Update

Canada's 1993 Mineral Fuel Production

The value of the mineral fuels produced in Canada in 1993 increased by 10.8% to $23.0 billion from $20.7 billion in 1992 according to Natural Resources Canada. Individually, the value of crude oil rose 2.3%, natural gas 26.8%, natural gas by-products 14.7%, and coal 6.8%. Crude oil production increased 4.3% to 97.2 m^3 (611 million bbls) with a value of $11.2 billion, natural gas production increased 10.8% to a remarkable 129.2 billion m^3 (4.56 trillion ft^3) with a value of $7.2 billion and the production of natural gas liquids increased to 28.5 million m^3 (179 million bbls) valued at $2.8 billion. Coal production in 1993, after falling in the two previous years, increased 4.6% to 68.6 million metric tonnes with a total value of $1.8 billion. The export prices for Canadian metallurgical coal have, however, fallen.

Natural gas exports have benefitted from developments in the US where increasing volumes of Canadian gas are used for the generation of electricity. Average spot prices in that market were estimated at US $2.11/million BTU in 1993, an increase of 17% over 1992. US imports of Canadian gas were estimated at 2.3 trillion ft^3, up 7% from the previous year.

20th Anniversary of International Energy Agency

On February 24, a special joint meeting of the International Association for Energy Economics, The Energy Council of Canada, the Petroleum Society, and the Ottawa Economics Association was held in Ottawa to mark the 20th anniversary of the International Energy Agency (IEA). Frau Helga Steeg, retiring Executive Director of the IEA, presented a review of the Agency's activities and an outlook for its future.

During the first years of the IEA, member countries were heavily dependent upon oil imports, with the sole exception of Canada. In this period, energy policy was primarily directed to reducing this dependence by expanding indigenous production, encouraging energy efficiency and fuel diversification, and promoting new technologies. Later, in the early 1980s, most governments moved towards more market-based policies. The progress made by the IEA countries over the past 20 years in improving energy security is now apparent. As a group, though the IEA countries still import two-thirds of their oil requirements, Canada, Norway, and Britain have been consistent net exporters over these years. The intensity of use of energy in the IEA countries has declined and the diversity of sources, both in terms of fuel types and number of suppliers, has increased. At the same time, great progress has been made in understanding energy markets, making them more transparent and flexible, and increasing trade and competition. The ratio of oil and gas reserves to production is at an historic high today. Though less energy is now needed to produce a unit of GDP, energy services must now be of a higher quality. Nevertheless, it is still necessary to maintain the capacity to respond to crises because the Middle East remains a politically volatile region. It is ironic that, with the end of the Cold War, the potential for crises, if anything seems to have increased, with the potential for disruptions in the supply of natural gas to Europe from the east being a case in point.

Looking to the future, the Ministers of the member nations agreed in June of 1993 to a new set of shared goals as a foundation for energy policy in the next decade. These goals continue the effort to achieve free and open markets, energy security and diversity, and flexibility of supply as in the past, but now there is emphasis on a new trinity of energy security, economic growth and environmental sustainability.

There are many environmental issues confronting Ministers, but the most important is their response to global climate change. Twenty-two of the 23 member nations are signatories to the Framework Convention on Climate Change. In the IEA studies, CO_2 emissions will rise about 15% between 1990 and 2000, and by nearly as much again to 2010, assuming no new policies. In Canada, the national studies indicate emissions in 2000 will be about 10% higher than in 1990, again with no new measures. The growth in emissions in emerging countries will be still higher.

IEA Energy Ministers are therefore meeting to discuss possible responses, given the agreement to set out national plans and projections by September 21, 1994. In the IEA studies it was found that very high taxes of the order of US $300/tonne of carbon would be necessary to stabilize emissions in the OECD group of nations at the 1990 level by 2010. No country has seriously considered a tax of this level and it seems clear that all governments will use a mix of policy measures to meet their commitments under the Convention. Nevertheless, five of the member countries have adopted some kind of carbon tax but some of them have made exemptions for exactly the fuel users whom the advocates of such a tax would like to target — namely coal consumers and heavy industry in particular. In the transportation sector, however, most European countries already have gasoline taxes that amount to US $500 or more per tonne of carbon. But with high unemployment in many countries, the need to meet environmental goals must also take into account the effect on jobs and that is why new and innovative approaches to reduce the emissions of greenhouse gases are being sought.

