision of technical and supervisory assistance to the clean-up operations.

(c) Renewable Energy

The Department has several programs related to renewable energy (e.g. Environmental Management Service's forest biomass program) and is the focus for interdepartmental and inter-governmental experiments based on integrated use of renewable energy (e.g. ARK for Prince Edward Island).

(d) Energy Analysis

The first phase of an important Energy Analysis Study has been completed as a joint project of the Department, EMR and Statistics Canada. The technique will enable net energy costs and benefits to be considered on a basis similar to net economic costs and benefits when evaluating the national advantages and disadvantages of energy activities. Initial analyses have been completed for construction of CANDU reactors, northern gas pipelines, and western Canada coal development.

(e) Analyses of Future Needs

The Department's Western and Northern Region is undertaking a study, with the assistance of Headquarters committees, of the likely trend of developments in central and northern Canada that will determine the need for environmental baseline information, environmental impact studies and guidelines, and Departmental "positions". Such activities relate to energy policies and developments.

1.7 References to Section 1

1. Energy, Mines and Resources Canada, "An Energy Strategy for Canada", Ottawa, 1976.

2. McCallum, B., "Environmentally Appropriate Technology", Ottawa, Environment Canada, 1975.

3. Marshall, J.C., Petrick, G., and Chan, H., "A Look at the Economic Feasibility of Converting Wood into Liquid Fuel", Ottawa, Environment Canada Information Report Ex. 25, February, 1975.

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2. REVIEW OF THE ENERGY SITUATION IN ONTARIO

2.1 Introduction

The future development of the electrical power system in Ontario will be a very important factor influencing the quality of Ontario's natural environment. Therefore forecasts of likely developments in electrical power generation are important to the Department in determining in which areas its efforts should be focused. Choices among different options for electricity generation can, however, be understood only in the context of the current energy situation in Ontario along with indications of the likely future price and availability of different forms of energy.

Therefore this section provides an overview of the energy picture in Ontario, including its historic and expected future dimensions, with particular emphasis on the electrical power system. In reviewing the information available on the Ontario energy situation, it was difficult to obtain a clear perspective on this relatively complex, yet vital, subject. This was due to the lack of information (particularly in the area of future energy end use), to the diversity of sources required to construct a reasonably complete picture, and to the format of the available information. In this section, an attempt has been made to bring together, synthesize, and present in a schematic manner, some of the information available as an aid to developing a reasonably complete perspective on energy production and use.

2.2 The Current Ontario Energy Picture

Ontario consumed approximately 36% of the 6,380 x 10^{12}BTUs of primary energy consumed in Canada in 1974 (Figure 2-1). Ontario's per capita primary energy consumption is average for Canada, in spite of its proportionately greater industrial sector (per capita basis). As virtually

PRIMARY ENERGY CONSUMPTION: CANADA AND ONTARIO - 1974*

* NOTE:

Hydro and nuclear generated electricity and purchased electricity are considered here as primary energy as per Statistics Canada (Cat. 57-207) at a conversion rate of 3413 BTU's per KWH

SOURCES:

1, "An Energy Strategy for Canada", EMR, 1976 (adapted from table 2)

2, "Ontario - Towards a Nuclear Electric Society?" R.M. Dillon, Oct. 16, 1975. (adapted from fig. 1 - preliminary)

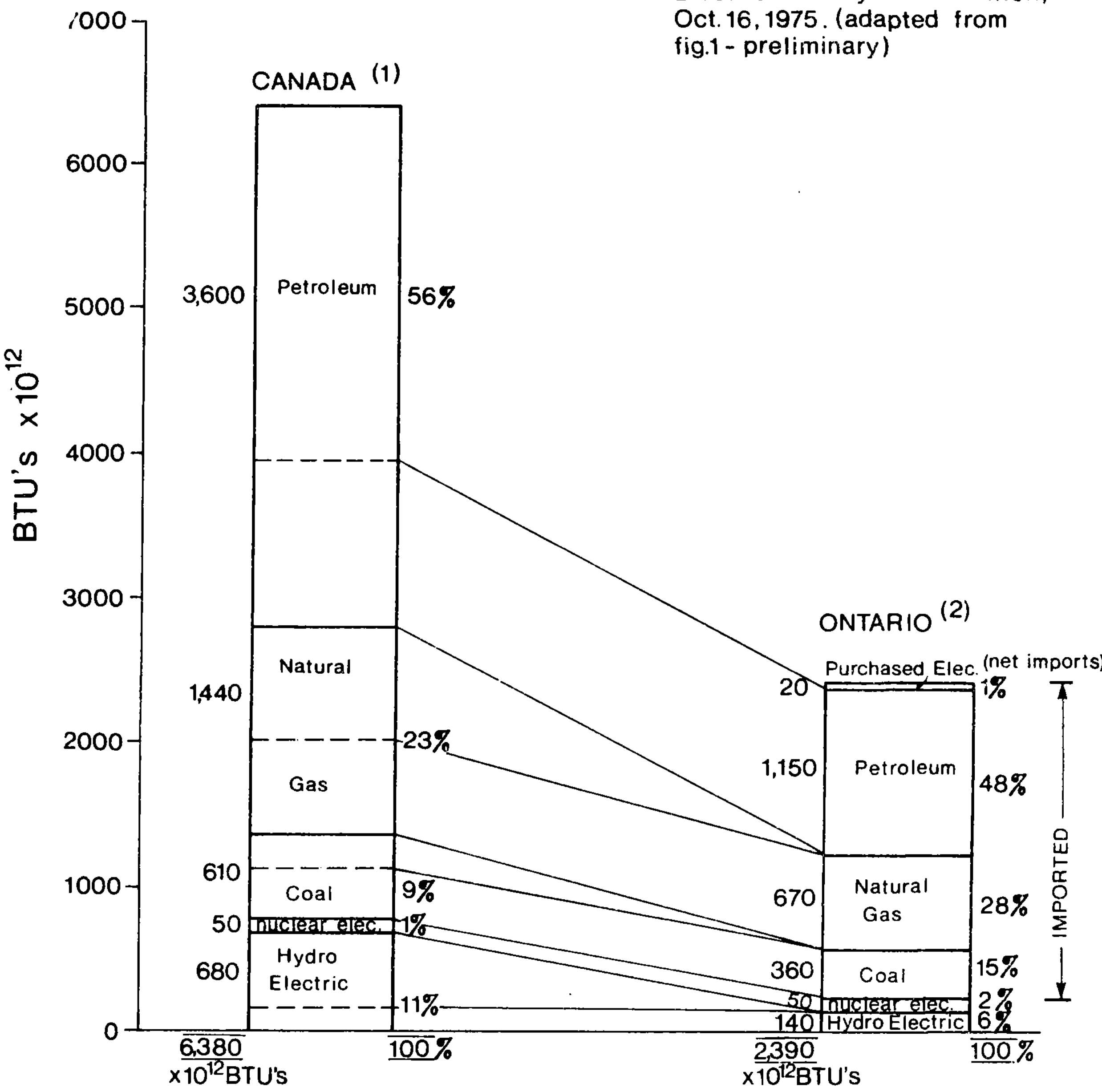


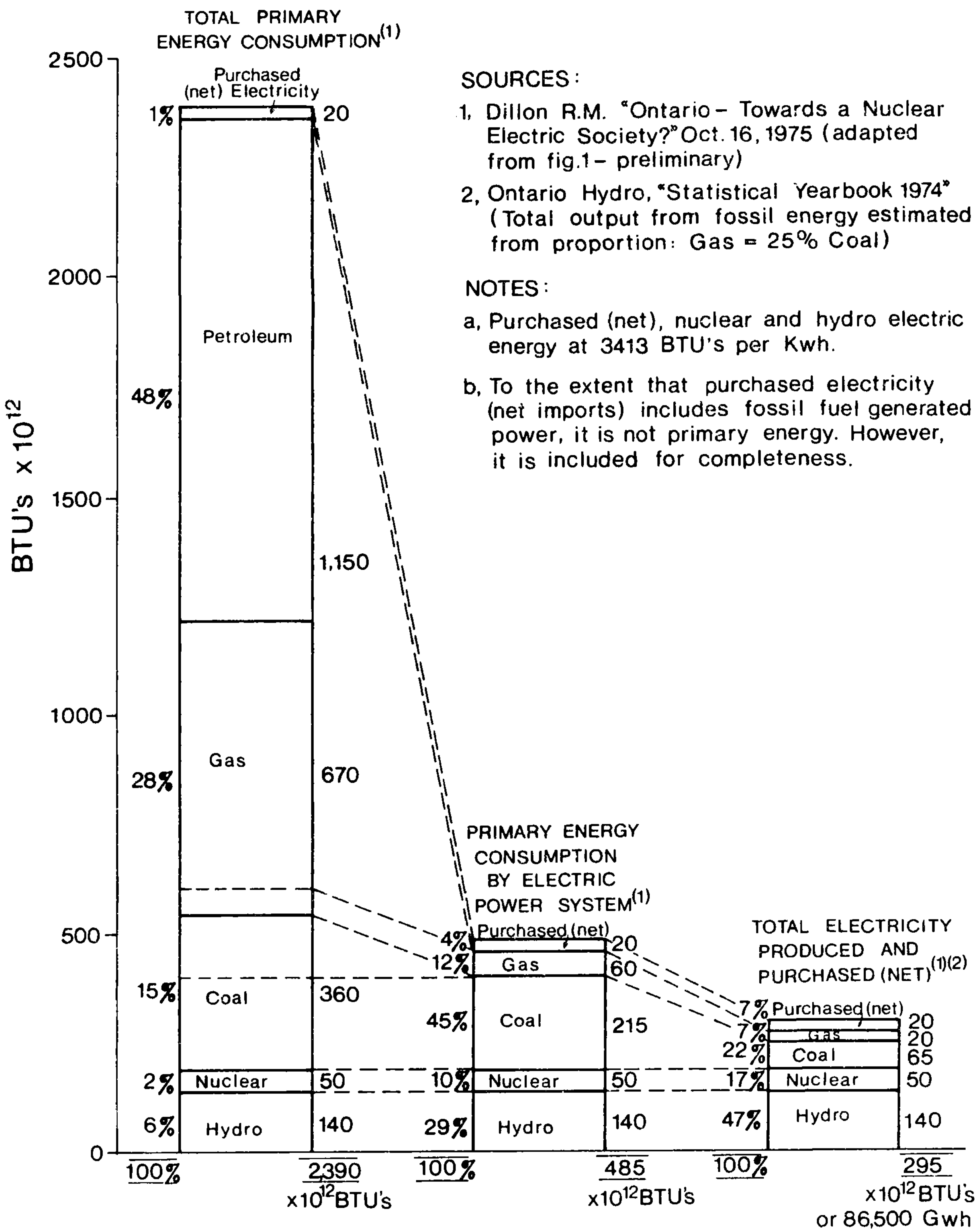
FIGURE 2-1

all of the petroleum, natural gas, and coal which account for 91% of primary energy consumed are imported, Ontario is highly dependent on external sources of energy. Since the Department's interests are both national and international, the dependence on energy sources in other parts of Canada and the rest of the world has important implications. Decisions regarding energy supply options will result in environmental impacts in other jurisdictions where fuel is extracted, upgraded and transported to the Ontario market. Conversely, environmental management and regulations in other jurisdictions may affect the price and availability of different types of energy to the Ontario market, thus affecting the energy supply system in Ontario and ultimately its impact upon the Ontario environment.

Figure 2-2 shows that, of the 2,390 x 10^{12}BTUs consumed by Ontario in 1974, approximately 20% of this was consumed by the electric power system which, in turn, converted this energy into 295 x 10^{12}BTUs of energy in electric power form. The conversion rate for electricity at its output value of 3,413 BTUs per kwh is assumed throughout. Figure 2-2 shows that the major fossil fuel consumed in electricity production is coal. However, in terms of electrical energy produced, coal-fired stations accounted for only 22% of total kilowatt hours produced in 1974 while hydro power was a contributor of close to half the electric power produced. Nuclear power amounted to only 17% of power produced, but this proportion is expected to increase in the future.

Figure 2-3 presents a graphic picture of how both total energy and electrical energy were consumed in Ontario, in this case for the year 1973. In terms of total energy consumption, the heavy demand of the

ONTARIO PRIMARY ENERGY CONSUMPTION AND ELECTRIC POWER SYSTEM ENERGY INPUTS AND OUTPUTS - 1974



SOURCES:

1. Dillon R.M. "Ontario - Towards a Nuclear Electric Society?" Oct. 16, 1975 (adapted from fig.1 - preliminary)
2. Ontario Hydro, "Statistical Yearbook 1974" (Total output from fossil energy estimated from proportion: Gas = 25% Coal)

NOTES:

a. Purchased (net), nuclear and hydro electric energy at 3413 BTU's per Kwh.

b. To the extent that purchased electricity (net imports) includes fossil fuel generated power, it is not primary energy. However, it is included for completeness.

FIGURE 2-2

ONTARIO ENERGY CONSUMPTION BY SECTOR & END USE, 1973

SOURCES:

1. Statistics Canada, Cat. 57-207, 1973
2. Ontario Hydro, "Energy Utilization ...." submission to RCEPP, tables 6.2-6 to 8
3. Puttagunta, V.R., AECL-5235, 1975 table 3.4 : Canada, 1969

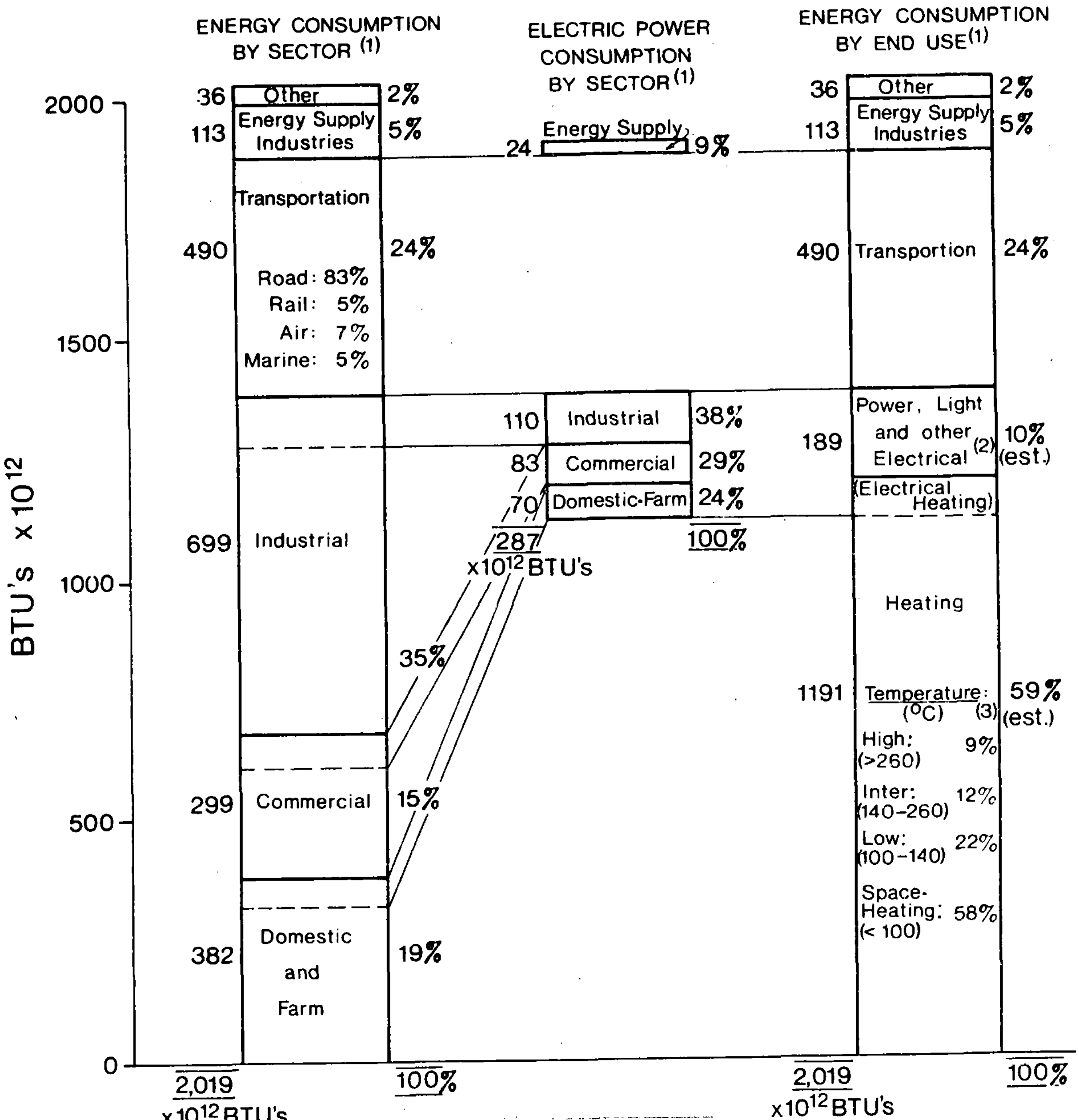


FIGURE 2-3

province's industrial sector is evident (35%). Transportation was the second highest consumer of total energy. It is interesting to note the complete domination of road travel and, particularly, the motor car as a consumer of energy in this sector. The middle vertical bar shows the breakdown for electric power consumption. Again, the industrial sector dominates. Most of the electric power use by industry (76%) goes to drive electric motors, while in the residential sector, most of its energy use (55%) is accounted for by space and water heating (see reference #2 on Figure 2-3).

It is appropriate in some cases, particularly when analyzing alternate energy sources, to identify energy consumption by end use, and then match the characteristics of available energy supply technologies to specific end uses. There may be possibilities for satisfying the same end use using quite different forms of energy. This perspective helps identify possibilities for improvements in efficiency as well as possibilities for interfuel substitution, a major objective of current federal energy policy (4).

The third vertical bar in Figure 2-3 presents a breakdown of the major energy end uses for Ontario in 1973. The striking factor here is the high proportion (estimated roughly at 59%) of energy consumed as heat. Of this component, a major proportion (80%) is consumed for low grade and space heating purposes. From the point of view of longer-term energy planning, much of this lower grade requirement could conceivably be met from sources such as low grade waste heat from power generation and solar energy.

2.3 Future Energy Consumption in Ontario

Levels of economic activity, demographic conditions, and the relative price of energy are the major determinants of energy demand. The combined influence of these factors indicates that rates of growth in energy demand in Ontario and Canada as a whole will tend to decline somewhat in the future. A general decline in population growth rates is forecast for the next 20 years. Ontario's population is expected to grow from 8.2 million in 1975 to 10.7 million in 1995. This reflects a decline in annual population growth from approximately 1.5% in the 1975-80 period to 1.0% in the 1990-95 period (2). Decelerating growth is also forecast for Ontario's economy. The real growth in Gross Provincial Product of 5.0% per annum during the 1971-75 period is expected to have declined to 3.9% by the 1991-95 period (3).

With this forecast decline in both population and economic growth, it is unlikely that recent growth rates in energy consumption will continue, particularly when the impact of rising energy prices is felt. Conservation policies and programs are intended to reduce energy consumption in Canada beyond those reductions caused by price increases. Historically, Canadian energy consumption has grown at the rate of about 5.5% per year (4). The latest national forecasts now seem to indicate an average annual energy growth rate over the 1976-1990 period of from 3.7% to 4.8% (5).

By sector, energy consumption in the commercial sector and the energy supply industry are expected to increase more quickly than in other sectors (6). Forecasts of heat energy use, which accounts for one-half of total Canadian energy use, indicate a growing fraction of total heat energy will be consumed as space heat and relatively low temperature heat (7). This is again indicative of the potential for substituting lower grade energy sources for increasingly scarce high grade energy forms, particularly for space heating.(8)

Growth in electric power demand historically has exceeded growth in energy demand. Over the past 50 years, Ontario's electric power consumption has grown at the annual average rate of 6.8% (9). Thus, it has increasingly accounted for a greater proportion in total energy consumption (assuming Ontario's energy growth rate has been similar to the national average). Ontario Hydro's 1974 long-range plan assumed a 7% annual growth rate over the next 20 years. This would imply an approximate fourfold increase in production over the same period (6). The 1976 plan has reduced the expansion plans to a 3.5-fold increase in production from 1976 to 1995 (10) with expansion limited to 6% per annum maximum (11).

On the basis of the 7% growth rate, Ontario Hydro's assumptions were that population increases would account for 2%, per capita increase in consumption for 3%, and a shift from other energy sources to electricity for another 2% (12). The forecast slowing in both population and economic growth, combined with substantial jumps in the cost of electric power (an over 30% increase is being requested for next year (13)) indicate the difficulties inherent in defining with any degree of certainty the future demand picture as a basis for power system expansion planning, particularly on a longer-term basis. In addition, conservation policies and programs could further affect the need for electric power system expansion. The degree of "interfuel substitution", which is determined largely by technology, institutional criteria and relative prices among the various energy options, creates further uncertainty.

The way in which the electric power generation system will develop in Ontario is substantially determined by the availability of and relative costs among the various primary energy sources. The overview of primary energy source availability which follows is discussed further in the individual subsections of Section 5.

(i) Hydro

Although Canada still has substantial hydro power potential as yet untapped (such as the lower Churchill in Labrador, James Bay Development, etc.), Ontario's potential in this regard is quite limited. Although smaller sites may be exploited in future, there are no major developments planned.

(ii) Coal

Currently, Ontario Hydro obtains most of its coal from the United States. U.S. coal reserves are substantial and it is unlikely that there will be unmanageable problems in securing U.S. coal in future, according to a recently released study on behalf of the C.D. Howe Research Institute (14). The study concluded a cut-off would more likely result from a general breakdown in the U.S.-Canadian energy relationship or from a general embargo, than for reasons of tight supply. Western Canadian coal from Alberta and British Columbia, where 80% of Canada's coal reserves lies, is another potential, but higher cost, source. The availability of this coal will be dependent on the policies of provincial governments with regard to exploitation of the coal reserves, (15) and technological and economic feasibility. Environmental regulations in coal mining areas could also significantly affect its price and availability. This availability of coal from several sources and in potentially abundant amounts will be a major factor in Ontario Hydro's choice of generation plan type in the planned expansion program.

(iii) Oil

Ontario Hydro currently utilizes little oil in its power production system. The questionable reliability of supply of foreign sources of oil, together with the uncertain potential for large scale discoveries in Canada, severely restrict the potential for petroleum as a significant component for long-term power generation in Ontario. In the longer term, increasing reliance may be placed on tar sands or synthetic oil and gas from coal (16).

(iv) Natural Gas

The availability of natural gas appears somewhat more promising. However, the exploitation of frontier and northern sources such as the Arctic Islands, Mackenzie Delta, and perhaps the east coast, still have a number of hurdles to cross such as sufficient proven reserves, environmental impacts, the settlement of native land claims, and the raising of the enormous amounts of capital required. It is unlikely, however, that natural gas will be used extensively for electric power production in the future.

(v) Uranium

The same limitations regarding future fossil fuel availability are not likely to face uranium as a source of fuel for Ontario. Ontario appears to possess a large portion of uranium reserves relative to the rest of Canada. A sufficient amount has been set aside for Canadian use to provide for a 30-year operating life for all existing stations and for those planned or committed through to 1985 (17). This ready and assured availability of uranium is a deciding factor in plans to depend largely on nuclear power for power production expansion in Ontario.

(vi) Municipal and Industrial Wastes

Processed municipal solid waste is another source of energy for thermal power generation being seriously considered at the present time. In theory, the estimated 6 million tons of municipal refuse produced annually in the province could provide approximately 2.4% (57×10^{12}BTU/YR) of Ontario's current energy consumption. This possible source could take on a new significance in terms of industrial or district heating planning concepts, since municipal refuse is a readily available local supplementary fuel source. Liquid or semi-solid industrial wastes, having a significant hydrocarbon content, are another possible energy source.

Current Ontario Hydro plans for system expansion are for an increase in power production of from 90,800 Gwh in 1974 to 316,000 Gwh in 1995 or an approximate 3.5-fold increase. This increase will be accounted for largely by expansion of the nuclear power generation component. Power generation from coal will almost double. However, given the potential availability of substantial coal reserves in both Western Canada and the United States and the chances of significant capital cost increases for nuclear power plants, coal-fired plants may be called upon to carry a substantially greater proportion of the proposed expansion program. Hydro, oil, and gas will decline in relative importance as sources for electric power production.

Ontario Hydro's current long-range plan proposes the addition of a number of new generating stations to the system. The major portion of the additional stations will be located along the shorelines of Lakes Ontario, Erie, and Huron. These would be in addition to the present system which consists of generating stations of from 10MW to 2,431MW in capacity together with a number of small units (18).

2.4 Summary Implications

The availability of oil and gas is limited. It seems likely that there will be proportionately more use of coal and nuclear sources and, to some extent, municipal and industrial wastes for electrical power generation purposes. The tightening energy situation will also encourage interest in other "alternative" sources. This shift in the energy source picture for electric power generation has formidable implications for the quality of the environment in future, particularly when the magnitude of the power generation and transmission systems expansion program is considered. Since current plans are for coal and nuclear sources to play an increasingly important role in electric power generation, the environmental implications both within and external to the province, of Ontario's reliance on these two sources is of particular interest to Fisheries and Environment Canada. The Department is also particularly interested in ways to reduce the need to expand the power system through energy conservation and in the potential role that "alternative" energy sources might play in meeting the energy needs of the province. Both conservation and alternative energy sources, however, will also need to be carefully examined for environmental and social impacts.

In addition to the environmental implications, socio-economic implications must be considered in order to provide a broader context for energy development planning. These are discussed in the following section.

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3. ENERGY/ENVIRONMENT RELATIONS: SOME BROADER CONSIDERATIONS

3. ENERGY/ENVIRONMENT RELATIONS: SOME BROADER CONSIDERATIONS

3.1 Introduction

There are a number of complex problems involved in assessing the environmental impacts of energy developments. They include difficulties in assessing the environmental costs of energy production and distribution systems themselves, as well as, more subtly, the impact which energy developments have on environmental quality through their impacts on economic activity and the direction of technological change.

3.2 The Indirect Impact of Energy Developments on the Environment

Assessment of the environmental impact of energy supply proposals is complicated by what might be termed the indirect impact of energy developments on environmental quality - those effects which are determined by the influence of energy supply developments on economic activity and upon the availability of capital and funding for research and development for alternative resources.

Decisions with respect to energy being made now in Ontario and elsewhere in Canada will affect the lifestyles and options available to future generations. Due to the substantial implications to both current and future society of this development, it is important that decision-makers be given a number of alternatives to choose from based on a variety of possible future developments. In analyzing and evaluating these alternatives, full consideration must be given to factors which go beyond traditional decision-making criteria which concentrate on technological and financial criteria. Social, economic, and environmental factors must also be given due consideration. Before discussing the more detailed and direct environmental implications associated, in particular, with the electric power system (Sections 4 and 5), this section seeks to present a relatively brief outline of some of the more important elements and considerations essential to the development of a planning and decision-making framework for long-range electric power planning that pertains to the broader socio-economic area.

3.2.1 The Effects of Size and Complexity

Electric power systems are capital intensive, centralized, technologically advanced systems which require long lead times and careful planning to change power production capabilities. All of these characteristics have implications for the natural environment and for the shape of society as a whole.

As relatively cheap and readily accessible energy resources, such as oil, gas, and hydropower, become more costly and less available, technology is being called upon increasingly to provide substitutes. In Ontario, current plans indicate that nuclear power will be called upon to meet most of the province's electric power expansion needs for the next 20 years. Concentration on high cost technological options of this nature can detract from the potential in less sophisticated or smaller-scale technologies, which may be preferable from the environmental point of view. Continued focus on nuclear energy will pave the way for even more technologically advanced options such as the recycling of spent fuel and fusion power, which will require funding and support to the extent that there will be little left to support other options.

Capital intensive, high technology electric power systems also require long lead times to expand their power production capability. Ontario Hydro has found it necessary to examine long-range projections of future power system development for periods of 20 or more years ahead (1). Once committed, it is both difficult and costly to make changes in the expansion program, even if the energy demand or alternate supply picture changes substantially. Continued reliance and dependence on large-scale energy systems, with their limited ability to adapt to changing conditions, effectively reduces future options and locks society into a development pattern which may not be appropriate in terms of tomorrow's realities.

As much as $180 billion may be needed over the next 14 years alone to satisfy capital requirements necessary to meet the anticipated demand for energy of all forms in Canada (2). This degree of investment would raise the proportion of energy investment from a recent average of 3.5% of GNP to an average of 5% of GNP over the 1976-1990 period (2). Capital requirements in the electrical utility sector would consume a major component of this investment (2). These requirements could range from 50 to 75% of the $180 billion, of which Ontario Hydro plans to spend $30 billion over the next 10 years. Expenditures of this magnitude "would appear to dictate some shift in investment flows away from other sectors of the economy, such as highways, hospitals, and housing (and environmental protection), towards the energy industries" (3). It may also seriously limit the funds available to give serious attention to the development of other sources of energy such as solar, wind, and biomass or the more efficient use of existing sources.

Thus decisions being made today with respect to electric power systems will have a profound effect on environmental quality now and in the future. Capital investments and research and development funds required by high technology systems may hinder the development of alternative energy sources as well as diverting scarce capital funds away from other uses, of which environmental protection and enhancement are important examples. It further helps shape the future of environmental quality in Ontario by determining the way a large proportion of our energy supplies will be obtained for a considerable period of time. It has been argued that decisions with respect to energy supply affect the environment and society in a number of subtle and indirect, as well as direct ways. It could be further argued that measures to protect the environment from substances associated with the generation of electric power will have a significant affect on the price and availability of energy; hence on the nature of society itself, including its political characteristics. For example, there is some concern that strict regulations required to guarantee the isolation of plutonium from the environment (and from diversion) might restrict civil liberties and individual freedom (4).

3.2.2 Total Energy Utilization Efficiency

Efficiency of energy utilization at the point of application is important from an environmental perspective. Any increase in efficiency of utilization which reduces the need to generate more power (with its attendant environmental impacts throughout the total fuel cycle) or to expand the electric power system (with its attendant impact on land use, etc.) represents, in effect, a contribution to environmental quality.

Efficiency of energy utilization relating to electric power may be considered in two parts - the efficiency of electric power production and the efficiency of electric power utilization. In the case of power production from fossil and nuclear sources, energy losses can occur at any stage of the fuel conversion, generation, and transmission stages. Energy losses which are released to the environment as waste heat are of particular interest from the environmental point of view.

When dealing with questions of energy efficiency, it is usually the First Law of Thermodynamics which is being considered. The First Law concerns the quantity of energy; e.g., BTUs or KWHs available, both before and after a conversion process.

However, the Second Law of Thermodynamics is concerned with energy quality. It is the quality of energy that determines its ability to do work. For example, given a certain quantity of BTUs of heat energy, more useful work can be derived from it where it is available at a high temperature, intensified state than at a low temperature, diffused state. From the point of view of energy conservation, high quality sources should be utilized in applications requiring high quality sources. Electrical energy is a high quality source. To utilize it for a low quality application such as space heating is extremely inefficient according to the Second Law. Lower quality sources such as heat or solar energy from rooftop panels would be more efficient (Second Law) in this application, thus conserving the high quality electricity for more appropriate uses.

Efficient use of energy must be based on not only energy quantity, but energy quality considerations if the maximum usefulness is to be derived from the diminishing store of available energy resources.

3.3 Total Costs and Total Benefits

In balancing the benefits and costs of energy options as mentioned in Section 1, it is necessary to give full consideration to all costs - private social, and environmental - of both energy supply options and conservation programs (5). This balancing of total costs is an appealing and relatively straightforward concept in theory, but represents a difficult task in practical terms.

It would be ideal to know all the environmental costs and benefits associated with alternative energy developments as well as their distribution among individuals and over time. However, assessing environmental costs involves systems of great complexity, difficult measurement problems, the great theoretical and practical difficulties of evaluating environmental intangibles, uncertainties, and lack of knowledge.

Establishing environmental costs and benefits in such a way as to compare them with the economic costs and benefits, expressed in well understood dollar terms, is a particularly complex and difficult problem. First, environmental costs and benefits may be quite difficult to quantify. Many, for example, are intangible, difficult to define and formulate in operational terms, especially factors related to human health and aesthetic considerations. As a result of the difficulties of pinpointing and measuring intangible costs and benefits, they have often been neglected in assessing the desirability of developments. In a recent case study review of six major resource development projects in northern Canada, the Science Council of Canada concluded that "...largely 'economic' concerns permeate the decision-making process. Other concerns -- environmental problems, social issues, technological concerns ... are relegated to an inferior supportive position..." (6). These somewhat intangible factors are no less real or important than those that can be quantified. In fact "people may well respond more to their aesthetic perceptions of changes in their surroundings than to the potentially measurable, but more restricted and visible changes in an ecological system." (7)

The tendency to give less than full consideration to intangibles is not merely due to difficulties in measurement, but also to the economic nature of the environment. Dollar values are difficult to establish because of the common property nature of environmental resources, which are not subject to the usual market mechanisms for allocating resources when buyers and sellers exchange privately in the marketplace. Values are not established because the environment cannot be owned, bought and sold to establish its value relative to other goods and services (8), (9).

Environmental resources are simply appropriated by firms and individuals attempting to minimize private costs by using the environment at zero cost for the disposal of wastes and thermal effluent. These "externalized costs" are left to be borne by the environment and ultimately by society.

The costing of environmental impacts is severely handicapped by the overwhelming complexity of the environment and its ecosystem components. This makes the full assessment of the effect of even a specific human action on the environment virtually impossible. Some effects may take decades to work their way through ecological pathways and to manifest themselves in an observable manner, by which time the causal relationship has been lost. Pollutants may interact synergistically among themselves and with elements in the ecosystem to produce new compounds whose biological impact may far exceed the impact arising from the original pollutant. For example, sulfur dioxide from fuel combustion oxidizes with the aid of nitrogen oxides to form sulfur trioxide which, in turn, hydrolyzes to sulfuric acid mists and ammonium sulfate aerosols (10). In addition, relatively insignificant quantities of a material may be accumulated to levels highly toxic to both man and animal. PCB compounds exemplify this phenomenon. The continued increase in population, human activity, energy production, and the creation of highly toxic chemicals will greatly increase the difficulties in understanding environmental impacts and in taking action before biological elements are irreversibly affected. Only through the prevention of environmental impact at source, or through the pursuit of alternative policies such as planning energy programs which are environmentally sound, can there be reasonable certainty that irreversible impacts will be minimized.

In some important cases of environmental regulation the idea of dollar cost does not apply. Dollar costs have direct relevance only to those pollutants that have "nuisance" features which can be dealt with by the assimilative capacity of the environment and which do not have sustained ecological effects (11). The costs of a temporarily degraded river as "paid for" by downstream users can be reflected in the analysis in both quantified or qualified terms. However, in the case of pollutants which tend to accumulate in the environment, and which have biological effects, the traditional cost-benefit approach has only limited relevance, if any (11). Examples of such pollutants include: cadmium, mercury, lead, and polychlorinated biphenyls, all of which are released into the environment from sources which include the electric power system. The limitation of the analysis may stem both from a lack of awareness that the pollutant has any adverse biological effects, and in the case where the effects are known, the inability to place any meaningful value on them or to establish a cause and effect relationship. Where adverse effects are not fully known and/or cannot be valued, standards based on cautious assessment of epidemiological and other physical information will be required in order to protect society and the environment (11).

Questions of the distribution of costs and benefits over time and across different segments of the population also present difficulties. Further problems in dealing with uncertainty may add a significantly subjective element to the determination of environmental costs and benefits.

Uncertainty is an important factor in assessing potential environmental impacts. This is particularly true where complex and perhaps poorly understood ecological interactions are involved. Problems posed by uncertainty are especially important in assessing those technologies in which there is a small probability of a serious accident which would impose large costs in terms of damage to human life and environmental quality. Nuclear energy, where there exists the possibility of the accidental release of radioactivity into the environment, is most often cited, though the degree of potential damage is uncertain. Other systems impose risks as well. These include large-scale oil spills which could be associated with Arctic development, and climatic change which may occur in response to the increasing CO_2 content of the atmosphere. In all of these cases, cost-benefit analysis is an inadequate evaluative tool. Some form of risk-benefit analysis must be used by which the tangible benefits of such energy developments can be weighed against possible costs to human health and the environment. This however, inevitably leads to ethical judgements as to the acceptability of risks which, in turn, are unavoidably subjective (12).

In addition to the recognition that cost-benefit analysis may be of limited value where risk and uncertainty is involved, the distribution of costs, risks and benefits of energy developments is an important consideration. This is a broad ranging issue which can be subdivided into two main areas, one involving essentially private costs and benefits, the other involving essentially social or environmental costs and benefits. First, any environmental policies which affect the price and availability of energy will have an impact upon the real income of individuals. It is the relative incidence of such policies upon groups in society which brings up questions of fairness (8), (13). Secondly, many of the costs of energy development are environmental costs, and consideration of distribution equity should be expanded to include the distribution of environmental costs and benefits as well as economic costs and benefits (8) (13). Will the environmental benefits of energy conservation accrue mainly to the well off? Will environmental regulation of energy production and distribution cost the poor relatively more than the well off? Such questions are of fundamental importance both in broadening the concept of wealth and its distribution and in understanding the nature of environmental management.

A further fundamental question of fairness or equity is the distribution of costs and benefits between generations. Particular interest has been focussed on long lived toxic nuclear wastes, which will be left in the care of future generations. Attention could also be given to the destruction of unique natural habitats, or the use, rather than conservation for the future, of valuable fossil fuel supplies.

Where cost-benefit analysis is appropriate, there is an ever increasing need to include intangible environmental effects in a form which gives them more weight than a brief description of these effects. In response to this problem, staff members within the Department have undertaken conceptual work on the development of a general method of evaluating intangibles (14). Basically, the approach suggested is to identify the major factors pertaining to a project from which benefits or costs will arise (e.g. hydro power, ecosystem protection, erosion control); sort them into two basic types, tangible and intangible; describe each factor as fully as possible either quantitatively or qualitatively; and then, through a ranking process, determine the imputed value or "shadow price" for the intangible factors. Although the need for considering environmental intangibles is becoming increasingly recognized, the tools for doing so are still somewhat primitive relative to the task, and much conceptual and practical work in this area remains to be done. This should not, however, serve as a rationalization for ignoring or giving inferior recognition to such factors.

Another approach to the difficulties posed by intangible costs and benefits is to go directly to source and seek the participation of the public in the decision-making process (15). Effective public participation can help to overcome some of the difficulties in attempting to evaluate social priorities and concerns through social costing techniques. The potential role for public participation in decision-making and program implementation as they relate to environmental management in particular has been discussed in a recent Environment Canada working paper (16). In order to ensure public values as they relate to the future state of society are reflected in government plans, the State of Washington has developed an innovative, on-going program for structuring broad-based public participation into the long range State planning process (17). The approach of the Commission itself in seeking to involve a broad spectrum of the public is particularly vital to ensure that social values and concerns are reflected in long range energy planning in Ontario.

3.4 Summary

Ontario's electric power system will be a significant determinant of the quality of life available to future generations. As the state of the environment is an essential component in this quality of life, the relation between energy and environment must be reviewed in its broadest context. Consideration of the total cost and total benefits in energy and environmental planning and decision-making processes, will help to ensure an energy system which will be compatible with the needs and values of tomorrow's society.

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4. LAND USE IMPLICATIONS

4. LAND USE IMPLICATIONS

4.1 EXPANSION OF THE POWER PRODUCTION SYSTEM

4.1.1 Demand for Land

Ontario Hydro forecasts that its annual energy production will increase to 316,437 Gwh in 1995, based on its latest (1976) load forecast (1). This represents an almost 3.5-fold increase from 1974 levels. The increased production is planned to be met almost entirely by thermal nuclear power generation, although financial constraints could force a shift in plans to include more coal-fired generation capability. Section 5 will deal with the more direct environmental impacts arising from the power production and transmission system. This section presents an overview, from a land use perspective, of the impacts arising from the development and expansion of the system. This expansion process places a severe demand on land for plant, stock-pile, safety, and transmission (and waste disposal) purposes (2). Thus, the magnitude of the expansion program ensures that these impacts will continue to be substantial in both land use and environmental terms, particularly if this degree of exponential growth continues into the next century.

The development of power system components such as control dams and storage reservoirs, mining and fuel processing facilities, fuel transportation systems, and power generation centres and transmission systems, removes land from alternate uses. There is not only the immediate impact on existing land uses, but future impacts in the form of opportunity losses, of which the future value may be considerably underestimated at present. Future opportunity losses include a reduction in forest and woodland resources; the destroying of woodland, field, and wetland habitats; limitations on recreational opportunities; and the irreversible consumption of prime agricultural land.

4.1.2 Development of Hydro Power Potential

Hydro power developments are major consumers of land. Departmental estimates indicate that the total land area requirements for Ontario's hydro-electric generation plants and related facilities is in the order of 870,000 acres (based on 1972 capacity) or 0.4 per cent of the total land area of the province. The creation of water storage reservoirs constitutes the major land consumption component. Due to the limited expansion envisaged for the development of the remaining hydraulic power potential in the northern part of the province over the next 15 years, the additional consumption of forest resources and recreational potential should not be significant. However, the development of pumped storage facilities and smaller scale hydro power developments may have more significant land use implications, particularly if undertaken in the southern part of the province where forest resources, recreational potential, and wildlife habitats are becoming increasingly limited relative to need. However, the recreational loss could be offset by the development of the reservoir potential in terms of fishing, boating, and swimming.

4.1.3 Development of Primary Energy Sources for Thermal Power Generation

4.1.3.1 Coal

The exploitation of the limited coal reserves in the northern part of the province is not expected to take place in the foreseeable future. However, the development of coal reserves in Western Canada to provide a substantial proportion of Ontario Hydro's future fossil fuel needs is a strong possibility. The recently revealed coal development policy of the Alberta Government will be a significant determinant of the locations where such development might take place (3) (4). Whether it is the consumption of prairie farm or grazing land, or the reduction of wildlife habitats, forest resources, recreational potential, and the scenic qualities of the Rocky Mountain foothills, the land use implications of large scale coal production facilities will be significant. The transportation of large quantities of bulk coal across the prairies will require additional land either for rail transport expansion or for pipelines, and for storage and transhipment facilities at Thunder Bay.

4.1.3.2 Uranium

Development and expansion of uranium mining in the province will be concentrated largely in the Elliot Lake and Bancroft areas. Land use implications stem largely from waste disposal which causes environmental degradation and includes the loss of forest resources in the vicinity and the recreational potential of the water basin affected. Land use implications of the uranium fuel cycle will also extend to the fuel upgrading sites and to areas chosen for disposal of radioactive wastes.

4.1.3.3 Natural Gas

Natural gas and oil are likely to remain a relatively small component of electric power production in Ontario. However, the need to develop and pipe natural gas (assuming reserves prove feasible to exploit) to southern markets from either the Mackenzie Delta or Arctic Islands could be stimulated by continued use of this fuel for power generation in southern markets. The land use implications of piping natural gas across the permafrost and tundra regions of the Mackenzie River Basin or the Hudson-James Bay lowlands mainly relate to the destroying of protective, delicate tundra cover over permafrost, the damaging of wild-life habitats, the disturbance of animal migratory patterns, and the disruption of human settlements.

4.1.4 Plant Expansion

The major land use impacts of the power system expansion program will be caused, not only by the development of primary energy sources and their associated transportation systems which affect less populated areas, but also by the development of additional generation and transmission capacity (transmission will be discussed later in this section) in heavily populated southern Ontario. The planned trend toward increasing size of generation units from 500-600 MW (similar to Pickering) through steps of 750-850 MW (Bruce), and 1,250 MW units by 1995 (5) (usually four units per site) will concentrate power generation into fewer locations than if Pickering size units were employed to achieve the same output. Assuming area requirements per site do not increase with increasing capacity, the reduction in the number of sites required will correspondingly reduce the land area consumed.

4.1.4.1 Natural Land Uses

The major determinant of land use impact is not so much the number of sites, but their location. Criteria for nuclear plant sites include location near a large body of water to ensure adequate cooling water, and in close proximity to consumers in order to reduce transmission costs and power losses (6). Future generation sites will be located largely along the shores of Lakes Huron, Erie, and Ontario. Unfortunately, future land use opportunities in Southern Ontario are becoming increasingly restricted as development pressures continue unabated. River valley, meadow, woodland, wetland, and coastal zone ecosystems are being increasingly disrupted or destroyed, reducing their capability to provide both human enjoyment (at a time when outdoor recreation is becoming increasingly needed) and the essential life support systems for human, bird, animal, aquatic, and plant life.

4.1.4.2 Agricultural Land Uses

The siting of generation facilities in Southern Ontario will also put additional pressure on farmland. Recent estimates indicate that improved farmland has declined by 2.5 million acres in the past 30 years and the trend continues (7). Although most of this loss has been due to farm abandonment, and transfer to recreational purposes, an increasing component of uniquely valuable agricultural land is being irreversibly consumed by urban growth and development processes. The value of prime agricultural land is grossly under-rated by current market conditions in terms of its future importance. It has been estimated that 12 million acres would be required to feed the Ontario population in the year 2000 (7). The statistics show that, by 1971, productive agricultural land had already declined to under 11 million acres. These results are indicative of the potential gravity of the situation, as population increases place increasing demands on the agricultural base for food while, at the same time, irreversibly consuming this base for non-agricultural purposes. In the past 25 years or so, productivity increases have been a major contributor to overall food production, due mainly to intensified use of capital and energy and to intensive farm practices (monoculture and chemicals). As limitations on the availability of capital and energy resources increase, future productivity gains may be substantially constrained. Also, further productivity gains from monoculture and chemical aids appear limited. In addition, the situation could be aggravated by growing climatic instability after a half century of uniquely stable conditions. A one degree drop in average temperature could cause a decline of up to 12 per cent in food production (7). At a more global level, the predicted world food crisis will motivate compassionate Canadians to respond by sharing the available food supplies. Clearly, continued consumption of such a potentially valuable resource as agricultural land is irrational in both economic and moral terms.

Consumption of prime agricultural land will have indirect environmental implications as well when its finite nature becomes evident. Increased food demand will result in marginal lands being brought back into production and the exploitation of woodlands, wetlands, and other natural and environmentally sensitive areas where exploitation might not have been necessary had prime agricultural land been protected in the first place.