Finally, Frau Steeg referred to the growing dialogue with non-IEA countries. The IEA has carried out several energy policy country reviews in Eastern Europe and Asia and completed a study with the World Bank in 1993 on the alternatives to relying upon unsafe nuclear reactors in the eastern economies in transition. The motive for these efforts is to reach out to key players in the global energy market to share IEA experiences, both good and bad, and exchange views on future market developments. It is even possible the Agency will expand its membership in the coming years.

A limited number of copies of this presentation are available from the International Energy Relations Division of Natural Resources Canada, 580 Booth Street, Ottawa, Ontario, K1A 0E4 (Fax:(613) 995-5576).

Energy Maps

In the course of presenting results obtained by way of systems analysis using the MARKAL linear programming model (See *ESR* 5:3, p.240), Dr. Douglas Hill, a US energy consultant, has devised a useful new type of drawing called an Energy Map. The problem is to represent data obtained by so-called decomposition equations which interrelate the principle variables in the energy system. The equations in Figure 1 illustrate one commonly used set of decomposition relationships in the study of CO_2 emissions. Two of these relationships are illustrated graphically in Maps 1 and 2.

Map 1 illustrates the share of fossil fuels in the primary energy mix as related to the carbon intensity of the fossil fuel mix. As shown in the inset legend, the arrows for each region represent (before the break) the possible progression with no further constraints on CO_2 emissions while the arrowhead (after the break) represents the situation with the maximum possible reduction in CO_2 emissions in 2020. There are two noteworthy features of this energy map: the large difference in the situation between Ontario and Quebec, and the effect of adopting procedues for the capture and sequestering of CO_2 in the Netherlands and Belgium. In the latter case, the sequestered carbon is deducted from the fossil fuel carbon which results in the carbon intensity of the total fossil fuel mix falling below that of natural gas, the lowest value possible without the sequestering procedure.

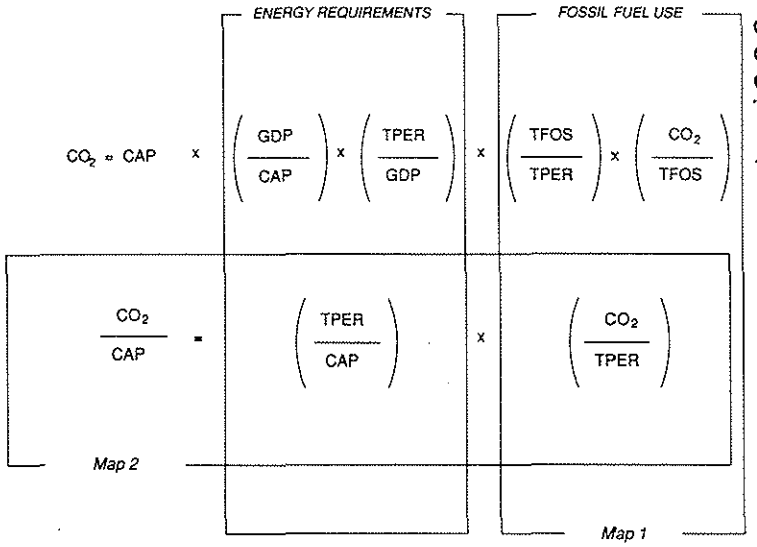
Map 2 illustrates the carbon intensity of the total primary energy consumed in relation to the total primary energy consumed per capita. Again, large differences can be seen between Ontario and Quebec. This is a very convenient way of representing complex relationships visually and will likely find wide application in energy studies and possibly other fields as well. (Source: *IEA ETSAP News*, February 1994.)

New Pipeline Facilities

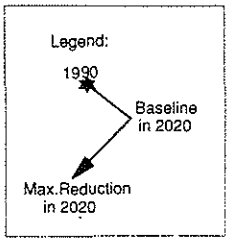
On January 31, 1994, the National Energy Board approved plans by Interprovincial Pipe Line Inc. (IPL),

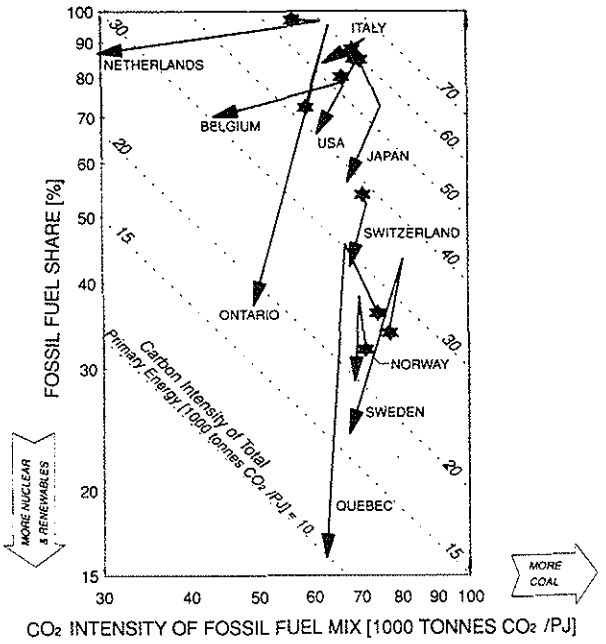
Figure 1: Decomposition Relationships in the Study of CO_2 Emissions

TOTAL CARBON DIOXIDE EMISSIONS CAN BE EXPRESSED AS FOLLOWS:

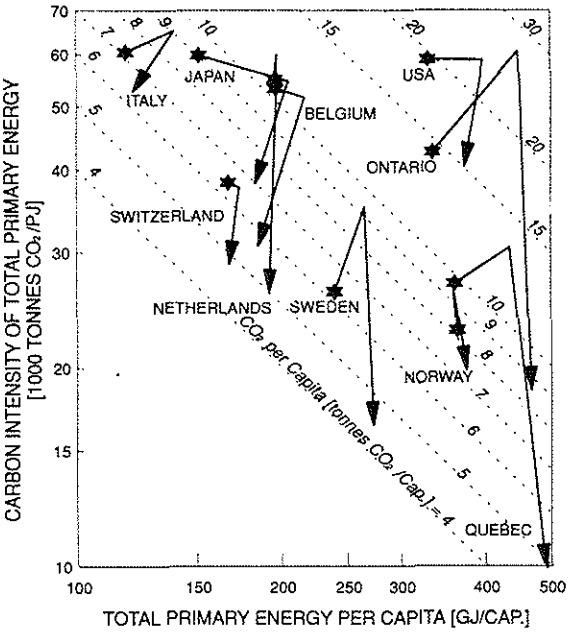


CO_2 = Total CO_2 emissions
CAP = Population
GDP = Gross domestic product
TPER = Total primary energy requirements
TFOS = Fossil primary energy requirements





Map 1: Fossil Fuel Use



Map 2: National Energy

the operator of the world's longest petroleum pipeline, to construct $256 million of new pipeline facilities in Canada in 1994. Average deliveries reached record levels of 190,302 m^3/d (1,197,000 bbls/d) in 1993. The total cost of the expansion (including sections in the US) is about $430 million and will be the largest construction project on this pipeline system since 1983.

The main construction will involve 492 kms (305 miles) of 508 mm (20") line from Hardisty, Alberta, to Regina, Saskatchewan. The Board found that the supply of liquid hydrocarbons available to IPL will exceed capacity through to the year 2001 and that markets served by IPL can absorb additional volumes up to the level of the available supply. The proportion of light crude oil shipped has declined over the past five years reflecting the gradual depletion of reserves of light crudes and the increasing volumes of medium and heavy crudes. This expansion should provide sufficient capacity to prevent the need to shut-in production as has occurred in the past few years.

On March 16, 1994, the Board received an application from TransCanada PipeLines Limited to construct additional pipeline and compression facilities on its mainline transmission system in Ontario and Quebec. These facilities, expected to cost $120.1 million, would provide 1.048 million m^3 (37 million ft^3) of long haul firm service gas deliveries to customers in Canada and 918,000 m^3/d (32 million ft^3/d) of service to export markets by November 1, 1995.