4.1.4.3 Cumulative and Regional Effects

The power generation system is a significant factor in the process which is increasingly restricting future land use options. Generation plant sites are direct consumers of land. The Bowmanville property for the Darlington nuclear power station site will ultimately contain above 1,400 acres (8), which is about 0.01 per cent of Ontario agricultural land in production. This may be a relatively insignificant amount in itself, but the cumulative effects of continued exponential growth in the power supply system cannot be ignored. Although land use options are not entirely eliminated on site (some habitat areas may continue to exist), they are severely limited. Land use in the vicinity of sites such as the Bruce heavy water plant is also restricted as witnessed by the closing of Inverhuron Provincial Park to overnight camping. There is also the possibility that such sites may influence regional development patterns in the vicinity by acting as a catalyst for growth or affecting nearby land values. In addition, the location of large generation facilities close to already highly developed areas, such as the Toronto-centred region, supports the forces of development and makes government attempts to encourage balanced development throughout the province more difficult. The deliberate restriction on the development of generation sites close to centres which are already undesirably large could clearly signal government intentions to favour other centres in the province where land use options are less critical. The location of generation sites close to desired future consumer centres, based on long-range provincial land use plans, might be a more appropriate location criterion.

4.1.4.4 Socio-Economic Effects

In addition to land use impacts, power generation sites have socio-economic impacts in the vicinity. Due to the relatively small operating staff required to run the plant and to the nature of material inputs to keep it operating, the local economy may be little affected once the plant is in regular production. However, the impacts during the construction phase can be substantial, particularly if the surrounding region is rural in character. Rural and smaller centres are particularly vulnerable to the "boom-bust cycle" of projects of this order to magnitude. The environmental quality of the region can suffer from noise and dust pollution, runoff problems, disruption of coastal zones, and the transportation of large amounts of materials to the site. In addition, the stimulation of land speculation in advance of the project and the speculative holding of land can affect the productivity of neighbouring lands.

4.1.5 General Land Use Implications of Plant Expansion

The local and regional land use and related implications arising from expansion of the power production system are not well documented. The foregoing discussion, although general in nature, is indicative of the problems that may be expected from continued expansion of the generation capability as planned. The effect of one additional site may only be marginal, but the cumulative and synergistic effects may be substantial over the longer term.

The planned expansion program for Ontario Hydro's overall power production system will have a significant impact on land use and the availability of future land use options. This impact will not be confined to areas in the vicinity of generation sites. It will extend throughout the land areas related to the thermal fuel cycle, including extraction, transport and upgrading of fuel, and eventual disposal of waste materials. As components of this fuel cycle take place in other parts of Canada and in the United States, the land use impact will extend beyond the provincial boundaries. In order that the optimum use of Canada's increasingly valuable land resource base be realized, both in terms of current use and future potential, the expansion of large energy systems, such as the electric power system in Ontario, must be analyzed in their totality on a long-term time horizon, and must be guided by a greater awareness, understanding, and sensitivity to broader social, economic, and environmental considerations.

4.2 TRANSMISSION AND DISTRIBUTION OF POWER

4.2.1 System Description

Large centralized generation systems require extensive transmission and distribution networks in order to deliver the generated power to the user and also to ensure the reliability of the overall system. Ontario Hydro's bulk power transmission system comprises a network of transmission lines at 500 KV, 230 KV, or 115 KV, which connect the generating stations (currently 40 generating stations from 10 MW to 2,431 MW in capacity, plus a number of smaller stations) to consumer centres and to each other. This network integrates the generation stations into a single system (9). This system is interconnected with similar systems in the provinces of Manitoba and Quebec (only individual stations are linked from Quebec) and with power companies in the States of New York and Michigan. It is thus a component of a much larger power grid which covers most of central and eastern United States and five Canadian provinces (10). Delivery of power from the bulk power transmission system to the ultimate user involves a series of step-down voltage transformers and local distribution systems. In total, Ontario Hydro has more than 23,000 miles of transmission lines and 54,700 miles of distribution lines covering Ontario (11). The existence of this extensive transmission and distribution system, including associated construction and maintenance activities, has a substantial influence on provincial land use and environmental quality. As discussed below, this influence is much greater than the total actual transmission line land requirement for Ontario would indicate (Departmental estimates for 1973 place this figure at roughly 60,000 acres or 0.6 per cent of Ontario agricultural land in production).

4.2.2 Right-of-Way and Local Land Use Effects

The land use effects of the transmission and distribution system include both direct land consumption and its effects on land use patterns adjacent to the right-of-way. Components in the system, such as the power line towers, transformer stations, switch yards, and associated facilities such as access roads, are land consumptive in the sense that other land use options are effectively denied. Other land areas within the right-of-way may permit alternative use options such as natural vegetation, wildlife habitats, and farming. Recreational pursuits such as snowmobiling and hiking trails are gradually being allowed within the right-of-way, as well as urban gardening in plots. Given the increasing scarcity of land suitable for uses such as the above, it seems highly desirable that single purpose or consumptive land uses be avoided wherever possible, and that the full potential of the power line right-of-way be made available. This would be subject to cases where the protection of human health and safety can be assured, where use conflict can be kept to satisfactory levels, and where adjacent property uses are not infringed upon. The transmission right-of-way may also have the beneficial effect of preserving natural areas in urban centres which might otherwise have been consumed by buildings or pavement. However, the net beneficial effect would be negligible if it merely served to deflect development pressures toward the consumption of other natural areas such as river valleys or parklands.

One use conflict which can be particularly detrimental in environmental terms is the use of the cleared portion of the transmission right-of-way through forests and woodlands by snowmobiles and all-terrain vehicles.

The right-of-way may permit such motorized vehicles to access and cut through environmentally sensitive areas to chase or track down wildlife. The situation can be alleviated somewhat in the former case by reducing decibel levels, but the increasing popularity of leisure pursuits using motorized vehicles can only add to the burden on the natural environment by an affluent society. Other forms of access such as hiking and cross-country skiing are more environmentally benign and should be encouraged except where particularly sensitive areas will be affected.

4.2.3 Regional Land Use Effects

Transmission and distribution systems have effects on land use which extend far beyond the right-of-way. Linear land consumption by transportation modes such as road, rail, pipeline and transmission line tend to fragment and force the evolution of land-based activities into less than optimal patterns. Urban and regional development, farming operations, and wildlife movement patterns are examples of areas affected. The barriers or constraints caused by linear land consumption not only influence unplanned development patterns, they also reduce the potential for effective use of the land resource base for future generations. Thus, linear consumption of land can result in somewhat intangible, but nevertheless real, social, economic, and environmental costs in the longer term which rarely are reflected in current analysis. One way to reduce such adverse effects is through the multiple use of linear corridors. Coordination of right-of-way use among power transmission lines, pipelines, roads, rail lines and communication lines could reduce both land use and environmental effects. Although additional width may be required and environmental impacts may be more concentrated, these disadvantages can be outweighed considerably by obviating the need for additional corridors, and through careful route selection.

4.3 TWO-WAY RELATIONSHIP BETWEEN ENERGY AND LAND USE

There is a close, two-way relationship between energy and land use. The impact of energy developments such as the electric power system on land use has been shown to be substantial. In turn, land use patterns are a determinant of not only the spatial layout of energy systems, but also the productive capacity requirements of those systems. Urban sprawl in the form of "dormitory" suburbs requires massive quantities of energy to move people back and forth between home and work in the downtown core. As was seen from Figure 2-3, transportation consumed one-quarter of Ontario's total energy consumption in 1973, of which 83 per cent was consumed by road transportation, which, in turn, can consume one-third of the land area in urban centres. Low density communities make energy distribution more costly and reduce the feasibility of increasing the efficiency of energy utilization through district heating. (However, low density communities increase the feasibility of meeting space heating requirements through solar energy). Figure 2-3 also shows that one-half of energy end use in Ontario is for heating purposes alone. Thus, an essential determinant of land use planning should be the effective design of energy systems such as the electric power system, and the efficient utilization of scarce energy resources.

4.4 References to Section 4

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(3) Kennedy, Thomas, "Alberta's Coal Policy Described as Deterent to Most Programs", The Globe and Mail, Toronto, June 29, 1976.

(4) "New Coal Development Policy. Alberta sets a balance between environmentalists, developers, investors and the government." Oilweek 27(21), July 5, 1976, as described in New Additions, Science Council of Canada Library, July 16, 1976.

(5) Ontario Hydro, "Generation Planning Processes", Submission to the RCEPP, May 1976, pp. 11.0-33.

(6) Muntzing, L. Manning, "Siting and Environment: Toward an Effective Nuclear Siting Policy", Energy Policy 4(1), March 1976.

(7) Ontario Institute of Agrologists, "Foodland - Preservation or Starvation", Hillsburgh, Ontario, 1975.

(8) Ontario Hydro, "Darlington, G.S. - A Site Evaluation Report", report to the Atomic Energy Control Board, June 1974, p. 8.

(9) Ontario Hydro, "Reliability", Submission to the RCEPP, May 1976, p. 10.0-1.

(10) Ontario Hydro, "System Interconnections", Submission to the RCEPP, June 1976, p. 1.

(11) Ontario Hydro, "Ontario Hydro Statistical Yearbook 1974".

(12) Ontario Hydro, "Transmission Planning Processes", Submission to the RCEPP, June 1976, pp. 12.0-60.

5. SPECIFIC ENVIRONMENTAL CONCERNS

5.1 PRODUCTION OF ELECTRIC POWER: HYDRO

5.1 PRODUCTION OF ELECTRIC POWER: HYDRO

5.1.1 Hydro-electric Power Potential

Until about 1960, the hydro-electric resources of Ontario met most of the demand for power. However since then further development of hydro-electric sites in Ontario has proven increasingly uneconomic due to their inaccessibility and distance from load centres. Thus large installations of thermal generation have been installed, so that today the majority of the energy consumed in Ontario is produced by thermal plants from fossil or nuclear fuels. Ontario Hydro predicts that the forecasted increase in energy consumption over the period 1983-1993 will be met by further thermal installations and that the development of the few additional hydro-electric sites is a remote possibility (1).

Although no significant hydro-electric development is presently being planned, such developments could become a possibility, particularly if thermally generated electricity becomes less attractive due to fuel depletion, rising costs, or unacceptable environmental effects.

5.1.1.1 Potential Supply

Ontario has developed most of its available hydro-electric potential with the present installed capacity at approximately 7,000 Mw (2). Only one major conventional hydro-electric system remains undeveloped, this being the complete development of the Albany River with major diversions from the Winisk and Attawapiskat Rivers and the rediversion of the Ogoki River (3) (4) (5).

This project would entail the construction of 15 power dams plus diversions while yielding approximately 3,000 Mw of capacity, roughly equivalent to a single 3,000 Mw nuclear or fossil thermal generating station (1). A number of smaller sites or pumped storage sites may also be developed to produce peaking power, a commodity of increasing importance in a system dominated by thermal generation. A listing of Ontario's remaining large hydro-electric potential developments is given in Table 1 while the possible pumped storage sites are listed in Table 2.

TABLE 1

Estimate of Ontario's Remaining Conventional Hydroelectric Potential, in the Larger Developments (Note 1)

River and Site	Hours of Peak Output (Note 2)	Estimated Increments in Peak Capacity in MW: Installed	Dependable	Average Annual Energy, in Average MW	Capacity Factor of Increment, % (Note 3)
A. NEW SITES UNAFFECTED BY ALBANY RIVER DIVERSIONS					
ABITIBI					
Long Sault Rapids	2	80	69	27	39
Nine Mile Rapids	-4 (Note 4)	128	121	66	54
	-2 (Note 4)	256	243	71	29
MATTAGAMI					
Grand Rapids	-4 (Note 5)	109	102	62	61
	-2 (Note 5)	218	190	77	41
MADAWASKA					
Highland Falls	2	95	91	16	18
MISSINAIBI					
Thunderhouse Falls	-7	13	13	10	77
	-2	42	42	20	48
Long Rapids	-7	31	31	25	81
	-2	100	100	49	49
MISSISSAGI					
Gros Cap	2	262	258	47	18
MOOSE					
Grey Goose	2	188	175	74	42
Renison	2	188	186	76	41
WHITE					
Chigamiwingum	8	16	15	14	93
Umbata	8	14	14	12	86
Chicagouse	8	11	11	10	91
B. NEW SITES AFFECTED BY ALBANY DIVERSIONS — POTENTIAL ASSUMING CONTINUATION OF EXISTING ALBANY DIVERSIONS					
ENGLISH					
Maynard Falls	8	51	46	27	59
LITTLE JACKFISH					
Mileage 12.5	8	38	36	26	72
Mileage 7.5	8	46	46	33	72
C. NEW SITES AFFECTED BY ALBANY DIVERSIONS — POTENTIAL ASSUMING TERMINATION OF EXISTING ALBANY DIVERSIONS (to English and Nipigon Rivers)					
ENGLISH					
Maynard Falls	N/A				
LITTLE JACKFISH					
Mileage 12.5	N/A				
Mileage 7.5	N/A				
ALBANY					
Achapi	4	131	131	33	25
Eskakwa	4	268	166	119	72
Miminiska	4	57	57	35	61
Frenchman	4	95	95	61	64
Washi	4	73	73	47	64
Kagiami	4	117	117	83	71
Martin	4	70	70	51	73
Nottik	4	73	73	55	75
Buffaloskin	4	101	101	83	82
Wabimeig	8	217	119	163	137
Chard	8	536	536	376	70
Hat	8	422	399	284	71
Blackbear	8	402	402	279	69
Biglow	8	382	382	268	70
Stooping	8	308	308	206	67
Total of Albany Developments:		3252	3029	2143	71

The above capacities presume the following diversions are made into the Albany River:
Whiteclay Diversion
Winisk-Attawapiscat Diversion

Sheet 1 of 2

Source: Figure 11-2 in Reference [1].

TABLE 1 - Continued

River and Site	Hours of Peak Output (Note 2)	Estimated Increments in Peak Capacity in MW: Installed	Dependable	Average Annual Energy, in Average MW	Capacity Factor of Increment, % (Note 3)
D. EXTENSIONS OR REDEVELOPMENT OF EXISTING STATIONS					
Schemes Unaffected by Albany Diversions					
ABITIBI					
Canyon	2	790	714	20	3
Otter Rapids	2	175	161	4	2
MATTAGAMI					
Little Long	2	122	106	17	16
Harmon	2	136	107	18	17
Kipling	2	136	118	19	16
Smoky Falls	-4 (Note 6)	102	100	43	43
	-2 (Note 6)	157	239	66	28
MISSISSAGI					
Red Rock Falls	2-3	36	33	2	6
OTTAWA					
Otto Holden	2-3	202	156	6	4
Des Joachims	2	696	640	19	3
MONTREAL					
Hound Chute/Ragged Chute Redevelopment	2	98	98	19	19
E. EXTENSIONS OR REDEVELOPMENT OF EXISTING STATIONS					
Schemes Affected by Albany Diversions — Potential Assuming Continuation of Existing Diversions (to English and Nipigon Rivers)					
ENGLISH					
Ear Falls	8	7	5	4	80
NIAGARA					
SAB #2 (Existing Tunnels)	1/2	305	199	0	0
SAB #3 (New Tunnel)	1	458	501	138	28
NIPIGON					
Pine Portage Ext	8	27	22	1	5
Cameron Falls Ext	8	18	17	2	12
Alexander Ext	8	19	13	2	15
Schemes Affected by Albany Diversions — Potential Assuming Termination of Existing Diversions (to English and Nipigon Rivers)					
ENGLISH					
Ear Falls	N/A				
NIPIGON					
Pine Portage Ext	N/A				
Cameron Falls Ext	N/A				
Alexander Ext	N/A				
NIAGARA					
SAB #2 (Existing Tunnels)	1/2	305	199	0	0
SAB #3 (New Tunnel)	1	458	501	138	28

Note 1: The table includes new sites capable of producing 10 or more average MW. It does not include potential sites on the Severn, Winisk, and Attawapiskat Rivers because little data are available on them.

Note 2: These are the hours of operation at the dependable peak capacity that the site can provide under extremely low water supply conditions.

Note 3: The Capacity Factor corresponds to the Increment in Average Annual Energy and the Increment in Dependable Peak Capacity.

Note 4: The 4-hour peak applies if Nine Mile Rapids is developed in step with the existing generating station at Otter Rapids.
The 2-hour peak applies if Otter Rapids is extended to provide 2-hour peaking, and Nine Mile Rapids is developed in step with it.

Note 5: The 4-hour peak applies if Grand Rapids is developed in step with the existing generating stations at Little Long, Harmon, and Kipling.
The 2-hour peak applies if Little Long, Harmon, and Kipling are extended to provide 2-hour peaking, and Grand Rapids is developed in step with them.

Note 6: The 4-hour peak applies if the existing generating station at Smoky Falls is redeveloped in step with the existing generating station at Little Long.
The 2-hour peak applies if Little Long is extended to provide 2-hour peaking, and Smoky Falls is redeveloped in step with it.

Table 2

Some Aboveground Pumped Storage Sites
Studied by Ontario Hydro since 1965

(Derived from "Generation Planning Processes" Ontario Hydro Submission to the RCEPP)

Site	Hours Of Pumping	Hrs/Day of Generating	Generating Capability: Installed Peak Capacity MW	Generating Capability: Dependable Peak Capacity MW	Generating Capability: Ave. Annual Energy MW	Generating Capability: Annual Capacity Factor**
Delphi Point	8 hr/day+weekends	4	2912	3060	378	12
near Collingwood	8 hr/day+weekends	6	2000	2100	378	18
on Georgian Bay	8 hr/day+weekends	8	906	960	231	24
	10 hr/day	8	1450	1530	378	25
Matabitchuan River near Lake Timiskaming						
- HWL 940*		8	440	429	105	24
- HWL 920*		8	234	226	56	25
Jordan-Erie	daily cycle	4	1120	1031	132	13
approx. 2 miles	weekly cycle	10.5	1120	1031	326	32
south of Jordan Harbour which is on L. Ontario	annual cycle	(16 for 4 mos) (4 for 8 mos)	1120	1031	253	25

* HWL refers to high water level in upper reservoir

** Based on average energy and dependable peak capacity when generating.

5.1.2 Environmental Impacts

The environmental impacts of a hydro-electric development can range from relatively insignificant to massive, depending on a number and combination of factors including plant size, operation, surrounding environment and downstream environment. The following sections contain a general discussion of effects in the immediate or reservoir area, a general discussion of effects in the downstream area, and an application of these effects to the possibility of a development of the Albany River in Northern Ontario.

5.1.2.1 Environmental Effects of Reservoirs

The reservoir of a hydro-electric development may be the expansion of an existing lake or lake system or the creation of a new lake by the flooding of a river valley. The creation of a river reservoir is generally a much more drastic alteration to the environment than the extension of an existing lake or lake system. In steep-sided river gorges the local effects are usually limited to the loss of the wild river environment and changes in the aquatic biological community.

(a) Effects on Land Use

The most immediate and noticeable effect of an impoundment is the flooding of the surrounding land area. If the area has low relief characteristics, the flooding can be extensive and environmental effects widespread, whereas the flooding of a river gorge can contain the area involved to a minimum and confine the impacts to a generally less biologically productive area. Extensive flooding may result in the loss of important resources, such as farm land, forest resource areas, wildlife habitat, mineral resources, archaeological sites, and human settlements. In northern areas large hydro-electric projects can also seriously disrupt the lives of the native people.

The Albany River development would involve reservoirs covering 1,000,000 acres of territory including existing riverbed and lakes.

(b) Erosion and Sedimentation

The shorelines of new reservoirs tend to be unstable and are subject to erosion for a number of years due to the natural forces of waves, currents, ice, and water level fluctuations due to the operational mode of the plant. Where permafrost occurs, shoreline changes may be particularly extensive and prolonged as the permafrost melts. Flooded terrestrial vegetation helps to stabilize a new shoreline and thus reduces erosion.

Increased erosion normally compounds the problem of sedimentation that may occur through impoundment. Reservoirs are usually very effective sediment traps and much of the sediment settles within the reservoir. In addition to the environmental effects of the accumulated sediment load, it often reduces the reservoir's capacity and its useful life by reducing the effective water volume. The trophic status of a reservoir may be significantly altered if the sediment contains a substantial amount of organic material. It can gradually decompose, releasing nutrients to the water which may stimulate biological productivity.

(c) Earthquakes

Large deep reservoirs have been suspected of causing earthquakes in their immediate area by increasing the pressure on geological formations due to the weight of the water. Little of this activity has been recorded in Canada nor have the cumulative effects of man-made lakes been determined elsewhere.

(d) Biological Communities

The general sequence of events during and after the inundation of an area through impoundment is the mortality and migration of terrestrial life forms (both plant and animal) followed by the selection and elimination of organisms according to their adaptability to the new environment and the physiochemical, feeding and reproductive conditions it provides them. Normally, with the creation of a lacustrine environment there is a decrease in species diversity. The new lake experiences a burst of productivity due to the massive nutrient release from the previously unflooded substrate but this increased productive capability is usually short-lived and reverts to a stability level somewhat lower than that experienced following the first few years of inundation. Aquatic organisms, including fish, initially exhibit a higher reproductive potential, their growth rates increase, and their early life stages' survival rates are improved through the increased availability of food and cover. However the carrying capacity of the reservoir rapidly diminishes as the nutrients are depleted and a new lower productive capability level is reached.

In areas of low relief, flooding creates extensive shallow water zones where light penetration to the bottom permits rooted aquatic vegetation to develop. Normally highly productive bottom-dwelling communities develop within these shallow zones and provide an abundance and variety of ecological niches. Reservoirs created in steep-walled gorges do not provide similar situations and their biological productivity is somewhat lower than that of the former.

Flooded trees and shrubs provide optimum habitat for organisms that attach or cling to surfaces projecting from the bottom. These organisms are important in determining the productive capability of the lake for higher animal life. The optimum reservoir for the production of plants and animals is therefore one that provides an abundance of shallow water where light penetration is high, gently sloping shores, aquatic and terrestrial vegetation, small low islands, floating and standing dead trees, and a low sediment load. The operation of most reservoirs for hydro-electric production tends to have a detrimental effect on most of these characteristics.

The conversion of a river (a running-water system) into a reservoir (a standing-water system) involves the loss of riverine habitat and spawning areas, and a probable decrease in species diversity. In terms of game fish, this means a reduction in cold water species such as brook trout and rainbow trout in favour of warmer water species such as northern pike, perch and walleye. More subtle but perhaps more significant effects occur in the physiochemical properties of the water, density currents, and plankton communities. These changes alter the structure of the food pyramid at its base and hence the effects can significantly alter those resources closer to the pyramid's peak, which are considered most important to man's environment.

(e) Water Quality

Impoundments can affect the quality of the water contained in them and the characteristics most often affected are temperature, turbidity, dissolved solids, and chemistry.

Standing water bodies, like natural lakes and reservoirs, undergo thermal stratification according to the seasons. In the spring, warmer inflowing water spreads over the surface of the lake or reservoir and is warmed by solar radiation until a stable summer condition of a warm upper layer over a cooler lower layer is achieved. In the late fall surface cooling and colder inflowing water breaks this stratification down and causes "overturn", resulting in relatively isothermal conditions followed by a winter thermal stratification similar to that of summer.

These thermal variations are extremely important to many fish species especially during the critical spawning season, but the most serious effects frequently occur downstream.

During fall overturn the concentrations of oxygen throughout the entire reservoir are relatively uniform. However under stratified conditions in the summer and winter, the upper levels, which are relatively oxygen rich, do not mix with the lower levels which have become oxygen deficient due to the oxidation of organic material. The effects of such depletion of oxygen may be measured downstream if the operation of the dam involves water discharges from the lower, oxygen deficient levels of the reservoir.

The most prominent effect of an impoundment is on anadromous fish. The migration routes are interrupted unless special provision is made for routing the fish past the dam, and even then their spawning grounds may have been rendered useless by flooding.

(f) Climatic Effects

The creation of a large reservoir can affect the climate in the local region to a varying degree depending on the size of the reservoir, the hydrologic characteristics, the surrounding topography, and the climatic regime. Although little information has been documented on climatic effects, changes have been predicted for some large projects. Among the more prominent expected changes are those in precipitation patterns, cloud patterns and fog occurrences, seasonal air temperatures, and wind speed frequency and direction.

5.1.2.2 Environmental Effects Downstream

Many of the downstream environmental effects are a direct result of conditions which occur within the reservoir. These include the release of water subjected to oxygen depletion, nitrogen supersaturation, or temperature changes. The effects can usually be modified through regulation practices or by the inflow from a natural wild stream immediately downstream of the dam. However, if a reservoir system is one of continuous developments along a river, these effects tend to compound themselves to an even more significant level.

Nitrogen supersaturation occurs when water falls into a deep plunge basin wherein the pressure forces atmospheric gases into solution at supersaturation levels. Ingestion of this supersaturated water has caused fish mortality in some areas of Canada but technological developments and regulation changes have mitigated the downstream problem of nitrogen supersaturation.

Flow regulation for the production of power often has significant environmental effects. Most riverine organisms have rather narrow preference limits for flow velocity and altered discharges can affect the stimulus for migration, spawning, survival of eggs and juveniles, food production, species composition, and water quality. The timing of the discharge is also a major factor affecting riverine communities. The life cycles of lotic (river living) species are frequently related to the natural seasonal variations in discharge, and delays caused by high or low flows can serve as physical barriers for some species. In addition to timing, variations in discharge can have a marked influence on organisms having a narrow depth tolerance. In some situations fluctuations can result in the temporary desiccation of part or all of the habitat for some aquatic organisms.

The creation of a reservoir disrupts the normal downstream energy and nutrient transfer from the upper reaches of the river and serves as a nutrient sink. Normally the downstream river communities are dependent upon the continual transfer of suspended or dissolved nutrients from the upper reaches. Unlike lakes or reservoirs, rivers do not normally recycle nutrients. The area immediately below a dam develops new and highly unstable plant and animal communities, while further downstream the input from feeder streams may tend to mitigate the effects of the impoundment.

During the initial filling of a reservoir, the reduced downstream flows cause portions of the river to dry up, destroying the benthic organisms and fish habitat existing there. Recolonization of those areas does take place but the process is usually slow and frequently, with a new and artificial flow regime, the new plant and animal communities differ from what previously existed. In many river systems, annual spring floods are important in maintaining the characteristics of floodplains and deltas. The reduction of the spring freshet can lead to the loss of valuable marsh and wetland habitat.

5.1.2.3 Other Environmental Effects

(a) Road Construction

The construction of facilities in remote areas necessitates the introduction of new roads to provide access to the site. Such roads have direct and indirect environmental effects such as increased exploitation of resources, the disruption of land drainage, the interference with fish movements, and siltation problems. Without reclamation, sand and gravel pits developed as borrow areas to provide building materials may subsequently permanently scar the landscape.

(b) Transmission Lines

The clearing of a right-of-way for a transmission line can permanently scar the landscape, although the impact will vary according to the quality of the landscape along the selected corridor. Herbicides, often used as defoliating agents, can, if improperly selected, seriously harm wildlife and water quality. The generated noise of transmission lines may also affect wildlife.

5.1.2.4 Impacts in Ontario

Since there is only one major potential hydro-electric project which could be considered as an alternative to thermal installations in Ontario, this discussion will deal mainly with that area, the drainage systems of the Hudson Bay and James Bay Lowlands. All other projects are very small by comparison or are intended for rivers which are partially developed. In either case, the effects would tend to be very localized and usually not too significant on a provincial basis.

In the Albany, Winisk, and Attawapiskat basins, most of the area is mantled with marine deposits and, due to poor drainage, has developed extensive peat bogs capped by muskeg. String bogs and quaking bogs are gradually filling in many lakes and ponds. Stream flows tend to be sluggish due to the gently sloping topography and most river channels show long straight reaches with broad troughs that are being deepened and widened in many parts through the erosive action of the spring floods and drifting ice. Sediment loading is heavy especially during the spring floods, and deltas occur in the mouths of the major rivers.

Spring break-up of ice in the rivers begins about mid-May in the Albany and Attawapiskat and slightly later in the Winisk. During and following the break-up, flood peaks can rise as high as 50 feet above mid-summer river levels. During periods of lows, flows in some streams are intermittent. Freeze-up begins usually in early November in the Winisk and progresses to the Albany by the end of the month. The open water period for the area is therefore relatively short and the frost-free period is between 3 and 4 months. The three rivers account for about 50% of the total discharge in the Ontario section of the Hudson Bay and James Bay drainage. The Albany alone accounts for about one-third of this discharge.

(a) Fish

Within the three watersheds, several species of fish are found, the most important for commercial and consumptive uses are whitefish, walleye, northern pike, sturgeon, and lake trout. None of the waters within 150 miles of the coastline are commercially important to the region but the midreaches of the Albany, including the Kenogami branch are licenced to the native people. Any development in the area will retard the existing poor drainage patterns and thus accelerate the encroachment of bogs into the existing lakes. This could seriously affect the spawning habits of the fish population as would the daily and long-term fluctuations in reservoirs due to power plant operations.

(b) Wildlife

Most of the Ontario coastline of Hudson and James Bay is heavily used by migrating waterfowl and shorebirds. The estuaries of the rivers are of critical importance to these migrating birds as staging and feeding areas during spring and fall migration. Some estuaries provide optimum nesting and brook rearing habitat, particularly for dabbling ducks and shorebirds. The Attawapiskat and Albany River estuaries provide extensive mudflats and well developed tidal marshes dissected by numerous streams. They are of extreme importance to the Lesser Snow Goose and the less populous Canada Goose during migration.

Estimates, as high as 70,000 birds, have been made for the number of geese killed for food by the native population of James Bay during spring and fall migration. In addition, commercial goose hunting camps have been established on the coast, some operated by tourist outfitters; others, more recently, operated by the native people. These camps account for the harvest of several thousand more birds and provide a significant annual income for the area.

One of the factors which contribute to the success of this area as a waterfowl habitat is the spring flooding, which provides the sediment necessary to create deltas and marshland. It also carries nutrients necessary to revitalize the food growth in the estuaries. Developments along the Albany River would definitely reduce the sediment loading as well as reduce the spring flood.

Less information is known about the ecological contribution of the interior lowlands but they do support nesting waterfowl and other migratory birds that are important both in Canada and the United States. Ontario provides two polar bear maternity denning areas, southwest of Cape

Henrietta Maria in the Winisk watershed and on Akamiski Island opposite the mouth of the Attawapiskat River in James Bay. These areas contribute to an Ontario mainland and James Bay islands summer population of about 200 animals. Hunting of polar bears is currently carried out by the Ontario native people. Between 1969 and 1975 a total of 28 bears were taken by hunters from Winisk, Attawapiskat and Fort Albany.

Probably the most common and abundant marine animal of the lower Hudson and James Bay is the ringed seal. Recent population estimates are at approximately 61,000 animals but little use has been made of this mammal either for fur or food by the native population. Other marine animals found in the area are the harbour seal, Atlantic walrus, and white whale. Little direct effect would be felt by these animals from a hydro-electric development on the interior rivers but the changes in the food chain prompted by developments could gradually have some long-term effect on populations.

The furbearer production of the three watersheds has traditionally provided the native people with a majority of their income. In terms of dollar value, the industry has been supported by beaver, mink, and otter, although muskrat and marten have provided large catches particularly in the Albany River basin. Extensive flooding of the basin area would reduce some populations directly while forcing other portions to a more hostile habitat, the results of both actions having a direct effect on the native income.

(c) Land and Population

About one-eighth of the coastal region's human population is located at the mouths of the three watersheds in the communities of Fort Albany, Attawapiskat and Winisk. Native people make up the majority of the residents of these communities and obtain most of their income from trapping, fishing, guiding and labour.

The forest cover of the area between the height of land and the coast is dominated by black spruce along with some larch and jackpine. White spruce, balsam fir, trembling aspen, and poplar occur along river valleys and south-facing slopes. Most of the commercially exploitable forest occurs in the head-water region of the Albany River.

A full development of the Albany River would involve reservoirs covering approximately 1,000,000 acres of territory including existing riverbed and lakes, with the diversions from the Attawapiskat and Winisk Rivers adding slightly to this total.

5.1.3 Conclusion

There is only one remaining potential hydro-electric system in Ontario which could be considered as an alternative to a fossil or nuclear station in the development plans of Ontario Hydro as dictated in Report 556 SP. This is the full development of the Albany River system with possible diversions from the Winisk and Attawapiskat Rivers. Although the feasibility of such a development would be determined mainly by the economics of the number of dams involved, costs of construction, relative inaccessibility, and transmission costs, the environmental impacts of each development would have to be examined very carefully.

The area of the hydro-electric development covers extensive territory dominated by wilderness areas and supports a small native population in a natural environment. Commercial resource exploitation is small and lies mainly in trapping and sport fishing and hunting. The dominant wildlife feature is the migratory waterfowl. The lower reaches of the three rivers, as important feeding and staging areas during spring and fall migration, support large populations of migrating birds.

Thus the two most important groups affected by any large-scale development in Northern Ontario would be the native people and waterfowl. All environmental assessments would necessarily have to evaluate the contribution of development impacts either directly or indirectly on their present respective lifestyles.

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5.2 PRODUCTION OF ELECTRICAL POWER: THERMAL FOSSIL FUELS

5.2 PRODUCTION OF ELECTRICAL POWER: THERMAL FOSSIL FUELS

5.2.1 Fossil Fuel Usage and Future Potential

5.2.1.1 Oil

At present, Ontario Hydro has no plans to expand the use of residual oil fired thermal generating stations beyond the Lennox G.S., currently under construction, and the proposed Wesleyville G.S. (1). Supplies of crude oil currently are provided by Golden Eagle Refinery in Quebec (Venezualan crude). Future supplies are likely to be forthcoming from Petrosar in Sarnia (Western Canadian crude). Ontario Hydro predicts their total annual residual oil usage to be 13.7 million bbl by 1985 and to level off to 10.0 million bbl by 1995. This would represent 2% of their total annual energy production in 1995.

5.2.1.2 Natural Gas

Natural gas is considered a premium fuel and, as such, the priority for its use in boilers is very low. Ontario Hydro uses gas only at the R.L. Hearn G.S. and no new gas fired facilities are planned for construction (1). At present, Ontario Hydro has a firm contract with Consumers Gas Ltd. to supply a nominal 49 billion cubic feet per year until 1981. Supplies for subsequent years depend on the availability of Arctic gas. By 1995, it is estimated that less than 1.5% of Ontario Hydro's annual energy production will be supplied by natural gas.

5.2.1.3 Coal

Although it is projected by Ontario Hydro that nuclear generating stations will be the main source of future electical power production (63% by 1995), the long lead time required to bring nuclear fueled generating stations into production, along with an uncertain petroleum supply, dictates that coal will continue to be the main interim source of energy. Current Ontario Hydro plans (1976) indicate an approximate twofold increase in coal generating station capacity by 1995. As this increased reliance in coal is the expected pattern of development for the entire continent, the coal production cycle must be considered in the continental context rather than the domestic one. Currently, in excess of 10 million tons of coal per annum are supplied from U.S. markets. To ensure a security and reliability of supply, Ontario Hydro is negotiating for Western Canadian supplies, and it is expected that 4.0 to 6.0 million tons per annum will be shipped to Ontario by 1980 (1).

5.2.1.4 Summary

As noted previously in Section 2, the feasibility of future oil and gas supply is, at best, uncertain. Long-range domestic supplies will be dependent on the success of the Athabaska Tar Sands Project and pipeline delivery of Arctic reserves. Thus, with the current uncertainty of these supplies, as contrasted with vast known reserves of domestic coal and uranium, the emphasis will be on the latter two sources for the supply of Ontario's future electric power generation needs.

5.2.2 Net Energy of Fuel Production

The net energy of power production in terms of the electrical energy extracted from the fuel, is partially determined by the energy inputs required to extract, upgrade, and transport the fuel to the plant. Fuel obtained from Arctic sources will require significant energy inputs to extract and deliver to southern markets. Coal will also suffer a "net energy" loss, although to a lesser extent, primarily due to the longer haul distance for Western Canadian sources. The energy input required will serve in effect to lower the "net energy" output at the electricity delivery end of the system.

5.2.3 Environmental Impacts

5.2.3.1 Overview of Environmental Impacts

The environmental effects arising from the production of electric power from fossil fuels occur at every stage of the total fuel cycle: exploration and extraction, upgrading, transportation, storage and handling, power generation, and waste disposal. Figures 5.2-1, 5.2-2 and 5.2-3 present an environmental impact matrix for oil, natural gas, and coal. Each matrix notes some of the more significant sources of impacts on the air, water, and land environments that can be produced at each stage of the total fuel cycle.

Since Ontario essentially imports all of its fossil fuels, the direct impacts on Ontario's natural environment will be confined largely to the storage and handling, power generation, and waste disposal stages. Environmental impacts arising from earlier stages in the fuel cycle are "externalized" to other parts of Canada (western coal, Arctic gas and oil); the United States (coal); or abroad (oil). Externalization of environmental impacts also occurs indirectly from transboundary movements of pollutants from the production process which are either airborne or water borne. The Department of Fisheries and the Environment is interested in the total environmental impacts from power production, whether they be direct or indirect and whether they occur within the province or in other parts of Canada, the United States, or abroad.

Since oil and natural gas are expected to play a relatively insignificant role in Ontario's future power production, their respective environmental impacts will not be discussed further in this section. However, in view of the likelihood that electricity from coal will

FIGURE 5.2-1

Electric Power from Oil: Potential Environmental Impacts

	Air	Water	Land
Exploration and Extraction	Fuel Combustion Products	Drilling Accidents Brine Disposal	Permafrost Damage Seismic Lines
Upgrading	Sulphur Oxides Nitrogen Oxides Carbon Monoxides Hydrocarbons	Thermal Discharge Sulphuric acid Spent caustic	Spent Clay Spent Phosphoric Acid Catalyst
Transportation	Power Source Emissions	Tanker Spills and Flushing	Pipeline Spills Permafrost Damage Land Consumption by Pipeline
Storage and Handling	Hydrocarbons	Spill Runoff	Land Consumption by Storage and by Containment Facilities Tank Spills
Power Generation and Waste Disposal	Sulphur Oxides Nitrogen Oxides Particulates Thermal Discharges	Thermal Discharges Fallout from Atmospheric Emissions	Fallout from Atmospheric Emissions Land Consumption by Plant

Source: Adapted from Reference (2).

FIGURE 5.2-2

Electric Power from Natural Gas: Potential Environmental Impacts

	Air	Water	Land
Exploration and Extraction			Permafrost Damage Seismic Lines
Upgrading	Sulphur Oxides		
Transportation	Nitrogen Oxides at Compressor Stations		Land Consumption by Pipeline
Storage and Handling			
Power Generation and Waste Disposal	Nitrogen Oxides Thermal Discharges	Thermal Discharges	Land Consumption by plants

Source: Adapted from Reference (2).

FIGURE 5.2-3

Electric Power from Coal: Potential Environmental Impacts

	Air	Water	Land
Exploration and Extraction	Fuel Combustion Products Waste Pile Fire Particulates	Acid Mine Drainage Leaching of Waste Piles Erosion and Silting of Watercourses Fallout of Particulates	Strip Mining Effects Land Subsidence Land Consumption by Mine Area Fallout of Particulates
Upgrading	Particulates from Coal Processing and Wastes Waste Bank Fires	Plant Effluents Leaching of Waste Piles Fallout of Particulates	Coal Cleaning Waste Sulphur Waste Fallout of Particulates
Transportation	Particulate Blow-off (windage losses)	Fallout of Particulates	Fallout of Particulates Land Consumption by Rail or Pipeline and Related Facilities
Storage and Handling	Particulate Blow-off (windage losses)	Fallout of Particulates Coal Pile Runoff	Fallout of Particulates
Power Generation and Waste Disposal	Sulphur Oxides Nitrogen Oxides Particulates	Thermal Emissions Fallout from Atmospheric Emissions	Fallout from Atmospheric Emissions Fly Ash and Slag Disposal

Source: Adapted from Reference (2).

increase substantially in future, the remainder of this section will concentrate on the environmental impacts of the total power production process related to coal-fired generating stations.

5.2.3.2 Exploration, Extraction, and Upgrading

As the mining of coal has taken place over many centuries, the occupational, safety, and environmental hazards are well documented (3) (4) (5). Waste piles left unattended have eroded and contaminated water courses. Untreated acid mine drainage has polluted ground surface waters. Strip mining has left scars on the land as evidence of its existence. It has affected flora and fauna, destroyed wildlife habitats, and disrupted fish populations which, in turn, has reduced or destroyed the recreational potential of the exploited area.

In some instances, the response of government agencies has been to enact legislation requiring that certain minimum environmental standards be maintained during the life of the pit and that, on closure, the pit be returned to an acceptable condition (6). The money required to comply with these standards is generated as a surcharge on the sale of the product and is ultimately borne by the consumer.

5.2.3.3 Transportation

The increasing attention being paid to the development of Canadian coal markets requires that Thunder Bay port facilities be expanded for trans-shipment and that Canadian shipping by bulk carriers be increased (7). The present capacity of the Thunder Bay coal transfer facilities is 3.5 million tons per year with plans for an increase to 6 million tons.

The present method of bulk shipment from Western Canadian coal fields is by rail. With the prospect of increased traffic in most coal trains to the Lakehead, Canadian National Railways is planning a program of double tracking its main line in the Prairie Region (8).

The environmental effects of a rail haul system of transport are readily apparent. The control of dust during storage and transport require that chemical or petroleum sprays be applied to bind the coal particles and that car washing techniques be improved. The noise impacts of rail traffic in Thunder Bay have been identified as significant and will increase with increasing movement of coal unit trains (9).

There are alternatives to rail shipment that would help to mitigate some of the environmental impacts. One such alternative would be a coal-slurry pipeline from Alberta to Thunder Bay. At certain levels of use, a pipeline could be more economical than rail. For example, at four million tons per year, the saving relative to rail would be $1.50 per ton over 25 years and, at six million tons, it would be $4.00 per ton over 25 years (10).

Another alternative to rail shipment of coal would be the gasification or liquifaction of coal near the mine site, and the subsequent transfer of the liquid or gaseous fuel by pipeline. The process is costly at present and its chief advantages lie in the reduction of the environmental impacts of fuel transfer. There is also interest in the underground gasification of coal (11). This process can result in economics of extraction where the seams lie in strata that would otherwise be difficult to work. Underground gasification can also convert excess methane into part of the useable fuel thus changing a potential hazard into a benefit.

The feasibility of transmitting electricity produced from coal fired generators close to the mine sites is also under consideration. In theory, electrical transmission should be more efficient than coal -- the conversion of electricity to work being that much more efficient than the comparable calorific quantity of coal (12). In practice, however, the line losses of long distance electrical transmission may offset part of the advantage. In addition, there may not be sufficient reliability in a national electrical grid to satisfy the requirements of Ontario Hydro.

5.2.3.4 Power Generation

a) Atmospheric Emissions - National Air Quality Objectives.

National Air Quality Objectives have been set out under the Clean Air Act (submitted under separate cover). The preamble to these Objectives states, in part:

> "Under the Federal Clean Air Act, the national ambient air quality objectives are designed to protect public health and welfare by setting limits on levels of pollution in the air. For each major pollutant, the Clean Air Act calls for three levels of air quality objectives: desirable, acceptable, and tolerable. The objectives now being promulgated concern only the first two of these levels.
>
> Maximum tolerable levels denote concentrations of air contaminants that require abatement without delay to avoid further deterioration of conditions to an air quality that endangers the prevailing life-style, or, ultimately, to an air quality that poses a substantial risk to public health.
>
> The maximum acceptable level is intended to provide adequate protection against effects on soil, water, vegetation, materials, animals, visibility, and personal comfort and well being. It represents the realistic objectives today for all parts of Canada. When this level is exceeded, control action by a regulatory agency is indicated.

> The maximum desirable level defines the long-term goal for air quality and provides a basis for an anti-degradation policy for the unpolluted parts of the country and for the continuing development of control technology. It is acknowledged that the effects of sulphur dioxide, carbon monoxide, particulate matter, nitrogen oxides and oxidants on the public health and welfare are not necessarily understood to the extent considered desirable. As more information on the effects of these and other air pollutants becomes available, the national ambient air quality objectives will be revised appropriately."

b) Sulphur Oxides

(i) Atmospheric Concentrations and Air Quality Objectives

In the Toronto area, the decrease of ambient sulphur dioxide concentrations since 1965 has been encouraging. At the present time, the desirable annual objective of 0.01 ppm is being approached, the actual level being at 0.014 ppm in 1974. In the Nanticoke area, which is essentially undeveloped at present with the exception of the power station, the desirable annual objective of 0.01 ppm was just being met in 1974, with the station operating at less than one-third of planned capacity. In the Sarnia area, in 1974, the sulphur dioxide concentration was 0.026 ppm which is well above the desirable level.

The stations in question emit 77% of the sulphur dioxide in Toronto, 90% in Nanticoke, and 64% of the Canadian emissions affecting Sarnia. Thus, for example, in Toronto, while the desirable limit is now being approached, no further improvement can be envisaged unless the major source in the area curtails emissions. In Nanticoke, the desirable limit has already been reached with the station operating at well below capacity. Thus, there will be need for emission reduction when the station is operating at rated capacity of 4,000 megawatts and other planned developments in the area, with their attendant sources of sulphur dioxide, are operating. Any additional activity will have to be accompanied by corresponding reduction in emissions from established operations to ensure that air quality standards are not exceeded. Finally, the present pollution level in Sarnia greatly exceeds the desirable limit. Even though there are other major sulphur dioxide sources on both sides of the international border, there can be no improvement unless major sources, of which Lambton is one, are curtailed. Remedial action being taken in the U.S. is indicated in Canada. Any additional power generation will add to the pollution load.

(ii) Airborne Transport

A number of recent studies (13) (14) have identified that a significant portion of the contaminants entering the Great Lakes do so as fallout from atmospheric emissions. This tends to confirm the Department's view that dispersion from tall stacks is not a solution, in the long run, to air quality maintenance. Secondly, emissions from point sources should not be considered in isolation, but rather in a "regional" context. Thus, the emissions from all major sources on both the Canadian and U.S. side of the Great Lakes must be assessed to fully evaluate their impact on air quality and on the Great Lakes. To illustrate this point, it was noted above that the air quality objectives for SO_2 are just being met in the Nanticoke area. It should also be noted that this area is also being affected by sulphur dioxide emissions from other industrial sources including those in the United States.

In view of the potentially harmful effects of the long-range transport of pollutants, Environment Canada has recently prepared an analysis of the issues and identified a study program for Ontario. A copy of this report has been submitted under separate cover for review by the Commission.

(iii) Acid Precipitation and Particulate Sulphates

If no measures are taken to control the emission of SO_2 at source, then a concern of perhaps equal importance to that of ambient sulphur dioxide concentration is acid precipitation and particulate sulphates resulting from sulphur dioxide emissions. The long-term effects of acid precipitation are now being documented in terms of reduced crop and forest growth (15), reduced fisheries due to lake acidification (16), and in an acceleration in the corrosion of materials. Additionally, there is preliminary evidence to indicate that particulate sulphate levels in some parts of the United States may be directly associated with adverse public health effects (17).

iv) Abatement Options

Several options are available for the abatement of sulphur oxide emissions. Fuels of lower sulphur content will of course produce less sulphur oxide when combusted. Low sulphur coals are available in Canada and techniques such as washing can be used to substantially reduce the natural sulphur content of many coals. Coal gasification is a further way of producing low sulphur fuel.