New Reports Available

The Challenge of Climate Change

On March 10, 1994, The Conference Board of Canada, a leading private applied research institution with affiliates in many countries, released an 11-page report entitled *The Challenge of Climate Change — Policy Options for Canada*, authored by Gilles Rhéaume, a senior member of its staff. This report provides a succinct but comprehensive summary of the current situation in this field and assesses the main policy options available to governments. Among these policy options, the most desirable were found to be a carbon tax and a tradeable emission permit system, since these are the only two economic instruments that affect all sources of CO_2 emissions. These are believed to be more cost effective than such measures as mandated standards, gas guzzler taxes or more general energy taxes. In a tradeable emission permit system, overall targets for CO_2 emissions would be set, which then would be allocated or auctioned to emitters of CO_2. The need for international agreement before instituting such measures, with all the difficulties involved, is recognized, but the report does not deal specifically with the rising tide of emissions from the developing countries, particularly from such nations as China and India. The report concludes by noting that Canadian firms, to maintain a competitive position in the long run, will also need to take a lead in developing new energy sources and processes as well as new carbon sinks.

Copies of this report, numbered 112-93, may be obtained from The Conference Board of Canada, 255 Smyth Road, Ottawa, Ontario K1H 8M7 (Fax:(613) 526- 4857).

Canadian Coal 1994

The Coal Association of Canada has published *Canadian Coal 1994*, a brochure that contains much useful statistical and other information about the coal industry. Copies may be obtained from the Association at Suite 502, 205 Ninth Avenue S.E., Calgary, Alberta, T2G 0R3. (Fax: (403) 265-7604)

Cars and Climate Change

The International Energy Agency (IEA) has released a study entitled *Cars and Climate Change*. Energy consumed in the OECD countries for transportation purposes nearly tripled between 1960 and 1990. Though other deletrious emissions from transportation applications have been decreasing, this sector's share of CO_2 emissions is still expanding. Air travel, which has the highest energy use and greenhouse gas emissions per passenger-kilometre, has increased the fastest, but cars consume more energy than any other type of vehicle in the aggregate and produce more of these emissions. About 72% of greenhouse gases from cars are emitted from the exhaust during the operation of vehicles; 17-18% of life-cycle emissions arise from fuel extraction, processing and distribution; and a further 10% are released during the manufacturing stage.

Although technology is available that could improve the fuel economy of cars by a factor of three or more, the changes in car style and performance necessary would be unacceptable in today's market. Using currently commercial technology, studies in the US and the UK suggest that the economic potential is probably at least 20% better than the current average fuel economy. The consensus among informed observers is that fuel consumption per km could fall by 10-20% between now and 2005.

The report divides alternative fuel options into four main groups: (1) fuels that offer little or no greenhouse gas abatement but may be attractive for other reasons, such

as synthetic liquid fuels produced from fossil fuels or electric vehicles using power from existing generation mixes; (2) alternatives available now, or expected to become available by 2005, including diesel and LPG fuels, which can reduce greenhouse emissions by 10-25%; (3) synthetic fuels produced from wood or other low-input biomass feedstocks which are not yet technically demonstrated but could offer 60-80% greenhouse gas abatement; and (4) fuels derived from completely renewable sources including hydrogen produced by the electrolysis of water using electricity generated by renewable sources and synthetic fuels from zero-input biomass feedstocks which can result in over 80% greenhouse gas abatement.

This report, catalogued as ISBN 92-64-13804-8, is available from bookstores marketing OECD publications or from the IEA, 2 André-Pascal, 75775 Paris Cedex 16, France.

Two National Energy Board Reports on the Natural Gas Market

At the end of 1993, the National Energy Board (NEB) released two reports dated November 1993 in its Market Assessment series. The first *Natural Gas Supply — Western Canada* summarizes recent developments from 1982-1992 and provides an outlook for short-term deliverability until 1996. The excess productive capability that has characterized the market in recent years has diminished substantially. The peak-day productive capacity from the Western Canadian Sedimentary Basin will likely increase from about 453 million m^3/d (16 billion ft^3/d) in 1992 to 567 million m^3/d (20 Bcf/d) by 1996 based on estimates of increases in exploration and development drilling activity and planned increases in deliverability from upstream gas storage reservoirs. Pipeline capacity is expected to increase by almost 113 million m^3/d (4 Bcf/d) over the same period so that sufficient transportation capacity will be available to move these increased volumes of gas.

In the second report, *Canadian Natural Gas Market Mechanisms: Recent Experiences and Developments*, the NEB found that as the industry moved towards an era of "just-in-time-gas" where deliverability is in close balance with demand, it is necessary to improve communications between market participants and to prepare for sudden and sometimes unexpected changes in supply and demand. The report concluded that there is a growing range of products and services available to buyers and sellers of Western Canadian gas which will enable improved management of supplies even during periods of peak demand.