Sulphur oxides can be removed from flue gas by one of the many flue gas desulphurization (FGD) systems now available. Research and development in the field of flue gas desulphurization (FGD) has been at a high level in recent years to the point where there are now 5,573 MW of installed capacity of F.G.D. units in the U.S. and a further 8,870 MW under construction (18).

c) Nitrogen Oxides

Thermal stations are significant sources of nitrogen oxides. The thermal stations of Ontario Hydro are known to emit millions of pounds of nitrogen oxides annually (23). Nitrogen oxides are known to be precursors to oxidant formation, along with hydrocarbons, and much international effort is being directed to the determination of the mechanism of oxidant formation. Crop losses due to oxidant damage in Ontario have been reported (24). Thus, it is necessary that the question of the effect of gross emissions of nitrogen oxide be examined.

d) Particulate Emissions

The current state of control technology is such that the removal of up to 99% of particulates by the use of electrostatic precipitators is possible. Neverthless, there is concern about heavy metal emissions from power generating stations. Although, in absolute numbers, the control of particulates may be satisfactory, the remaining emitted particulates are in the respirable range (19). There is a growing evidence which suggests that heavy metals are concentrated in these lighter fractions of particulate (20), resulting in concern about possible biological and health effects. The relationship between power generated from coal and estimated quantities of heavy metal emissions is shown in Reference (22).

As noted previously, the effects of these emissions cannot be considered in isolation for each source but, rather, must be evaluated in the "regional" context by taking into account all significant sources of emissions both in the U.S. and Canada.

e) Coal Dust Particles

The soiling of property due to loss of coal particles by blowing dust when the coal is being stored and handled (the so-called "windage losses") can be a very significant local problem, and specific methods of dust suppression are necessary to keep it under control. In addition to the local soiling problem, with its substantial effect on nearby land values, there is the potential for these sources to add significantly to the total particulate loading of the atmosphere in the general area. The extent to which the particles of coal dust can act as vehicles for transport and reaction of other chemicals in emissions from a variety of sources needs to be considered also. Most of these problems are site specific, dependent not only on the design and location of storage, handling, and transport facilities, but also on the type of coal and method of coal mining and cleaning. There are estimates of windage losses as high as 1% of the coal handled. Thus, the loss can become a very significant amount when the total coal consumption of a major generating station is considered.

f) Thermal Emissions

Fossil fueled electric generation plants release waste heat mainly to the water environment from the plant cooling system. The "once through cooling system" is utilized by Ontario Hydro in all of its thermal generating stations. Environmental impacts associated with this form of cooling include: changes in water temperature and the associated impact on aquatic biota and climate, stresses on biota arising from passage through the condensors, and impingement of fish on the intake screens. The environmental implications of thermal plant cooling systems is discussed in the subsequent section on thermal nuclear plants (Section 5.4). This section will also review some of the beneficial uses of waste heat.

Fossil fueled plants release a smaller portion (about 15%) of their waste head directly to the atmosphere. Concentrated thermal emissions such as might occur from an "energy centre" can affect the local and regional climate through fogging, increased cloudiness, and through increasing the possibility of storm activity. There may also be more global climatic effects arising from thermal releases produced from the use of non-renewable energy sources such as fossil and nuclear fuels. Section 5.6 discusses the two-way relationship between energy and climate in more detail.

5.2.3.5 Solid Waste Disposal

Associated with the use of fossil fuels for electrical power generation is the generation of significant quantities of solid and semi-solid residues from combustion and stack gas cleaning.

The solid wastes commonly associated with fossil fueled generating stations are bottom ash, slag, fly ash from coal fired plants, and a variety of chemical slurries from water treatment and conditioning processes. Wet scrubbing of stack emissions, used to reduce the sulphur dioxide content of flue gases, produces a sulphur containing by-product. In some parts of the world, this by-product is sold to offset operating costs. However, in the United States, the by-product is disposed of by lagooning or stabilization and by land fill.

The disposal of ash and scrubber sludge is a major concern because of the land required and the potential for leaching.

Consideration must be given to proper disposal in order to prevent possible water pollution sources arising from either ponding or landfilling operations, i.e. runoff water or leachate which may contain soluble toxic species (e.g., significant concentrations of arsenic in effluents from fly ash ponds). Excess levels of sulphate or chloride and excessive chemical oxygen demand may also be contained in the leachate.

It has not been clearly established whether any of the above potential pollution problems are serious threats to the environment. Given a particular hydrogeological setting, and climatic conditions conducive to leachate generation, a significant environmental impact from contaminant loadings to receiving waters is possible. It seems clear that leaching and runoff must be minimized to assure that ground water or stream pollution does not occur.

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5.3 PRODUCTION OF ELECTRIC POWER: SOLID WASTE MATERIALS

5.3 PRODUCTION OF ELECTRIC POWER: SOLID WASTE MATERIALS

5.3.1 Potential Supply

The amount of solid waste generated in Ontario municipalities is approximately 6 million tons per year. This includes residential waste, commercial waste, and housekeeping waste from industries (i.e., not including industrial processing wastes such as slags or sludges).

This waste stream has an average energy content of 4,500 - 5000 BTU/lb, and thus represents a renewable energy source containing 57 x 10^{12} BTU/year. This is equivalent to 10 million barrels of oil or 2 million tons of coal. If converted to electricity, the resulting power generation would amount to 3,360 x 10^{6} kWh or approximately 4% of Ontario's 1974 electricity consumption.

However, not all waste is generated in areas where energy recovery is feasible. Collection and transport costs mitigate against moving waste over long distances. Hence, the amount of energy recoverable in practice would be considerably less than the figures indicated above.

Wood and wood wastes from all stages of the forestry industry also represent a source of energy. Some of this energy is presently being recovered by pulp mills in Ontario which burn wood waste to produce steam for process and electricity generation purposes. In fact, it has been estimated that 49% of the 3 million tons of bark produced in Ontario each year are used as fuel (1).

A preliminary assessment of the use of wood as a fuel for commercial electrical power generation in the U.S.A. indicates that, for the major wooded areas of the U.S.A., the process is technically feasible and cost competitive with other types of fuel (2). Wood's relatively low polluting composition and its potentially sustainable supply make it an attractive alternative to coal, oil, or gas for incremental capacity additions.

5.3.2 Feasibility

Municipal solid waste has been utilized in travelling grate waterwall incinerators to generate electricity in Europe for many years. "As received" waste is burned to produce high temperature and pressure steam which is used to power steam turbines.

A recent North American development has been to pretreat the waste by shredding, and to burn it in suspension in conjunction with pulverized coal in electrical generating stations (e.g., modifications to the Lakeview Generating Station presently underway). It has been found that up to 20% of the boiler heat supply can be provided from waste without causing major problems (3) (4).

Other potential users of municipal solid wastes as an energy source are the pulp and paper industry and the cement manufacturing industry.

5.3.3 Environmental Impacts

In general, the incineration of solid waste causes more air pollution and less groundwater pollution than the other major alternative for waste management -- landfill, although ash landfill leachates characteristically exhibit high soluble salt and alkali metals content. Proper controls such as electrostatic precipitators and scrubbers can reduce particulate matter and chloride emissions to acceptable levels.

Municipal solid waste has a very low sulphur content. Thus, the replacement of other fuels will represent a lowering in the amount of SO_2 emitted to the atmosphere.

The reduction in waste volume of up to 95% during incineration reduces the amount of land required for final disposal of incinerator residues.

5.3.4 References to Section 5.3

(1) Neill, R.D., "Options for the Use and Disposal of Bark", Neill and Gunter Ltd., Fredericton, August 1975.

(2) Hall, E. H. et al., "Comparison of Fossil and Wood Fuels", Battelle Columbus Laboratories for Environmental Protection Agency, March, 1976, NTIS PB251 622

(3) Lowe, R. A., "Energy Recovery from Waste", Environmental Protection Agency (Solid Waste 36D11)

(4) Klumb, D. L., "Union Electric Company's Solid Waste Utilization System", Proc. of Conversion of Refuse to Energy Conference, I.E.E.E. Montreux, Switzerland, November 1975.

5.4 PRODUCTION OF ELECTRIC POWER: THERMAL NUCLEAR

5.4 PRODUCTION OF ELECTRIC POWER: THERMAL NUCLEAR

5.4.1 Introduction

The generation of electricity by nuclear power involves a series of operations commonly referred to collectively as the uranium fuel cycle. These operations include mining and milling of uranium, fuel fabrication, power production, transport and management of radioactive wastes. Each sequence in the cycle poses risks of adverse effects on the environment. The production of heavy water is another operation in the CANDU cycle that can pose risks to the environment. Some of the potential environmental risks associated with nuclear power are particular to this energy technology while others are similar to those posed by other means of generating electricity. The Department takes the position that the environmental risks associated with nuclear power should be balanced both against the benefits to be derived from the power generated and also against the environmental costs of alternate sources of energy. Furthermore, it is important that those elements of risk transmitted to future generations be minimined so that environmental quality for the future is not jeopardized.

5.4.2 Uranium Mining and Milling

Proven uranium deposits of commercial importance at current market prices occur at only two places in Ontario: at Elliot Lake (including Agnew Lake) and at Bancroft. The only two presently operational mines in Ontario are both at Elliot Lake, but it is anticipated that two more mines will become operational shortly. In Ontario, the uranium mining activities are carried out by pit mining processes. Milling operations are undertaken at the location of the sites. Projected increases in both domestic and foreign demands on Canadian, and specifically Ontario, uranium reserves will, of course, increase their rate of exploitation.

The first obvious environmental impact of uranium mining is that which occurs in the working environment of the mine itself. Natural decay of uranium produces various daughter products, such as thorium, radon and radium. Radon-222 (^{222}Rn) is a gas, and is released from rock faces into the mine atmosphere and water system. Radon itself decays quickly to daughter products which, usually adsorbed to water droplets or dust and smoke particles, can become suspended in the air. Because of their property of being retained in the lung, it is specifically the radon daughters that pose a health hazard to miners. The recently published report of the Royal Commission on the Health and Safety of Workers in Mines (1) concludes that:

> "under the conditions of exposure to radiation in Ontario Uranium mines in the period 1955-1974, there is statistical evidence that the persons on the Uranium Nominal Roll have experienced a risk of lung cancer that is related to radiation exposure received in Ontario. The tests, based on sample analysis, indicate that risk increases with exposure and that a linear dependance on cumulative WLM (Working Level Months) is consistent with the sample data"
>
> Ch. 3, p. 84

The relationship between total WLM experience in Ontario and risk of lung cancer is summarized in Figure C.1 of the aforementioned report and reproduced below as Figure 1. (A "Working Level" is the level of radioactivity in mine air when the complete decay of the combination of short-lived daughters of ^{222}Rn would yield a total Alpha energy of 1.3×10^5 MEV. A "Working Level Month" is exposure for 170 hours to air in which the radioactivity averages one Working Level).

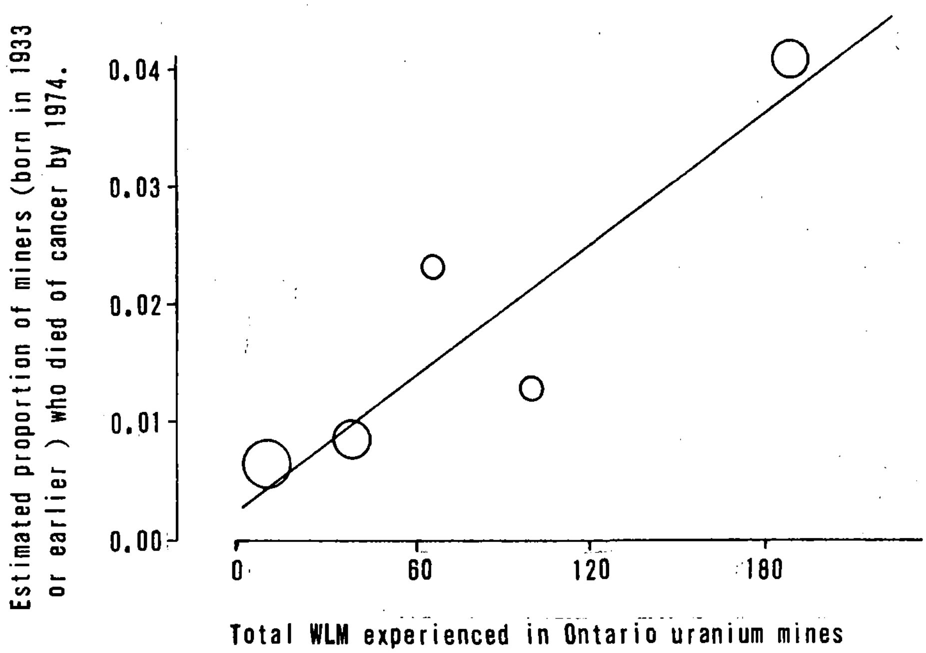

FIGURE I RELATIONSHIP BETWEEN TOTAL WLM EXPERIENCED IN ONTARIO AND RISK OF LUNG CANCER.

The major effect of uranium mining on the surrounding environment occurs during the processing of the ore. The leaching of the crushed ore results in the release of acidic leachates into the aquatic environment. At active mine and mill locations, the discharges are comprised of mill process wastes and mine water (which contain dissolved radon), natural runoff, and seepage from the tailing piles. The contaminants include both radiological and non-radiological components. Current daily radiological loading to the Serpent River (and hence to the North Channel) are approximately (2):

^{226}Ra	-	1,850 microcuries
Gross alpha	-	15,800 microcuries
Gross alpha	-	14,100 microcuries

The level of radium in drinking water supplied to the population of Elliot Lake was 4 pCi/l (pico-curies per litre) in 1970, decreasing to 2 pCi/l in 1975 although Sheriff Creek which runs into Elliot Lake was 7.5 pCi/l in 1975 (3). The Ontario Public Service Water Criterion for ^{226}Ra is 3 pCi/l (4). If carefully controlled effluent levels and operating procedures and control of abandoned tailing ponds are assured, the ^{226}Ra in the system can be reduced to permissible and acceptable levels.

The non-radiological components in the leachates and effluents include copper, zinc, lead and nickel, all in various chemical forms and all of which are potentially toxic to man and other organisms. The behaviour of both radioactive and non-radioactive pollutants in the Serpent river basin, although studied to some degree, is not completely known. Specifically, transport mechanisms and ecological kinetics need to be studied further to evaluate the possible buildup of these pollutants in various compartments of both the immediate and overall environment.

The amount of land required for the development of open pit uranium mines is considerable. Added to this is the requirement for large areas which must be set aside for the containment and disposal of tailing and other wastes.

Because of the comparatively low concentarations of uranium in mined material, waste products are of essentially the same quantity as the material orginating from the mines. At present, each mine at Elliot Lake processes 4,500 tons of mined ore per day, with plans to increase operations to process 7,000 tons per day each. An equivalent amount of waste is thus being produced. By 1978, 12,000 tons per day from each mine is anticipated to be produced. Estimates indicate that if all of Canada's 1974 electrical needs were met using nuclear energy, 1,000,000 tons of tailings would be produced yearly from high grade ore. At present, this is only one-tenth to one one-hundredth the amount of waste that would be produced from a coal mining operation to produce equivalent energy. As the demand increases, and the need for mining low-grade ores becomes of greater importance, the tailings produced from coal mining and uranium mining operations may become more nearly equivalent.

Careful management of uranium mine tailings is underscored by the problems encountered recently at Uranium City, Sask, and by locales with similar problems in the United States. In those cases, homes and other buildings had been constructed using contaminated (mainly with ^{226}Ra) material from the tailings; and as a result, higher than acceptable - i.e. 3 pCi/l over background - indoor levels of ^{222}Rn have been measured in occupied areas.

5.4.3 Fuel Production

Production of fuel elements and bundles for the CANDU reactors is virtually free of present and possible serious environmental impact. Indeed, general good house-keeping procedures render the environmental risks of this industrial operation almost non-existent.

5.4.4 Production of Heavy Water

Each of the four reactors at the Pickering Station needs 450 tons of heavy water for the moderator and the heat transport (coolant) systems. In addition, through leakage and chemical combination, each reactor loses about four tons of heavy water each year which must be replaced. In Ontario, Bruce A Heavy Water Plant (with a capacity of 800 tons per year) is currently operational; Bruce B Heavy Water Plant, with a similar capacity, is expected to be operational in 1978. Two more plants (Bruce C and D), each with 800 ton per year capacities, are planned.

The principal hazards associated with the operation of heavy water plants are the possible escape of H_2S into either the air or the water surrounding the plant, and SO_2 release from combustion of waste H_2S. During 1973 and 1974, at Bruce A, emissions criteria of the Ontario Ministry of the Environment were not exceeded; during 1975, the hourly H_2S criterion for ambient air quality was exceeded once. There is no evidence to indicate that plants or animals have been adversely affected by these levels of H_2S.

Emissions to water include both H_2S and chlorine (added to the circulating cooling water to control the growth of bacterial slimes on condenser tube surfaces). Standards have been developed for H_2S emissions to water by taking into consideration the most sensitive stages of development of fish species native to the area. These standards are highly conservative since they are based on assuming all H_2S is undissociated (highly toxic). In fact, at a lake pH of 8.0 and temperature of $11^{o}C$, only about 13% of the discharged H_2S would occur in the toxic, undissociated form (5).

The behaviour of chlorine in water requires a knowledge of temperatures and chlorine mixing and depletion rates in the thermal plume. Chlorine is added to cooling water in "shock" doses, the environmental effects of which will be highly dependent upon the time of year. The present units in operation do not strongly influence the lake area chlorine concentration. For Lakes Huron and Superior, water quality objectives of 0.002 mg/L are proposed by the IJC. With the projected increase to four units operating at this site, calculations indicate that chlorine discharges in winter, fall and spring, when water temperatures are low, could be potentially toxic to sensitive fish species (such as rainbow trout and coho salmon) entering the relatively warm plume area (5).

In order to minimize human health hazards arising from heavy water plants, plants are situated in remote areas and no habitation is allowed within a one-mile restricted area around each plant. Restrictions are placed on land use in a core area of 5 miles in radius around the plant. Such requirements may help in reducing the impacts of human health, but are expensive in terms of land use and do not consider organisms other than man in the vicinity of plants. However, ongoing studies at Bruce A have not detected changes in general health of trees or other vegetation in the area which can be attributed to aerial emissions. Similarly, no changes in aquatic life or in general water quality along the Bruce Nuclear Power Development shoreline have been observed which can be attributed to the emissions of H_2S from the Bruce Heavy Water Plant (5).

In addition, total continent-wide emissions of sulphur oxides are giving rise for concern. The addition of heavy water plant sulphur emissions to this total load must be considered, even though they are at present small compared to the amount from other industrial sources.

5.4.5 Power Production

At present, nuclear energy accounts for 16% of the Ontario generating capacity, or 3-4% of the total provincial energy demand. Pickering's four 500 MWe reactors produce most of this from a single site on the north shore of Lake Ontario, about 20 miles east of downtown Toronto. Proposed plans are to increase the nuclear capacity to about two-thirds of the total provincial electrical generating capacity by 1995.

During the operation of nuclear power plants, two types of radioactive by-products are produced: fission products and neutron activation products.

Fission products account for 99% of all radioactive by-products produced in a power plant. As their name implies, they are the radioactive atoms produced from the fission of ^{235}U, and comprise principally ^{131}I, ^{90}Sr, ^{137}Cs, ^{85}Kr, and ^{133}Xe. A 2,040 MWe reactor will produce a total of a few kilograms of such products per day. Since the short-lived fission products decay as others are formed, the amount of radioactivity rapidly levels off and the inventory of short-lived fission products reaches essentially a steady state value. Most of these fission products are retained within the zircalloy sheaths around the fuel bundles. Some ruptures do occur (less than 0.3% of individual bundles in a mature station) and a small amount of radioactive matter escapes into the coolant and spent fuel bay water. From there it either escapes into the environment or is recovered and stored. With the exception of the rather large inventory of tritium-enriched water (the level of radioactivity is about 1 Curie per kilogram in the primary heat transport system at equilibrium), heavy water reactors are otherwise similar to light water reactors with respect to their potential and actual release of radioactive materials to the environ- during normal operation.

Neutron activation products occur as a result of reactor materials and the coolant passing through the reactor being irradiated by neutrons released from the fission process, and include tritium (^{3}H), and carbon 14. Tritium is the major activation product of the CANDU system arising from the capture of a neutron by deuterium of the coolant. Similarly carbon-14 may be produced by the activation of ^{14}N and be released to the environment.

Since most metals become slightly corroded when they are immersed in water, there are traces of metal in the water in the cooling system. The metal in the water is activated when it pases through the reactor core. These activated corrosion products include cobalt-60 and chromium 51.

During the operation of nuclear power plants, there are two patterns of entry of radioactive materials into the environment: routine discharges of radioactive wastes (a few curies per day, resulting in a few microcuries/cc. in air or water in the immediate vicinity of the discharge point), and possible accidental release of radioactive material. The rates at which fission products escape from the fuel depend directly on the rate of fuel rod or bundle failure. In CANDU type reactors, fuel can be changed without shutdown, thus allowing defective elements to be removed. In this way, fission products reaching the coolant can be kept to a minimum.

Air contamination from nuclear plants is predominantly from radioactive noble gases as well as from ^{131}I and ^{3}H (tritium).

Levels of radioactivity in gaseous discharges for two Ontario generating stations are given in Table 1. The higher number for noble gases at the Douglas Point reactor is due to the production of ^{41}Ar by neutron activation of ^{40}Ar in the air constituting the annulus gas. The short half-life of ^{41}Ar (1.83 h.) renders both the resulting population doses and potential environmental impact negligible.

TABLE 1

GASEOUS DISCHARGES FROM TWO ONTARIO GENERATING STATIONS, 1974 (6)

Station	Curies per year			
	Particulates	^{131}I	Noble Gases	^{3}H
Pickering	0.034	0.004	4,380	24,820
Douglas Point	0.0047	0.047	21,170	5,110

Small amounts of low level radioactive wastes are discharged to the cooling water and reach the external environment. These will consist of both fission products and activation products. Delays before release allow time for substantial amounts of the short-lived radionuclides to decay before being released into the environment. In general, radionuclides having half-lives of less than 10 days are reduced to insignificant levels before they are released. The amounts of these contaminants in aqueous discharges from two Ontario generating stations are given in Table 2.

TABLE 2

AQUEOUS DISCHARGES FROM TWO ONTARIO GENERATION STATIONS, 1974 (6)

Station	Curies per year	
	Gross β*	^3H
Pickering	2.63	14,600
Douglas Point	1.24	3,430

*Individual radionuclides not identified quantitatively

The levels of tritium discharged from CANDU systems are much higher than from comparable U.S. reactor systems and are of importance since they will continually increase the radioactivity of the receiving waters used as public drinking water supplies.

The average radiological doses for an individual, derived from such sources are, nevertheless, very low in comparison with those received from natural background sources (Table 3).

TABLE 3

SUMMARY OF ANNUAL WHOLE-BODY DOSES PER CAPITA, EXCLUDING MEDICAL IRRADIATION, IN THE UNITED STATES (DATA FROM REFERENCE (7))

	Radiation Source	Dose (mrem/year)
MAN-MADE		
Occupational		0.8
Environmental	Globally dispersed radionuclides	4.05
	Nuclear Research Establishments	0.01
	Nuclear Power Reactors	0.002
	Fuel processing	0.0008
Miscellaneous		2.6
	TOTAL	7.5
NATURAL		
	Cosmic rays Terrestrial radiation, etc.	TOTAL 130

With regard to the possibilities of a major accident at a reactor site, the Department believes that there is a need for openly available information about accident probability in the CANDU type reactor, as well as the consequences resulting from various kinds of accidents. The consequences need to be evaluated primarily in terms of risks posed to man and the environment from the release of large quantities of various kinds and concentrations of radioactive materials.

5.4.6 Radiological Concerns

Although the effect of ionizing radiation on biological systems has been studied intensively for many decades, most information on the dose-risk relationship has been forthcoming from human subjects exposed to relatively high levels of radiation (e.g., survivors of atomic bombs at Hiroshima and Nagasaki and persons exposed to radiation in the course of their work). Delayed somatic effects include leukemia and other malignancies. Genetic effects of radiation, which range from inconspicuous to lethal, may not be revealed until many generations have passed. Little information is available concerning somatic and hereditary damage from continuous doses of radiation not much higher than background. It is unclear at present whether there is a safe threshold dose for somatic effect (i.e., a level below which no effects can be observed). However, man has always lived with radiation, and the body has the capacity to repair some radiation-induced damage.

In view of the relative uncertainty of the dose-risk relationship, a conservative view has been taken in arriving at radiation protection standards. In Canada, radiation exposure of humans is regulated by the Atomic Energy Control Board (AECB); the regulations are based on standards defined by the International Committee on Radiological Protection (ICRP). The assumption is made that a linear relationship, without threshold dose, should exist between the radiation dose and the delayed effect resulting from exposure.

These standards are concerned directly with the protection of human health. It is not automatic that specified "safe" or "acceptable" levels will protect other life-forms. Because of the bio-concentration of certain elements by some organisms, if these elements are radioactive, the organism will be subjected to unusually high radiation doses. Although reduced hatching and early mortality of larvae of a large number of marine and freshwater species have been observed below concentrations of 10^{-10} Ci/litre ^{90}Sr (8) (the IRCP maximum permissible concentration of ^{90}Sr in public drinking water is 3×10^{-10} Ci/litre), these results have not been reproduced by other radioecologists (9). The present concensus is that effects only become apparent at levels of about 10^4 higher than the quoted value. In addition, although criteria for "safe" levels of radioactivity have been arrived at by consideration of man alone, homo sapiens has been considered to be the species most sensitive to radiation. Note should be taken of the high value placed on protecting the individual in the case of protection of humans, whereas protection of other forms of life concentrates on the effect on species population or behaviour.

Monitoring measurements reported to the International Joint Commission (6), indicate that, in the waters of the Great Lakes, man-made radionuclides are predominantly those resulting from nuclear-weapons testing debris. Increased levels of radioactivity have been measured around nuclear facilities on the shores of the Great Lakes and can be related to the radionuclides discharged into the lakes by those facilities. The effects of these increased levels of radioactivity on organisms present in these locations is unknown, in part because it is difficult to predict the long-term overall ecosystem changes which may result.

With increased demands for nuclear energy, it can be predicted that, if technology similar to that being used today is continued, the radioactive effluents produced will increase proportionately. This is true not only for Ontario, but for the rest of Canada and for other nuclear nations. As a result of our proximity to the United States, and because of the occurrence of dense populations and nuclear installations in the Great Lakes basin, the effects of nuclear activities in the U.S.A. may be felt in Canada, and vice versa. This is especially true for southern Ontario which is primarily dependent upon water from the Great Lakes. Radioactive pollution cannot, therefore, be considered purely within the confines of political boundaries. If there is linearity between dose and effects of radiation, increased radioactive pollution will increase biological effects. Because of the slow ecosystem changes which may occur as a result of continual low-level exposure, and because of our inability to detect rapidly or predict any changes, these changes may become severe enough to be irreversible. Experience with other environmental contaminants (e.g., PCB's in waters of the Great Lakes) has demonstrated our lack of knowledge concerning environmental pathways and the fates and persistence of some materials in the environment. The technology is also lacking to remove such materials once they have become of widespread occurrence in the environment. The same appears to be true for some radioactive materials.

Radioactive materials of particular concern occurring in routine emissions are iodine (^{131}I), ^{85}Kr, tritium (^{3}H) and ^{137}Cs. The short half-life of ^{131}I (about 8 days), and its removal from effluents by specially designed filters and scrubbers, implies that it is technologically possible to reduce emissions of iodine to the environment to almost zero. The behaviour of iodine as a thyroid-seeker, and its rapid pathway to man (air → grass → cow → milk → man) are reasons for concern. Krypton-85, with a half-life of 10 years, is of concern because of its global dispersion, and therefore the world population is at risk.

For each reactor, the tritium produced (with a half-life of 12 years) increases with the age of the reactor. This, together with the increasing number of reactors, is likely to result in an almost exponential increase in the concentration of tritium in the receiving waters. Calculations for Lake Ontario (10) perdict that if present trends continue the dose for a person drinking the water will be 0.3 millirem from ^{3}H by the year 2000. The IJC objective is 1 millirem for all radionuclides. Tritium behaves similarly to hydrogen, and, usually as tritiated water, can enter into all biological processes involving water.

Caesium-137 is, next to ^{3}H, the major radionuclide released in aqueous discharge from nuclear power stations and is subject to both entrapment in sediments and bioaccumulation by fish. This, in time, will increase the radiological dose to man from the aquatic environment.

5.4.7 Effects of Waste Heat Discharge

The potential biotic effects of discharging vast amounts of heated water into the Great Lakes environment are very dependent, as could be expected, on the site and form of the discharge. Discharge may be through a pipe emptying directly into the lake (as at Douglas Point) or more often through a man-made canal. Effluents may be "tempered" or mixed with water taken from the lake before being returned to the environment. In all cases the water is discharged at the surface at or near the shoreline. Both types of discharges have, conceptually speaking, advantages and disadvantages in terms of reducing potential biotic damage. Tempering discharge water permits water temperatures to be lowered before being returned into the environment, although organisms are entrained for longer periods of time than if they were returned directly into the lake environment.

The permissible temperature limits of heated water have been much debated. Two major criteria are of concern: a) the maximum allowable heat rise (ΔT) of the lake water across the condenser tubes; and b) the maximum allowable temperature of the discharge water. Many laboratory studies have shown that water temperature above about $30^{o}C$ causes irreversible damaging effects to the kinds of organisms found occurring naturally in Ontario latitudes. Therefore, criteria should be set to prevent these upper lethal temperature levels from being reached. Local conditions depending on the location of the plant may necessitate maximum temperatures, or ΔT's, to be even less if particularly temperature sensitive biota are found in the area. The problem of inter-species modification, including parasitism and disease, at lower ΔT's also needs consideration and research in Canadian situations.

An element of concern is the destruction of large numbers of larval fish which apparently suffer very high mortalities from the combined effect of pressure and temperature shock and mechanical abrasion in both the pumps and condensers. The exact value of such loss is difficult to calculate since it would take many years for these life forms to obtain a size where they would become commercially important. The position and form of the water intake is critical in controlling this loss.

The lack of long-term biological studies at power stations and the complexities of Great Lakes ecosystems do not realistically permit modelling of nearshore biological communities. Thus, it is difficult to say what would be the long-term consequence of small, seemingly insignificant, annual perturbations. Since all trophic levels are related, a change in the lower levels might ultimately affect future fish populations. Similarly, it is difficult to state categorically that trout and salmon spawning migrations will not be negatively influenced or disrupted by thermal discharges. The possibility that this might happen cannot be overlooked.

Chlorine is used in some plants as a condenser defouling agent and, in these situations, regularly enters the environment. Chlorine can be toxic to fish and other aquatic organisms but, at present, it appears unclear as to whether chlorine levels from this source pose an environmental problem.

Recently there has been a great deal of debate concerning the potential beneficial uses of heated thermal discharges. The more commonly suggested uses include district heating, aquaculture (fish), agriculture (by either warming the fields or by controlling a greenhouse environment), and for recreation. There are many small scale feasibility studies being carried out on each of these applications in North America, but progress has been slow. Clearly, there is no one application which will be suitable at all plants. Evaluationsof a particular use have understandably been tied to economic returns for the increased capital costs of modifying the effluents for diversion, the problem of the effect of plant shut-down or interruption of discharge, etc.

In Ontario, where water and lakes are abundant, we are not limited to using Great Lakes water for condenser cooling purposes. A plant could be set up in a closed lake system where even serious changes in the water quality resulting from the discharging process would have limited external consequences. Even so, it does not appear necessary or desirable to consider that natural lakes should be "written off" for cooling purposes; such lakes may have great potential for recreational purposes or for aquaculture.

5.5.8 Nuclear Wastes

During the normal operations of nuclear reactors, a number of waste products occur. In the fuel elements, fission products accumulate with time until the fission process is interfered with. Fuel elements are, therefore, removed from the reactor well before all usable fuel has been burned. These elements contain plutonium-239 (which could serve as a valuable fuel source) and a large number of fission products. In Canada, at present, plutonium is not recovered. ^{239}Pu is toxic and radioactive; it is an emitter of alpha particles, and if it is absorbed by an organism, the potential for damage to internal tissues (particularly the lungs) is high. It has a half-life of 24,000 years; therefore very long periods of time are required for it to decay to a level where it no longer constitutes a biological hazard. Other biologically hazardous radioactive materials are caesium-137 and strontium-90, with half-lifes of 30.2 and 28.9 years respectively; these similarly require a long time to decay to a point where isolation is no longer required.

In addition to its radioactive nature, the spent fuel generates a considerable amount of heat. When a Pickering bundle arrives at the on-site spent-fuel bay (about 24 hours after leaving the reactor), it is generating about 6KW heat. After 1 year, 85 watts are still being generated.

Currently, fuel is stored in water-filled receiving bays at the reactor site and examined for defective or leaky bundles (about 0.3% of total bundles). Defective bundles are canned to restore the primary barrier to radioactivity escape. Intact and recanned fuel is then sent to the reactor storage bay where it will remain for several years or until the heat has reached a level low enough for convenient transportation (minimum 6 months). During this initial period, the water acts as both a coolant and as a radioactivity shield.

At present, all high-level wastes are being stored in this manner until suitable longer-term storage measures are decided upon and facilities established. Several options appear possible for the future which include permanent geologic disposal and long-term storage and retrieval.

The philosophy in Canada on which all waste management practices are presently based is that of storage and retrieval. In practice, this means that radioactive wastes will be stored in a facility for an extended period of time, and when the facility reaches the end of its useful life, the wastes will be removed and placed in a new, similar or improved, facility. This will be repeated until the activity of wastes has decayed to a negligible level. High-level wastes may be vitrified or otherwise solidified to decrease their changes of mobilization during storage.

Consideration must be given to adequate containment of material during storage, protection from contact with groundwater and complete retrievability of stored materials. Provision must also be made for monitoring the storage environment to detect any radioactive release from the fuel. Practical aspects, such as low annual operating costs and simplicity of the system using a minimum of equipment which could fail, should also be considered.

It is probable that the future disposal process will occur in three stages:

i) Spent fuel stored under water for at least 5 years at reactor sites to allow heat evolution to decay to a level that would be acceptable for other forms of storage.

ii) Transfer to air-cooled dry storage facilities. A 50-year life for these facilities is at present assumed, but this may be extended.

iii) Permanent disposal in underground geological structures, such as plutons and salt beds.

Considerable concern is felt at all stages of this process, not only as regards the safety of personnel handling wastes, but also as regards environmental protection. The high levels of radioactivity in the wastes, coupled with the long period of storage, increase the need for care to prevent leakages, etc. and access to ground and runoff water. Such risks can only grow with the increasing amounts of radioactive wastes which it is anticipated will be produced. At present, reactor wastes are being produced at a rate which will take a few years to fill available storage sites. Currently, there is no acceptable technology for alternate disposal in other than water-filled bays at reactor sites. Storage for several decades could, however, be physically accommodated within the reactor site properties.

The answers to the questions of long-term storage or disposal of high-level waste are dependent upon decisions to be reached regarding fuel reprocessing and the manner in which recovered material will be used. The present interim waste management system appears to be environmentally acceptable for the short term, but growing problems lie ahead. It may be unwise to proceed enthusiastically with an energy program without knowing ultimately how future society can be protected from the results of our present actions under that program. Indeed, the U.K. Royal Commission on Environmental Pollution reporting on Nuclear Power and the Environment[11] (the Flowers Report) recommends that ...

> "There should be no commitment to a large programme of nuclear fission power until it has been demonstrated beyond reasonable doubt that a method exists to ensure the safe containment of long-lived highly radioactive waste for the indefinite future"
> Ch. XI, p. 202

5.4.9 Decommissioning of Nuclear Installations

If a 25 to 35-year life of nuclear power plants is assumed, by about 1990 a number of plants will need to be decommissioned. Thereafter, the number to be dismantled or re-built will rise rapidly. Although not as large as conventionally fuelled power plants, nuclear plants will be more costly and difficult to decommission because of the radioactive substances remaining in the structure of the reactor and the primary circuit. Present technology is available for the decommissioning of reactors; successful operations of this type have been undertaken for the SL-1 and Elk River reactors in the U.S., and the Lucens reactor in Switzerland. Partial decommissioning has already taken place in Canada (the calandrias of the NRU and NRX reactors at Chalk River have been successfully replaced). Problems of dismantling will be more difficult if there has been an accident in the reactor. If a major accident has occured, it may be necessary to abandon the reactor in place, possibly embedding the entire structure in concrete to avoid spread of radioactive materials and to restrict access to the area. Environmental protection during and following decommissioning appears to be a matter of cost and careful management, but it may be a substantial part of the cost and must be specifically provided for.

5.4.10 Future Developments

Breeder Reactors

As uranium sources are depleted, reactors, such as breeder reactors, whose power costs can be insensitive to uranium prices, become increasingly attractive. By a process of neutron absorption, breeder reactors transform fertile materials such as ^{238}U into fissionable materials such as ^{239}PU, or thorium into ^{233}U, thus creating more fuel than they consume.

The waste problems associated with this type of reactor relate to the use of sodium as a coolant, and with plutonium. A major isotope of concern is ^{85}Kr (half-life approximately 10 years) since its disposal presents a problem; it can either be stored in bottles for long periods of time or its release can be spread over a long period of time. In the latter case, this will add to the accumulated ^{85}Kr in the earth's atmosphere. Liquid and solid wastes can be treated in a manner similar to those produced in more conventional reactors. Additonal environmental effects may be felt during the necessary fuel enrichment processes required for this type of system. ^{239}Pu is exceptionally hazardous and, with increased production and shipment, its accidental introduction into the environment becomes increasingly possible.

The concerns associated with the use of plutonium as a fuel in breeder reactors relate not only to the highly carcinogenic properties of plutonium but also to its potential for use in the manufacture of nuclear weapons. This potential introduces problems of security and safety factors of a greater degree than presently provided for. It is indeed questionable whether breeder technology should be introduced without thorough evaluation of alternate sources of power, and public and policy consideration of all the issues involved. The decisions cannot be taken on the grounds of energy needs and environmental protection alone. In its recommendations, the Flowers Report (11) states that:

> "The dangers of the creation of plutonium in large quantities in conditions of world unrest are genuine and serious. We (i.e. the U.K.) should not rely for energy supply on a process that produces such a hazardous substance as plutonium unless there is no reasonable alternative."
>
> Chapter XI, p. 204

Thorium Cycle Reactors

Another alternative is CANDU reactors on a self-sufficient thorium fuel cycle. These could operate with zero uranium feed and a very small feed of thorium. Seventy tons of thorium per year could suffice for Canada's present total electrical generating capacity of 55,000 MWe. Thorium is more abundant than uranium and occurs with it in some Canadian deposits. Mining of thorium would have no greater environmental impact than current uranium mining. In fact, because of the requie-ment for smaller quantities, and the possibility of reprocessing tailings from uranium mines, the environmental impact may be considerably lessened.

Nuclear Fusion

Fusion reactions harness the relatively large amounts of energy released when two nuclei of light elements are joined together to form the nucleus of a heavier element (12). The most favourable potentially practical fusion reaction involves the fusion of deuterium and tritium to form helium and a high energy electron. While nuclear fusion is physically possible, technology problems are involved with attaining sufficiently high temperatures (temperatures in excess of 50,000,000^{o}C are necessary to overcome the repulsive forces between the charged nuclei of deuterium and tritium), confining the reactants, and providing wall materials capable of withstanding high-energy bombardment. Both deuterium and lithium, the presently most practical tritium source material, seem to be sufficiently abundant to satisfy possible world fuel requirements for many centuries if a fusion process is used. While it is difficult to predict the environmental impacts of fusion systems, release of tritium in large quantities from fusion reactors is a possibility.

Magnetic confinement fusion technologies at present envisage a heavy use of niobium as a structural material; this would lead to environmental problems of waste disposal similar in some respects to those of wastes from fission reactors. Also, fusion reactors present the possibility for adding quantitatively to the total heat of the planet, for unlike solar-based power systems like fission reactors and fossil fuel systems which re-distribute or re-concentrate energy already within planet or being received from the sun, the fusion process adds new energy to the global environment.

5.4.11 Fuel Reprocessing

Fuel reprocessing involves dissolving the fuel in acid followed by ion exchange to remove fission products and to separate uranium and plutonium. Solid wastes, including metallic discards (leached sections of fuel sheath), are usually stored in concrete silos on site. These are designed to allow ultimate removal and final disposal after a very long decay period. Tritium appears as tritiated water, most of which is discharged to the environment. The bulk of the fission products are contained in aqueous solutions of nitrate salts of various metals after reprocessing. There are at present no commercial fuel reprocessing facilities in operation in North America. The United States plant at West Valley, N.Y. was shut down several years ago due, in part, to technical problems. One concern during its operation was the release of all of the ^{85}Kr in the spent fuel through the stacks. The fact that ^{85}Kr is dispersed globally and past operating experience of reprocessing facilities indicate that a commitment to reprocess spent fuel will increase the world-wide inventory of ^{85}Kr and the corresponding population dose from it, unless a technology is developed to prevent release krypton.

5.4.12 Review of Environmental Concerns Related to Nuclear Power Production

1. The behaviour of radioactive materials in the environment is insufficiently understood. Knowledge is inadequate regarding their dispersion in air and water, their absorption onto sediments or other particulate materials, their pathways through the environment and potential accumulation in plants, animals and geological formations. Of particular concern in Southern Ontario, with both operational and planned nuclear installations on the Canadian and United States sides of the Great Lakes, is the dispersion and accumulation of radioactive materials in the waters and sediments of the Great Lakes. The

dependence of large populations on these waters for drinking, bathing, recreational, and industrial uses makes specific knowledge of the whereabouts, concentration and behaviour of radioactive matter of high importance.

2. Criteria used for determining acceptable levels of radioactivity in effluents, allowable doses, times of exposure, etc. are currently based on human health considerations. While the direct sensitivity of human populations is understandably of prime importance, environmental considerations (such as the dispersion of radionuclides, their bioaccumulation and pathways), are important when developing standards.

3. The irreversibility of slow and continuing effects of exposure to low levels of radioactivity is of major concern. Monitoring of environmental components may be able to show changes which occur over long periods of time; however, relating these changes to ecosystem changes and their impacts is difficult. Even if such changes are detected, the long-lived nature of some radionuclides of widespread occurrence or accumulated in certain components of the ecosystem make remedial or removal measures impossible. This problem has already been experienced in the Great Lakes with such materials as PCB's, Mirex, etc. and elsewhere with mercury.

4. In considering the potential development of nuclear energy in Canada, it is necessary to determine carefully all the costs or risks and the benefits, and to whom and when these are accruing. Some benefits are immediately apparent: in the short-term, readily available energy and, with the development of other nuclear reactions (e.g. thorium cycle and fusion), this may extend into the mid- to long-term. Coupled with this will be the continued industrial expansion dependent upon such energy sources; a possibility for extended affluence; increased job opportunities for those with nuclear expertise, etc. Some costs are also apparent: increased exposure to radioactive materials; increased land-loss resulting from the development of exclusion zones around

nuclear power stations, fuel processing plants, waste product storage sites, etc. A complete cost-benefit analysis must, however, include a large number of comparisons; nuclear energy development in its entirety must be compared with alternate systems also in their entirety. To make such a comparison is a formidable task. A large number of components in such an analysis cannot be given a "dollar" value, e.g., deaths occurring per kilowatt produced in a coal-fired reactor (including deaths of miners, loss of life as a result of respiratory diseases caused by sulphur emissions, etc.) are difficult to determine, but must be considered, together with deaths occurring in the mining, extraction and use of nuclear fuel. For nuclear power, as with other power systems, there are a large number of "unknown costs". Present benefits must be related to future costs in a defensible way. In such schemes, efficiencies must also be carefully considered both qualitatively as well as quantitatively. The Department of Fisheries and the Environment believes, however, that for the sake of future prosperity and health, Ontarians must undertake such comparisons.

5. Although much research work has been done on long-term disposal of long-lived, high-level radioactive waste, there has been no acceptance of an implementable program. In effect, many questions and concerns remain unanswered. Some await decisions to be reached on the use of plutonium as a fuel. The nuclear industry has always taken a "cautious" attitude with respect to radiation risks and it is urged to adopt similar caution in its energy strategy, until the disposal question can be completely and thoroughly answered.

6. The expected development in other countries of plutonium breeder reactors is an area of concern due to the hazardous properties of plutonium and its association with nuclear weaponry. Clearly, other energy options should be seriously considered before any commitment by Ontario to plutonium breeders is made. These options, including thorium cycle reactors and develop-

ment of so-called "renewable" energy resources, should be thoroughly examined with regard to their overall environmental impact before comparisons with existing systems are made.

5.4.13 References

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(2) Second Report of the Radioactivity Work Group to the Great Lakes Water Quality Board of the International Joint Commission, 1975. 37 pp.

(3) Status Report, Water Pollution in the Serpent River Basin, 1976. Ontario Ministry of the Environment. A.C. Roy and W. Keller.

(4) Guidelines and Criteria for Water Quality Management in Ontario. Ontario Ministry of the Environment, (1972).

(5) Effer, W.R., "Some Environmental Effects of Emissions from CANDU Nuclear Generating Stations and Heavy Water Plants". In: Canadian Nuclear Association Sixteenth Annual International Conference, Toronto, Canada, 1976, pp. 1-13.

(6) Great Lakes Water Quality, Fourth Annual Report, Appendix D: Annual Report of the Radioactivity Subcommittee to the Implementation Committee, Great Lakes Water Quality Board, 1975. 48 pp.

(7) Nuclear Power and the Environment, International Atomic Energy Agency, Vienna, 1973. 85 pp.

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(11) Royal Commission on Environmental Pollution. Chairman: Sir Brian Flowers. 6th Report, Nuclear Power and the Environment, London. Her Majesty's Stationery Office, September, 1976.

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5.5 TRANSMISSION AND DISTRIBUTION OF POWER

5.5 TRANSMISSION AND DISTRIBUTION OF POWER

5.5.1 Construction and Maintenance

Electric power transmission and distribution systems have environmental impacts of both a local and broader nature. Construction activities such as removing vegetation, and building access roads and line carrying structures, including the use of heavy construction equipment, can be locally disruptive to the natural environment. Forest, wetland, and other wildlife habitats and ecosystem components can be irreversibly damaged in the process of construction. Water quality can be adversely affected during and after construction by increased soil runoff. The removal of shoreline and river basin vegetation can adversely affect water quality also by increasing maximum flows and decreasing minimum flows, and increasing water temperatures through shade removal. In most cases these effects are minor or local, and through effective restoration and proper environmental management, many of them can be avoided. Procedures for right-of-way maintenance include the use of herbicides for controlling vegetation growth. Use of chemical controls run the risk of increasing the levels of manmade chemicals being absorbed by the natural environment, with sometimes unforeseen and longer-term effects.