In February, the NEB announced an administrative restructuring which effectively eliminated a layer at the senior management level and reduced the number of branch directors. The changes were made possible in part by combining some functional areas. In 1984, the NEB and the Canada Oil and Gas Lands Administration (with which it was merged in 1991) had approximately 550 employees; this year the comparable number is 300. Operating expenditures in constant 1993 dollar terms have declined by approximately 40% from $54 million in 1984-5 to $30 million in 1993-4.

In March, the Board announced it had reached an arrangement with the Alberta Energy Resources Conservation Board (ERCB) to share geological and reservoir information for natural gas and crude oil pools. This sharing of information will result in a Common Reserves Data Bank for Alberta. The agreement provides for joint study of reserves, the sharing and the joint development of software, and the establishment of a Joint Reserves Steering Group. This agreement stems from the March 1993 Canada-Alberta Economic Summit, which directed the ERCB and the NEB to improve coordination.

These reports may be obtained from the NEB at 311 Sixth Avenue S.W., Calgary, Alberta, T2P 3H2 (Fax: (403) 292-5503).

Documents Released by the Office of Energy Research and Development of Natural Resources Canada

The Office of Energy Research and Development serves as the Secretariat to the Federal Program of Energy Research and Development (PERD). PERD is the principal supporter of energy science and technology in Canada (see *ESR* 4:2:185-87). A convenient booklet, entitled *Canadian Energy R&D Expenditures: 1983-1991*, has now been prepared. It provides many details in handy reference form. These expenditures are summarized for four key sectors: industry; electrical utilities; provincial governments; and the federal government. In 1990, these expenditures totalled $950.7 million provided 37% by industry, 23% by utilities, 31% by the Federal government, and 9% by provincial governments.

A 49-page report is also available which gives details of Canada's participation in the R&D activities of the International Energy Agency. The IEA, established in 1974 as an autonomous agency within the Organization for Economic Cooperation and Development in Paris, is the energy forum for 23 industrial countries, including Canada which was one of the founding members. (See 20th Anniversary of the International Energy Agency

in the second section above.) To contribute to the Agency's objectives, the Committee on Energy Research and Technology (CERT) was established. It facilitates the development and deployment of new and improved energy technologies which promote energy security, environmental protection and economic development of the member countries. The CERT Committee has the overall responsibility for the Agency's collaborative energy research, development, and demonstration activities, and for matters related to the deployment of technologies of importance to the energy industries. These collaborative efforts include: (a) activities in which member countries pool and coordinate research and development efforts which are negotiated in individual Implementing Agreements; (b) information exchanges and strategy development; (c) conferences and workshops where energy specialists from member countries share technology, research management and other expertise in the energy field; (d) reviews of the R&D activities in the member countries, and (e) outreach activities to non-member countries in the energy technology field. CERT receives advice on these activities from four Working Parties in the following specialized fields: Fossil Fuel Technology; Renewable Energy Technology; Energy End-Use Technology and Fusion Power. In addition there are two Technical Expert Groups in Electricity and Transportation Fuels. Mr. Bryan Cook is Canada's representative on the CERT Committee. The publication gives details of these activities and the membership of each of these groups including the respective Canadian representatives. There is also a complete list of the Implementing Agreements of the Agency indicating in which ones Canada is an active participant.

These reports and other descriptive material describing the work of the Program on Energy Research and Development (PERD) of the Federal government are available from the Office of Energy Research and Development, Department of Natural Resources Canada, 580 Booth Street, Ottawa, Ontario, K1A 0E4 (Fax: (613) 995-6148).