In wilderness areas, access and maintenance roads associated with the transmission line right-of-way afford means of travel and entry for hunters, tourists, etc., with consequent effects on the environment; but they also may be used by wildlife or humans in a beneficial manner.

5.5.2 Aesthetics

The presence of overhead transmission and distribution systems can be a factor in reducing the visual aesthetics of the human environment. Overhead wires, poles, and towers in urban, rural, and wilderness settings are aesthetically displeasing to many people. To an increasing degree, the public is willing to incur additional economic cost to reduce aesthetic "damage". The use of underground transmission is one solution to the problem of aesthetics. Ontario Hydro's study into the "DAMUT" (Ducted Air Medium Underground Transmission) System appears to indicate this system could in many situations be economically feasible relative to overhead transmission (1). Although underground transmission eliminates the "visual pollution" of overhead transmission, many of the environmental problems arising from the construction and maintenance phases noted above would still exist.

5.5.3 Operational Impacts

5.5.3.1 Ozone

The operational aspect of transmission line systems may also affect the environment. High voltage transmission lines can produce ozone. However, studies have shown there is apparently no significant addition to the amount of ozone present in the atmosphere at ground level under any weather conditions (2).

5.5.3.2 Electromagnetic Radiation

The biological effects of electromagnetic radiation appear to be still a matter of controversy. Ontario Hydro has concluded that "there are no significant deleterious effects on human health from high voltage alternating current electric fields" (3). A recent article which discusses electromagnetic radiation in its broader context notes that the increase in high voltage power lines, microwave towers, radar installations, and microwave ovens is raising concern about the effects of this form of radiation on human health (4). The article quotes from a report submitted to the U.S. Congress in May 1974 by the Office of Telecommunications Policy (OTP) that the proliferation of sources of this form of radiation may bring "an era of energy pollution of the environment comparable, in public health and ecological implication, to the chemical pollution of today". The OTP pointed out, however, that much of the data was obtained from "single experiments in a particular laboratory involving small numbers of subjects" and that more tests are needed, particularly to determine the effects of long-term exposure to low levels of radiation. In the same article, Soviet research is reported to show that chronic exposure to low level athermal microwave energy can produce a number of biological and psychological changes in human beings. This has prompted the Soviet Union to set permissible exposure levels at 1,000 times lower than those in the U.S. for long-term exposures and ten times lower for exposures of less than six minutes.

Given the Ontario context of a planned growth rate in electric power production and transmission equivalent to a more than threefold increase over the next 20 years alone, the eventual possibility of transmission line developments of voltages higher than 500 KV, the existence of Ontario Hydro's extensive microwave communications system (5), and the increasing use of electrical power for radiation emitting products such as microwave ovens, biological effects of electromagnetic radiation may become significant in Ontario. These effects could arise from both transmission and end use of electric power, and include environmental as well as human health factors of a longer-term nature arising from low level exposure.

5.5.4 Chemical Pollutants

5.5.4.1 SF6 Gas

In addition to possible radiation effects, the power transmission and distribution system may also be a factor in contributing to the increase in chemical levels in the environment. The transformer station insulant, SF6 gas, which is used by Ontario Hydro due to its outstanding properties as a dielectric, does not appear to cause any direct effects on human health (6). However, it has been stated that there are now between 200 and 400 thousand tons of SF6 in the atmosphere and the amount is increasing rapidly (7). The biological implications of increasing cumulations of this chemically inert gas in the upper atmosphere are not established. Escape of the gas could take place at any point in the gas production, gas transportation, transformer assembly, transformer operation, and disposal of equipment stage.

5.5.4.2 Polychlorinated Biphenyls (PCBs)

Another substance utilized in the transmission and distribution system which is of relevance to the environment is the family of chemical compounds called polychlorinated biphenyls (PCBs). Recent discoveries of the very persistent nature and widespread presence throughout the Canadian environment of the more highly chlorinated members of this family have been a cause for much concern within the Department. PCBs are a ubiquitous contaminant of water and aquatic sediments, air and land. They have been discovered in remote Arctic areas far from disposal sites. These toxic materials are biomagnified in food chains and have been found in tissues of fish, wildlife, and human beings. PCBs have been shown to adversely affect the health and inhibit reproduction in most fauna and human beings.

A recent joint study by the Department of Health and Welfare (Federal) and the Department of Fisheries and Environment, which also included representation by several Ontario ministries (8), concluded that the Great Lakes and associated regions are the areas most contaminated with PCBs so far identified in Canada. Despite recent restrictions on the use of these compounds (for over three years, the major importer to

Canada, Monsanto Canada, has supplied PCBs only to electrical equipment manufacturers), contamination of the Great Lakes by PCBs continues to be extensive and excessive (9). Due to the extensive marketing of PCBs for a wide variety of applications in the past, and to their highly persistent nature, the sources and pathways of PCBs into the environment are difficult to delineate with any great precision for control or prevention purposes. Entry routes include waste water treatment plant effluents, landfill leachate, sewage sludge disposal on agricultural land, and emissions from incinerator stacks. Potential sources would include all present and past users of these compounds. In the case of the electric power system, potential sources include the manufacture, use, maintenance, and disposal of transformers and capacitors. The phase out at the earliest possible date of all persistent PCBs is the only feasible way to prevent further build up of this substance in the environment. For this reason, PCBs will be given priority as one of the first toxic substances to be subject to regulation under the recently proclaimed Environmental Contaminants Act for Canada.

5.5.5 References to Section 5.5

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(2) Ontario Hydro, "Transmission-Environmental", Submission to the RCEPP, March 1976, pp. 3.3-46.

(3) Ibid., pp. 3.3-54.

(4) Editorial Staff, "Electromagnetic Radiation: An Increasing Hazard", The Futurist, Vol. 1X, No. 6, pp. 340-41, December 1975.

(5) Ontario Hydro, "Transmission Planning Processes", Submission to the RCEPP, June 1976, pp. 12.0-42.

(6) Ontario Hydro, "Transmission-Environmental", Submission to the RCEPP, March 1976, pp. 3.3-56 to 59.

(7) Hare, Dr. Kenneth, Comments made at the RCEPP Public Information Hearing, April 21, 1976 (p. 91, Summary Transcript of Hearing).

(8) Task Force on PCB, "Background to the Regulation of Polychlorinated Biphenyls (PCB) in Canada", Report to the Environmental Contaminants Committee of Environment Canada and Health and Welfare Canada, Ottawa, April 1, 1976.

(9) Great Lakes Water Quality Board, "Great Lakes Water Quality 1974 Annual Report", July 1975, Appendix A, pp. 47-54.

5.6 ENERGY AND CLIMATIC CHANGE

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5.6 ENERGY AND CLIMATIC CHANGE

5.6.1 Predictability of Climatic Change

During the first half of the Twentieth Century a pronounced climatic warming was reported from many parts of the globe and especially from the Atlantic sector of the Arctic. The warming was irregular. Over the past 20 years this trend in the Northern Hemisphere has become uncertain. Further, climatic conditions have become more variable in recent years than in the preceding decades, illustrating another significant characteristic of climate in northern latitude countries such as Canada. Departmental scientists have actively contributed to research and to the formulation of an international position on the subject of climatic change (1).

Practically no capability exists as yet to predict climatic change. The atmospheric environment system is exceedingly complex, and our understanding of the causes of fluctuations and major changes still incomplete. Possible theories include those based on a varying radiant energy output from the sun, the varying geometry of the solar system, and volcanic action. Besides these "natural" causes, many human activities which increase the amounts of dust particles and carbon dioxide in the atmosphere must have some effect on climatic change. Certainly no one mechanism can be considered in isolation from other influences, to be responsible for changes in climate.

5.6.2 Impact of Climatic Change on Human Activity in General

Climate has an overriding influence on many dimensions of human life and activity. It affects regional water balance and land use, food production, design and construction of housing and transportation networks, energy requirements, and many other facets of the human habitat and environment. Climatic variations have become of major world importance because of man's increasing demand for food and other limited resources, and because of society's increasing dependence on advanced technology, which has increased, rather than reduced, our sensitivity to climate. An example of this increased vulnerability is the serious shortage of food supplies and the increased inflationary pressures that resulted from the unusual climate of 1972. With progressively increasing demands on resources and the reduction of per capita food reserves, society and the economy will in the future be even more sensitive to climatic change (2).

Because of Canada's position as a food producing nation, and our relatively high per capita energy consumption compared to most other countries, Canadian activities are affected not only by specific changes in the climate of Canada, and broader worldwide changes, but by regional changes in the climate of other parts of the world, including the less developed countries. The energy needs of Ontario can be expected to be, to some degree, responsive to variations of climate in overseas countries to which Canada sends food or other products.

5.6.3 Impact of Climatic Change on Energy Production and Availability

It cannot be assumed that the climate of the future will be the same as it is today. It is reasonable to expect that within a human generation, or within the useful lifetime of man-made works, the climate will be sufficiently different to affect human activities and the productivity of Canada. Because of the difficulty in predicting with any degree of certainty how much, when, and in what manner the climate will be different than today, the mounting socio-economic significance of changes which could reasonably be expected make it essential that a range of potential climate variations be considered in planning long-term energy programs. Until the ability to forecast climatic change improves, a rational approach to planning for the effects of future variations must be based on scenarios from our present state of knowledge and on statistics for past climate histories.

Three alternative scenarios that should be considered are: (i) a cooler climate in all or large parts of Canada; (ii) a warmer climate than today; (iii) greater year-to-year or decade-to-decade variation in climate (3). For each of these scenarios, there are of course, a range of alternatives concerning climate characteristics throughout the year or from place to place that would have consequences for planning energy supply and use.

A sustained cooling trend in Canada could have significant effects on our use of energy. From simple degree-day ratios it may be estimated that a 2°C drop in mean temperature over the heating season would increase fuel consumption for heating in Toronto by 14%. Lower average temperatures or colder winters in southern Canada could alter and possibly reduce hydropower potential through reduced precipitation, delayed spring runoff and greater seasonal water flow fluctuation. Increased ice could increase engineering difficulties and operational costs. It would also reduce the season available for, or greatly increase the cost of, the shipping of oil or coal. However, a colder climate would mean a longer winter season that could aid seasonal operations in the north related to exploration and pipeline construction, and thus result in some, probably minor, reduction in energy development costs.

A period in which the climate is warmer than at present would reduce fuel consumption for heating. If the warmth persisted through the summers, this saving would be partially offset by increased use of air conditioning and refrigeration. Drought frequency would likely increase in semi-arid regions of Canada, with possible adverse consequences for agriculture and hydro power potential, but in other parts of Canada it is possible that precipitation would be somewhat increased. The ice-free shipping season would lengthen, changing the pattern of economic activity in ports, and highway and railway maintenance costs would be changed. The exploration, drilling, and construction seasons in the Arctic would be reduced where ice cover or permafrost use was important, but if the warm trend continued, problems and energy costs in the present zone of discontinuous permafrost, including much of the Hudson Bay slope of Ontario, would be less.

A change to a markedly more variable climate, with extremes of hot or cold or of wet or dry seasons, from year to year, or from decade to decade, would increase the difficulty of planning for efficient energy use. Variable climates appear in the past to have been characterized by enhanced regional differences in climate, and often unstable weather patterns. To cope with increasing climatic variability, a modern industrial country must make greater investment to cope with climate-induced influences on its normal activities. The results of such investments will be manifested in both low water and flood control works, elaborate and often unused snow-clearing facilities, more costly urban patterns and developments such as covered shopping malls or underground parking, artificially nurtured urban forests and large storage reservoirs, etc. The erratic nature of the climate would result in large year to year changes and regional differences. Regional drought, heavy snow, floods, or killing frosts, would cause year-to-year variations in productivity, with consequent higher costs for insurance, mortgages, short-term import and export agreements, fluctuating food prices and forest fire losses. All of these factors lead to erratic and unpredicted demands on energy or, in other words, periodically unused energy supply capacity, and to greater construction and maintenance costs for facilities.

5.6.4 Impact of Energy Production on Climate

The relationship between energy and climate is two-way. Not only does climate affect energy production and consumption but, in turn, energy production can have a significant effect on climate. Evidence exists that continued energy growth to the year 2000 and beyond has the potential to cause climatic changes which will be both global and irreversible (4).

Perhaps the most important potential climatic consequence of continued increase in use of fossil fuels would be the progressive increase in the concentration of carbon dioxide, dust particles, and chemicals in the atmosphere. It has been estimated that if world consumption of fossil fuels continued to grow at 4 per cent per year until 1980, and at 3½ per cent per year from 1980 until 2000, the present global average concentration of 320 parts per million of CO_2 would increase to 370 ppm by 2000; and this would increase the downward long-wave radiation to the Earth's surface sufficient to cause an increase in average world temperature of $0.5^{o}C$ (5). An increase of mean global surface temperature of $0.5^{o}C$ would have a significant effect on biological productivity in semi-arid areas and possibly in higher-latitude oceans. The increased CO_2 would also result in increased primary production in moist vegetated areas. The CO_2-induced increase in temperature could be considerably greater regionally; but it is also possible that changes in water vapor and cloudiness could, depending on the distribution, negate or enhance the radiation warming effect, so that unequivocal predictions of the climatic result of CO_2 from fossil fuel consumption are not possible (6).

The particulate matter released to the atmosphere from fossil fuel combustion can also have an effect on the regional and global climate by changing the radiation field - scattering sunlight, reflecting it back into space, or absorbing it and heating the atmosphere and reradiating in different, usually longer, wavelengths - and also by affecting the processes of water and ice condensation in the atmosphere, thereby affecting cloudiness, precipitation, and thus the reflectivity and heat exchange processes of the planet as a whole. The net effect of airborne particulates on surface temperatures may be plus or minus. The direction and amount of the effect will depend on the size of the particles, their horizontal and vertical concentration distribution, and the reflective properties of the underlying land or ocean surface. However, at present it is not possible to state the net effect of particulate matter from fossil fuel combustion separate from other man-caused particulates (from agriculture and industry) and natural particles (from plant decomposition, sea salt, volcanic action, forest fires, rock movement, etc.). Reasonable estimates would suggest that at present the man-made contribution to the total load of particles smaller than 20 microns radius in the atmosphere is between 5 per cent and 45 per cent, and that if fossil fuels combustion continues to increase as forecast, by 2000 the man-made fraction will be 20 per cent to 50 per cent (5). From the point of view of climatic effects of particulates, the most important man-made effect is the provision of SO_2 gas which reacts with ammonia and hydrogen sulphide gases to form complex sulphate particles that can potentially have an important role in the planetary radiation balance and cloud formation. Studies are under way in several countries, including Canada, to learn more about these affects.

Although global climatic effects of thermal emissions do not appear at present to be of immediate critical concern, there can be substantial regional effects, particularly where heat releases are concentrated as, for example, from "energy centres". Waste heat dissipation does affect local weather and atmospheric conditions, and could initiate anomalous cloud conditions and contribute to the development of convective storms, such as thunderstorms, hailstorms, and tornadoes. On a more global scale, predicted future levels and patterns of nuclear and fossil fuel energy use may produce large-scale circulation changes. Such anomalies could have important consequences on agriculture and other human activities. In addition to the thermal effects on climate arising from chemical and thermal pollution, the energy system can also affect other environmental elements associated with weather and climate. Releases of CO_2 and other chemicals, such as sulfates, and nitrates, increase the acidity of precipitation, ocean and lake waters, and soils. In some areas the change has been such that animal and plant life, including agricultural products, have been seriously affected (7).

Oil slicks formed on the ocean and on large lakes change the evaporation temperature and other characteristics of the surface water layers, affecting the water-atmosphere energy exchange processes and leading in general to warmer maritime air masses, and possibly greater coastal storminess.

The use of fossil fuels, nuclear power, and fusion power all introduce heat or substances to the earth-atmosphere system. The magnitude of their effects, though presently small, is sufficient to perturb the climate on local and regional scales. Marked changes may occur if present energy trends continue. In contrast, the utilizing of natural energy flows such as solar, wind, and water power in general add much less heat, chemicals or particulates to the global environment, and their effect on weather and climate can be expected to be small or insignificant.

5.6.5 References to Section 5.6

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6. CONCLUSION

6. CONCLUSION

The Department of Fisheries and the Environment has expressed a number of its concerns relating to energy production and distribution in general and to the production and transmission of electric power in Ontario in particular. In many areas effective management of both energy and environmental resources can be achieved through improved analysis, planning, and development of the power system in its broadest context. In the longer term, there also exists the potential for both more substantial modification of existing production systems as well as the development and introduction of more environmentally appropriate energy sources.

This submission has naturally concentrated upon the environmental impacts of energy production and distribution. This does not imply that the Department is "against" plans for electrical power development in Ontario. Rather, the Department is simply emphasizing the importance and the value of the natural environment which may be overlooked in times of economic uncertainty and concern over continued supplies of energy. The Department recognizes that major energy decisions cannot be based solely upon one particular dimension to the exclusion of all others. In that regard, an attempt has been made to provide a broader basis for discussion by considering in Section 3 some social and economic dimensions which, it is felt, have relevance to the energy situation, particularly in the longer term. Through the inclusion of this section in this submission, the Department is seeking to emphasize the importance of "multi-dimensional" planning and decision making where all significant costs and benefits, regardless of their degree of tangibility or intangibility, are given full consideration.

This is particularly vital in cases where such plans or decisions will, either intentionally or otherwise, be a significant determinant of the future quality of life and the options available to future generations.

In view of the Department of Fisheries and Environment's particular concern for the long-term environmental impacts of electric power generation in the province, the Department recognizes the heavy burden of responsibility on the Commission to deal with its mandate in the broadest possible terms and with full consideration to the long-term implications. These implications extend well beyond the current planning horizon of the electric power system. Fisheries and Environment Canada will endeavour to give all practical support possible during the forthcoming debate stage in order to assist the Commission in the fulfillment of its mandate.

APPENDICES

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APPENDIX 1

LIST OF DEPARTMENTAL ACTS AND REGULATIONS

LIST OF DEPARTMENTAL ACTS AND REGULATIONS

1. Government Organization Act, 1970 - Chapter 42
2. Fisheries Act - Chapter F-14
3. Removal of Obstructions to Fishways Regulations
4. Applications of Fines and Proceeds from Forfeitures Order
5. Tuna Fishery Regulations
6. Walrus Protection Regulations
7. Beluga Protection Regulations
8. Seal Protection Regulations
9. Otter Trawl Fishing Regulations
10. Quebec Fishery Regulations
11. Lobster Fishery Regulations
12. New Brunswick Fishery Regulations
13. Newfoundland Fishery Regulations
14. Prince Edward Island Fishery Regulations
15. Yukon Territory Fishery Regulations
16. Northwest Territories Fishery Regulations
17. British Columbia Fishery Regulations
18. Sanitary Control of Shellfish Fisheries Regulations
19. Fisheries Development Act - Chapter F-21
20. Fishing Vessel Assistance Regulations, 1970
21. Fishery Products Storage Regulations
22. Northwest Atlantic Fisheries Convention Act - Chapter F-18
23. Northwest Atlantic Fisheries Convention Regulations
24. Northern Pacific Halibut Fishery Convention Act - Chapter F-17
25. Atlantic Crab Fishery Regulations
26. Canadian Pacific Halibut Regulations
27. North Pacific Fisheries Convention Act - Chapter F-16
28. North Pacific Fisheries Convention Regulations
29. Fish Inspection Act - Chapter F-12
30. British Columbia Gravel Removal Order
31. Coastal Fisheries Protection Act - Chapter C-21
32. Coastal Fisheries Protection Regulations
33. Whaling Convention Act - Chapter W-8
34. Whaling Regulations
35. Bluefin Sport Fishery Regulations
36. Territorial Sea and Fishing Zones Act - Chapter T-7
37. Territorial Sea and Fishing Zones Geographical Coordinates Order
38. Pacific Fur Seals Convention Act - Chapter F-33
39. Fishing Gear Marking Regulations
40. Pacific Salmon Fisheries Convention Act - Chapter F-19
41. Fisheries Research Board Act - Chapter F-24
42. Fisheries Prices Support Act - Chapter F-23
43. Fish Inspection Regulations
44. Great Lakes Fisheries Convention Act - Chapter F-15
45. Freshwater Fish Marketing Act - Chpter F-13
46. Salmonidae Import Regulations
47. Haddock Conservation and Protection Regulations

48. Fishing Vessel Insurance Regulations
49. Navigable Waters Protection Act
50. Nova Scotia Fishery Regulations
51. British Columbia Fishery Boundaries of Tidal Waters on the Streams in British Columbia
52. Fraser River Salmon Fishery Regulations 1972
53. Narwhal Protection Regulations
54. Saltfish Act - Chapter 37 (1st Supplement)
55. Irish Moss (Nova Scotia) Regulations
56. Pulp and Paper Effluent Regulations
57. Chlor-Alkali Mercury Regulations
58. Arctic Waters Pollution Prevention Act - Chapter 2 (1st Supplement)
59. Actic Waters Pollution Prevention Regulations
60. Clean Air Act - Chapter 47
61. Forestry Development and Research Act - Chapter F-30
62. Migratory Birds Convention Act - Chapter M-12
63. Migratory Bird Sanctuary Regulations
64. Canada Water Act - Chapter 5 (1st Supplement)
65. Northern Inland Waters Act - Chapter 28 (1st Supplement)
66. International River Improvements Act - Chapter 1-22
67. International River Improvements Regulations
68. Atlantic Coast Herring Regulations
69. Game Export Act - Chapter G-1
70. Northern Inland Waters Regulations
71. Phosphorus Concentration Control Regulations
72. British Columbia Logging Order
73. International Pacific Halibut Convention Regulations
74. International Fishing Vessel Inspection Regulations
75. Lead-Free Gasoline Regulations
76. Petroleum Refinery Liquid Effluent Regulations
77. Canada Wildlife Act - Chapter 21
78. Fish-Chilling Assistance Regulations
79. Ambient Air Quality Objectives
80. Leaded Gasoline Regulations
81. Ambient Air Qualify Objectives, No. 2.
82. Weather Modification Information Act - Chapter 59 - Statutes 1970-71-72
83. Weather Modification Information Regulations
84. Ocean Dumping Control Act
85. Ocean Dumping Control Regulations
86. Environmental Contaminants Act
87. Migratory Bird Regulations

APPENDIX 2

THE ENVIRONMENTAL ASSESSMENT AND REVIEW PROCESS

Canada's Policy on Environmental Assessment For Federal Activities

October 1976

A BRIEF HISTORY

In creating a Department of the Environment in 1970, the Government of Canada responded to a deep public concern about environmental affairs and the potential for man-made disasters inherent in our way of life. The Government also recognized the impossibility of housing all federal environmental experts and related legislative instruments under one departmental roof because many government activities may impinge on the environment in one way or another. The responsibilities given to the Minister of the Environment reflected this understanding by directing that the Minister both "undertake" and "promote" programs to achieve environmental enhancement and protection. The Minister was directed also to coordinate such programs within the federal government as well as cooperate with other bodies, such as provincial governments, in programs having similar aims.

One of the first concerns of Environment Canada after it was formed was to examine the federal government's role as a polluter and make certain that federal projects were assessed and suitable remedial measures taken where required to prevent or abate such pollution. The federal Cabinet in June 1972, accepted a departmental proposal that all new projects initiated by the federal government be screened for this purpose, and directed that those requiring further assessment be referred to the Department of the Environment.

Although pollution is a major component of the environmental spectrum, it does not cover all the potential environmental aspects associated with federal activities. Many other considerations such as the impact of physical impediments on aquatic life and wildlife migration routes, or the indiscriminate use of non-renewable resources including land must be taken into account.

Consequently, on December 20, 1973, Cabinet decided to establish an Environmental Assessment and Review Process to ensure that:

a) environmental effects are taken into account early in the planning of new federal projects, programs and activities;

b) an environmental assessment is carried out for projects, programs and activities that are likely to have a significant effect on the environment;

c) the results of these assessments are used in planning, decision-making and implementation.

Federal projects are considered to be those that are initiated by federal departments and agencies; those for which federal funds are solicited and those involving federal property. This definition covers those projects that may originate outside the federal government but involve a particular federal department through funding or property considerations. In such cases, the federal department sponsoring the project is responsible for the environmental assesent. All federal organizations are bound by the Cabinet decision except proprietary crown corporations and regulatory agencies who are invited, rather than directed, to participate in the process.

The Cabinet decision also directed the Minister of the Environment to develop, in close cooperation with other ministers, the process and procedures required to accomplish the objectives noted. This was clearly a case of an environmental program promoted and coordinated by Environment Canada but involving all federal departments and agencies in the decisions required for implementation. To fashion a successful federal process it was recognized that planners, policy makers and operators in all federal agencies should give the same consideration to environmental consequences as they do to economic, social and technical factors in framing and implementing their programs and projects. The provision of sufficient "lead time" between the conception of a project and its implementation to permit a proper assessment of environmental concerns and identify suitable requirements for environmental protection and enhancement was another major consideration.

1. THE PROCESS BEGINS

The process now established is based essentially on the self-assessment approach. Departments and agencies are responsible for assessing the environmental consequences of their own projects, or those which they sponsor, and deciding on the environmental significance of the anticipated effects. Whether potential adverse effects are considered significant or not depends initially on the judgement of technical and environmental specialists within the government. This judgement takes into account the potential for concern and controversy that a project might create in the public and within professional communities.

As early in the planning phase as possible, a department screens projects and activities for which it is responsible to identify potential adverse environmental effects. Environment Canada has developed screening guidelines to help federal departments and agencies with this task. They were designed in matrix form to provide the user with a quick method of identifying the relationships between a broad range of human activities and the environmental elements involved with projects in general.

As a result of this initial screening of a project by the department or agency concerned, one of the following three decisions is possible:

1) There are (a) no anticipated adverse environmental effects associated with the project or (b) the anticipated environmental effects are known and are not considered significant.
2) The nature and scope of potential environmental effects cannot be readily determined during preliminary screening.
3) The anticipated adverse environmental effects are

considered to be significant and the project requires a formal environmental review by Environment Canada.

If decision number 1 is made, the department concerned is responsible for implementing measures required to prevent or mitigate the environmental effects identified, and satisfying all other legislative, regulatory and Cabinet requirements related to the development and implementation of the project. However, no further reference to the Environmental Assessment and Review Process is required.

2. THE INITIAL ENVIRONMENTAL EVALUATION (I.E.E.)

If a department is unable to identify the full environmental consequences and their significance through the screening procedure as indicated in decision number 2 above, then the project is subjected to a more searching examination called the Initial Environmental Evaluation (I.E.E.). Guidelines prepared by Environment Canada covering such project classes as Airports, Nuclear Plants and Linear Transmission Lines (e.g. pipelines) are available to help federal agencies prepare, or procure, this document. The I.E.E. provides a description of the project; of the existing environment and resource use; of potential environmental effects and impacts; of measures proposed to mitigate or prevent certain anticipated environmental effects; and a judgement concerning the impact of those effects that remain after all known measures for prevention and counteraction have been specified. In this description, the alternate ways of accomplishing the project are examined and the preferred alternative(s) identified.

Based on the review of the I.E.E., the department concerned then decides whether the proposed project involves significant environmental effects or not. If the effects are not considered significant, the department is responsible for implementing appropriate measures for environmental protection that have been specified, but no further reference to the Process is required, as in screening decision number 1 above. However, if the anticipated effects are judged to be significant, the department then submits the project to Environment Canada for a formal review as in screening decision number 3.

It should be noted that a department is only obliged to prepare an I.E.E. when it is unable to identify the nature of potential environmental effects during preliminary screening. No I.E.E. is required under Process procedures when screening decisions numbers 1 and 3 are made.

Departments and agencies are encouraged to seek environmental advice from the Department of the Environment during the screening procedure and in the development and review of I.E.E.s. Environment Canada has established Regional Screening and Coordinating Committees in each of its five regions to facilitate this advisory service. Advice from specialists in other departments such as Health and Welfare (health aspects), Energy, Mines and Resources (energy conservation) and Agriculture (pesticides) is also available on request. In addition, consultants outside the federal government could be used for this purpose. Known public concerns about specific projects constitute another important input to departments in making their environmental decisions.

In summary, the prime concern during the screening and I.E.E. phase of the Process for project alternatives under consideration, is to:

a) Specify preventative and mitigating measures for anticipated environmental effects that have been identified and are amenable to such measures. These measures would be incorporated when a project is implemented.

b) Identify anticipated effects which are "left over" after all known remedial measures have been specified and which may have significant impacts on the environment.

If the department involved considers these residual effects to be significant, it then requests Environment Canada to proceed with a formal review of the project by an Environmental Assessment Panel.

3. THE ENVIRONMENTAL ASSESSMENT PANEL

An Environmental Assessment Panel is a small body of experts (usually four to six) formed to review the environmental consequences of a specific project and its alternatives, and to evaluate the significance of the environmental impacts that might result from implementing the project.

A permanent Panel Chairman has been appointed by Environment Canada to administer Process procedures, particularly the operation of panels. He (or his delegate) chairs all panels established to review projects, and he reports to the Minister of the Environment on the recommendations made by panels. A project submitted for panel review may not be carried out until a decision has been reached on panel recommendations.

A separate panel is established for each project reviewed. Panel members are selected from within the federal Public Service and are chosen for their special knowledge and experience relevant to the technical and environmental factors associated with the proposed project. The Process also provides for the establishment of an Environmental Review Board by the Minister of the Environment composed entirely of members outside the federal Public Service. Projects considered special cases because of wide public interest are candidates for the Review Board. The decision to use this procedure rests with the Minister of the Environment and the minister of the department involved with the project under consideration.

4. THE ENVIRONMENTAL IMPACT STATEMENT

When an Environmental Assessment Panel is formed to assess a project, one of its first tasks is to develop specific guidelines for the preparation of an Environmental Impact Statement (E.I.S.). The E.I.S. is a detailed documented assessment of the environmental consequences associated with the project, and is prepared, or procured through consultants, by the department responsible for the project. It must be prepared in accordance with the guidelines issued by the Panel. The nature of the project and its proposed location will determine in many respects the type of detailed information required. The impact on people due to noise and land use would be prime considerations when assessing a proposal for a new airport. The potential for damage from radiation would be an important factor when a proposed nuclear power generating station is under review.

5. THE PROCESS AND THE PUBLIC

After receiving the Environmental Impact Statement, the Panel's next step is to obtain public reaction to the project. Both the guidelines issued by the Panel and the Environmental Impact Statement prepared by the federal agency initiating or sponsoring the project are made available to those interested before any formal meetings for public discussion are held. After this information has been issued, the Panel arranges to meet the public and receive briefs (oral and written) from individuals and groups who wish to present their viewpoints. Generally, these meetings will be held in the particular area proposed for the location of the project.

The federal assessment process attaches great importance to anticipated public concerns in determining the "significance" of potential adverse environmental effects. On the other hand, a Panel established to make such judgements must weigh the extent of such reaction and its validity in terms of the scientific and technical factors involved when making its recommendations. In unusual cases, the ministers involved may decide that it is advisable not to release information on a project.

6. THE DECISION

When a Panel has reviewed the Environmental Impact Statement, the public response, and any other information it feels is required, it prepares a report for the Minister of the Environment. This report contains the history of events associated with the project, a detailed examination of the vital environmental factors involved including their major impacts on the social and economic sectors, and recommendations concerning project implementation. A Panel could recommend that a project be halted, that it proceed as planned, or that it proceed with certain qualifying conditions and terms. These terms might include environmental requirements for project design, and the development of certain studies to obtain needed information. They might also include requirements for surveillance during construction and operation of the project to evaluate the performance of environmental protection measures used, and monitoring the actual environmental impacts for comparison with predicted impacts.

The Panel report is then submitted to the Minister of the Environment through the Chairman, and the Minister must decide whether to accept the recommendations or not. He must also decide whether the report should be made public. These decisions are made in consultation with the minister of the department initiating the project. If they agree to accept the recommendations made by the Panel, the report is released to the public and the initiating department is instructed to implement the recommendations. This ministerial decision would also identify the federal agencies responsible for any surveillance and monitoring needed.

There is the possibility of disagreement between the two ministers on the course of action that should be taken. In this case the matter would probably be referred to Cabinet for resolution. Regardless of the circumstances involved, the Minister of the Environment may release the report to the public if he believes the situation warrants this step.

Some proposed federal projects, such as airports, may have important environmental implications for provincial levels of government. In such circumstances a joint approach to environmental assessment by the federal and provincial agencies concerned is encouraged under federal assessment policy. Where a panel is formed to review a federal project of this kind, the provincial government involved is invited to contribute towards the specific guidelines developed by the Panel for the preparation of the Environmental Impact Statement. Each level of government enjoys the right to review the E.I.S. produced, and to act on the basis of its own conclusions about its adequacy. In this way the duplication associated with two sets of guidelines and two impact statements that might result if each government acted in isolation is avoided. Should there be federal/provincial disagreement in such cases, the action eventually taken would depend on the particular circumstances involved including the scope available for compromise.

Departments and agencies in the federal government are still grappling with the many complexities related to environmental affairs in general, and the Environmental Assessment and Review Process in particular. It is too soon to judge the performance of this procedure for environmental assessment but experience gained within the next three years should provide the measure of its success. The federal approach spreads the responsibility for decisions concerning the environment amongst departments and agencies to foster sound environmental planning at the source of activities, and involves the public in reaching the decisions that are made to ensure environmental protection. It is an approach that is not prescribed by law but underwritten by a commitment from federal ministers through a Cabinet decision. The degree to which all the participants in the Process accept their responsibilities, and the quality of the decisions that result will determine whether the objectives set for EARP are ever achieved.

For Additional Advice and Information on the Environmental Assessment Process the Following Sources may be Contacted

Chairman, Environmental Assessment Panel
Environment Canada
13th floor - Fontaine Bldg.
Ottawa, Ontario
K1A OH3

Secretariat
Regional Screening & Coordinating Committee
Pacific Region
c/o Environmental Protection Service
Environment Canada
Kapilano 100, Park Royal
West Vancouver, B.C.
V7T 1A2

Secretariat
Regional Screening & Coordinating Committee
Northwestern Region
Environmental Protection Service
901 - 10025 Jasper Avenue
Edmonton, Alberta
T5J 2X9

Secretariat
Regional Screening & Coordinating Committee
Ontario Region
Environmental Protection Service
135 St. Clair Avenue, West
Toronto, Ontario
M4V 1P5

Secretariat
Regional Screening & Coordinating Committee
Atlantic Region
Environmental Protection Service
P.O. Box 2406
Halifax, Nova Scotia
B3J 3E4

Secretariat
Regional Screening & Coordinating Committee
Quebec Region
Environmental Protection Service
P.O. Box 1330, Station B
Montreal, Quebec
H3B 3K9

APPENDIX 3

THE CANADA-ONTARIO ACCORD FOR THE ENHANCEMENT AND PROTECTION OF THE ENVIRONMENT

1972

CANADA - ONTARIO ACCORD FOR THE PROTECTION AND ENHANCEMENT OF ENVIRONMENTAL QUALITY

THIS ACCORD is entered into on behalf of the Government of Canada (hereinafter called "Canada") by the Honourable Jeanne Sauve, Minister of the Environment, and on behalf of the Government of Ontario (hereinafter called the "Province") by the Honourable George Kerr, Minister of the Environment.

WHEREAS management of the quality of the natural environment involves maintaining or enhancing the ability of the biosphere to produce a wide variety of resources and conditions useful to man; and

WHEREAS an understanding of the biophysical relationships of ecosystems is fundamental to successful attainment of environmental quality objectives; and

WHEREAS institutional systems established to govern man's activities including his impacts on the natural environment, are superimposed upon natural systems; and

WHEREAS both Canada and the provinces have jurisdictions and responsibilities in the field of environmental quality, including pollution prevention, control and abatement;

THEREFORE, the Governments of Canada and Ontario,

RECOGNIZING that programs aimed at achieving environmental objectives should be planned and undertaken in such a way as to ensure comprehensiveness and eliminate duplication;

AGREE to adhere to the principles and practices stated below in the development and maintenance of complementary programs with each government acting within its jurisdiction;

AGREE to develop new coordinating mechanisms and new complementary programs so that they are in harmony with existing cooperative or complementary arrangements in related fields flowing either from legislation or administrative practice; and

AGREE to the following principles and practices relating to the protection and enhancement of environmental quality;

General

1. This Accord applies to federal-provincial relationships involved in the protection and enhancement of environmental quality. This would generally encompass environmental assessment, design, protection, enhancement and related research.

2. The objectives of the Accord are:

   (a) to provide a more effective overall effort in the protection and enhancement of environmental quality through better coordination of the activities of Canada and the Province; and

   (b) to provide a broad framework within which specific agreements can be designed to cope with particular problems.

3. This Accord will be in force for a five-year period with provision for revision and/or renewal by mutual agreement if desired by either party at any time.

4. Canada and the Province agree to develop subsidiary agreements dealing with particular environmental concerns of mutual interest.

Interpretation

5. In this Accord,

"data" means data which describe the state or condition of the environment at the time collected and against which any change in that state or condition can be measured.

"federal facilities" means works or installations, owned or managed, operated or controlled by Federal Ministries, Departments and Agencies.

"guidelines" means recommended good practices to assist in achieving uniformity.

"objectives" means levels of environmental quality to be attained in either the short-term or long-term.

"regulations" means any rule, order, ordinance, direction, by-law, resolution or other instrument,

(a) issued, made or established in the exercise of a legislative power conferred by or under any statute, or

(b) for the contravention of which a penalty, fine, imprisonment or any other measure is prescribed by or under any statute.

"scientific criteria" means the objective quantitative assessment of risks to the receptor due to a particular pollutant in the environment together with the fundamental principles and scientific knowledge on which the assessment is based.

"standards" means legally prescribed limits of pollution.

Ambient Environmental Quality Criteria and Objectives

6. Canada agrees, after consultation with the Province and all other provinces, to determine and promulgate scientific criteria for air and water quality based upon the best available scientific information.

7. Canada agrees, after consultation with the Province and all other provinces, to establish broad national ambient quality objectives for air and water based upon nationally agreed scientific criteria.

8. Canada and the Province agree to identify specific geographic areas of joint interest and to establish specific ambient quality objectives or requirements for such areas based upon agreed scientific criteria. Existing agreements would not be affected by such undertakings.

National Baseline Pollution Control Requirements and Guidelines for Industry

9. Canada, after consultation with the Province and all other provinces, agrees to develop national baseline effluent and emission requirements and guidelines for specific industrial groups and specific pollutants. Specific groups or classifications of industries will be agreed upon from time to time for the purpose of establishing priorities.

Environmental Effects

10. Canada and the Province agree to have consult freely on possible environmental effects of proposed major developments or redevelopment projects. Canada and the Province undertake to provide each other with data and other general information necessary for an environmental assessment and review.

Pollution Control Implementation

11. Canada and the Province undertake to carry out pollution control programs for facilities under their respective control to meet agreed objectives and federal and provincial requirements.

12. The Province agrees to establish and enforce requirements at least as stringent as the agreed national baseline requirements. Such requirements would be applied at start-up for all new installations or for installations undergoing major plant modifications. In all other cases the national baseline requirements would be applied as a minimum as rapidly as possible to meet agreed objectives and time schedules.

13. Canada and the Province agree to appoint officers designated by either government to facilitate inspection

for compliance with national effluent and emission requirements. Appropriate arrangements for either federal or provincial inspection of federal facilities would be determined by specific agreements.

14. Canada agrees to take enforcement action:

(a) at federal facilities unless otherwise agreed to under Clause 13 above;

(b) at the request of the Province; or

(c) where the Province cannot, or for some reason fails to fulfill its obligations under this Accord, with respect to matters of federal jurisdiction administered by the Province.

15. Canada undertakes to accelerate promulgation of regulations for the safe and sanitary control of wastes from commercial vessels. Canada and the Province agree to cooperate in the control of wastes from commercial vessels at harbour facilities.

Monitoring and Surveillance

16. Canada and the Province agree to cooperate in monitoring the quality of air and water in areas of joint interest, to carry out surveys and to interpret trends in ambient quality in relation to agreed objectives.

17. The Province will undertake surveillance of the characteristics of effluents and emissions, including their influence on ambient quality and their compliance with agreed effluent and emission standards and ambient quality objectives.

18. Canada and the Province, in concert with other provinces, agree to harmonize monitoring and surveillance methods and analysis systems to ensure comparable results.

19. Canada and the Province, in concert with other provinces, agree to exchange all data freely and to develop procedures relating to the publication of data having due regard for confidentiality or security as may be required.

Special Agreements for Accelerated Action

20. Canada and the Province, in concert with other provinces as appropriate, agree to identify environmental problems in areas of mutual concern and to enter into implementation agreements to accelerate preventative actions and the clean-up of specific areas.

21. Canada agrees to assist in the implementation of these accelerated programs by assigning appropriate priorities in available financial assistance programs.

Contingency Plans

22. Canada and the Province, in concert with other provinces, municipal governments, agencies and industries as appropriate, agree to develop and to implement integrated contingency plans for environmental emergencies.

Research, Technical Advice and Training

23. Canada and the Province agree to cooperate jointly or in association with other governments, individuals, universities or industry on research and pollution control technology development programs in support of this Accord.

24. Canada and the Province agree to seek and make available to each other the advice of their technical experts in support of this Accord.

25. Canada agrees, where possible and appropriate, to provide supporting resources for technical training programs which the Province may request and undertake to develop. The type of training programs required would be the subject of discussions between the two governments.

Cost-Sharing

26. Where by specific agreement, Canada and the Province undertake joint programs of data gathering, assessment, research and design, cost-sharing will generally be negotiated on a 50/50 basis except where special circumstances indicate other proportions. Canada and the Province agree to adopt procedures for the audit and liquidation of claims for reimbursement with respect to these shared programs.

Other

27. A Canada - Ontario Committee will oversee the implementation of the Accord, consult on environmental matters and recommend on needs for specific agreements under the Accord.

IN WITNESS WHEREOF the Honourable Jeanne Sauve, Minister of the Environment, has hereunto set her hand on behalf of Canada, and the Honourable George Kerr, Minister of the Environment, has hereunto set his hand on behalf of the Province of Ontario, this 20th day of October 1975.

Signed on behalf of Canada, by the Honourable Jeanne Sauve, Minister of the Environment	(Sgd.) Jeanne Sauve
IN THE PRESENCE OF	
(Sgd.) J. B. Seaborn	
Signed on behalf of the Province of Ontario by the Honourable George Kerr, Minister of the Environment	(Sgd.) G. A. Kerr
IN THE PRESENCE OF	
(Sgd.) Everett Biggs	

APPENDIX 4

PROGRAM DESCRIPTION: ECOSYSTEM METABOLISM STUDIES

PROGRAM Ecosystem Metabolism Studies

PROJECT Impact of Thermal Generating Stations

SERVICE Fisheries and Marine

CONTACT
Dr. J. Cooley
Great Lakes Biolimnological Laboratory
Canada Centere for Inland Waters
Box 5050
Burlington, Ontario.

DESCRIPTION

To examine effects of electric generating station operation, primarily waste heat discharge, upon Great Lakes ecosystems. Results will assist in formation of water quality criteria and guidelines for power plants to lessen ecological impact.

In the framework of examining power plants in differing Great Lakes ecosystems, waste heat studies are in their fourth year and consequently fourth ecosystem. Studies at three generating stations - Pickering, Nanticoke and Douglas Point - are complete. Studies have been, and will be, directed at interrelating effects upon trophic levels and in their final major field year will include determinations of alterations in production assimilation, performance, behavior and community structure. Each aspect of the Project is directed by results and experiences of the previous years research and duplication from site-to-stie is applied when necessary to a particular research component. Field studies, 1976/77 Lennox GS will include:

1) Assessment of temperature regimes (and other environmental parameters where applicable) with particular reference to experiences by sedentary communities.

2) Epilithic periphyton - effect of conditions imposed by the generating station including 1) species composition, 2) chlorophyll a, 3) primary production. Preceding will be determined on natural communities and those colonizing artifical substrates.

3) Benthic macroinvertebrates - included in expansion to Quinte project and entails the assessment of the specific composition of "soft bottom" benthos in relation to temperature and oxygen. 1976/77 activities will include synthesis and write-up of previous 3 year's study.

4) Phytoplankton - assessment of the entrainment effects on phytoplankton by studying 14_Cuptake, chlorophyll and population structure of the community. Parallels 1975/76 studies except for a decrease in frequency of

experiments. Research will likely be done at Lakeview G.S.

5) Zooplankton - continuation of species abundance estimation and assessment of entrainment effects by *in situ* filtering rate studies. Foregoing is augmented by 1) using natural communities in laboratory experiments designed to simulate thermal history during entrainment and 2) continuation of development rate studies, see 1975/76 project 6-FR-BL-022.

6) Ichthyoplankton - assessment of thermal/mechanical stresses during entrainment by examining survival, condition and performance of natural populations and hatchery larval fishes.

7) Non-larval fish - continuation of acoustic census of community response to temperature alteration done by OMNR, Glenora, in conjunction with their programs in acoustics. 1976/77 includes final presentation of 4 years study.

REPORTS

1. Kelso, J.R.M. 1975. Movement of yellow perch (*Perca flavescens*) and white sucker (*Catostomus commersomi*) in a nearshore Great Lakes habitat subject to a thermal discharge. J. Fish. Res. Board Can. 32:000-000.

2. Kelso, J. R. M. and C. K. Minns 1975. Summer distribution of the nearshore fish community near a thermal generating station as determined by acoustic census. J. Fish. Res. Board Can. 32: 140901418.

3. Kelso, J.R.M., 1974. Influence of a thermal effluent on movement of brown bullhead (*Ictolurus nebulosus*) as determined by ultrasonic tracking. J. Fish, Res. Board Can. 31: 1507-1513.

4. Kelso, J. R. M., E. E. Pickett and R. G. Dowd. 1974. A digital echo-counting system used in determing abundance of freshwater pelagic fish in relation to depth. J. Fish. Res. Board Can. 31: 1101-1104.

APPENDIX 5

LIST OF ITEMS SUBMITTED TO THE COMMISSION UNDER SEPARATE COVER

List of Items Submitted to the Commission Under Separate Cover

1. Canada-United States Great Lakes Quality Agreement 1972
2. Canada-Ontario Agreement on Great Lakes Water Quality 1971 (revised 1976)
3. 1975 Great Lakes Water Quality Board Report
4. Report of the Ontario Regional Board on Long Range Transport of Air Pollutants
5. The Clean Air Act (Regulations and Guidelines; National Air Quality Objectives)