Reports issued by Environment Canada

(1) *CANADA'S NATIONAL REPORT ON CLIMATE CHANGE*

This 144-page *National Report*, dated 1994, has been prepared to show where Canada stands as of 1993 in regard to its commitments under the Framework Convention on Climate Change negotiated at the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in June of 1992. The report is divided into three broad sections. Section 1, entitled Canada and Climate Change, deals with such topics as Possible Impacts of Climate Change on Canada; Canada and Greenhouse Gas Emissions; and Canada's Framework for Action. Section 2, entitled Canadian Actions to Address Climate Change, deals with such subjects as Measures to Mitigate Climate Change; Climate Change Adaptation; Improving Decision-making, and International Cooperation. Section 3, entitled Assessing Canada's Progress in Mitigating Climate Change, deals with the National Inventory of Anthropogenic Greenhouse Gas Emissions, Climate Change Indicators, and Canada's National Emissions Outlook. Extensive statistical information is included and a list of selected references. The report concludes that additional policy measures are needed if Canada is to meet its climate change objectives. Copies of this report, catalogued as ISBN 0-662-211411-0, are available without charge from Environment Canada, Ottawa, Ontario K1A 0H3 (Fax: (819) 953-2225).

(2) SPECIAL ISSUE OF THE CO_2 *CLIMATE REPORT*

The special 15 page issue of the periodical CO_2 *Climate Report* assesses new developments in understanding climate change covering the period up to 1992. This subject was reviewed under the following headings: atmospheric composition; radiative forcing of climate; modelling climate change; climate change detection; CO_2 and climate change impacts. With 135 references, this issue provides a convenient update of the current situation in this field. The *Climate Report*, issued regularly by the Canadian Climate Centre of the Atmospheric Environment Service, is available from the Centre at 4905 Dufferin Street, Downsview, Ontario M3H 5T4 (Fax: (416) 739-4232).

(3) *REPORT ON THE THIRD TECHNICAL MEETING ON NATURAL SOURCES AND SINKS OF GREENHOUSE GASES*

This document is a record of a meeting held April 20-22, 1993, to review progress in the understanding of natural processes that govern fluxes of greenhouse gases into and out of the atmosphere in a Canadian context. The record, which became available in December 1993, provides a review of the state of scientific understanding of this question of importance to studies of the greenhouse effect. The appendix lists 70 participants with their addresses and so provides a wide range of contacts to workers in this field in Canada. Copies of this report are available

without charge from the Canadian Climate Centre, Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ont. M3H 5T4. (Fax:(416) 739-4232).

Full Fuel Cycle Chains and the Basket of Greenhouse Gases

This report is another in a series from the Netherlands Energy Research Foundation which presents an integrated analysis of options to reduce greenhouse gas emissions related to energy use in that country. While previous studies have concentrated upon CO_2, this study assesses the cost-effectiveness of emission reduction strategies for the Netherlands' energy system in relation to all greenhouse gases. Like previous studies, the option to capture and sequester CO_2 is specifically included in the analysis.

There are two surprising statements in the conclusions of this study: "Strategies in which greenhouse gas emission reduction is limited to direct CO_2 emissions do not automatically lead to a decrease in indirect emissions of CO_2, CH_4, N_2O and halocarbons" and "the difference in relative roles with respect to greenhouse gas emissions between coal and natural gas is hardly affected by the inclusion of the full energy chain and non-CO_2 greenhouse gases. Oil becomes relatively more attractive."

Copies of this report, numbered ECN-C-93-050, may be obtained from the Netherlands Energy Research Foundation, PO Box 1, 1755 Petten, The Netherlands. (Fax: +31 2246 4480)

Recent Reports Issued by the IEA Greenhouse Gas R&D Programme (Contractor in Brackets)

- OE1: *The Characterisation of Carbon Dioxide and other Greenhouse Gas releases from a Pulverized Coal Fired Power Plant equipped with Flue Gas Desulphurisation Facilities* (British Coal)
- OE2E: *Carbon Dioxide Capture — IGCC Additional Studies* (Netherlands Energy Research Foundation)
- OE6: *Long-term Advanced Carbon Dioxide Capture Options* (MIT Energy Laboratory)
- OE7: *Carbon Dioxide Capture: An examination of potential cryogenic processes for the collection of carbon dioxide and other greenhouse gases arising for power generation using fossil fuel* (INTECH).
- OE8: *Carbon Dioxide Capture: The characteristics of gas separation/ removal membrane systems applied to the treatment of flue gases arising from power generation using fossil fuels* (TNO).
- OE9: *The Characterisation of Carbon Dioxide and other Greenhouse Gases Released from a Natural Gas Fired Combined Cycle Power Plant* (SINTEF).
- OE9E: *Carbon Dioxide Capture: Alternatives of the capture of carbon dioxide produced from natural gas combined cycle systems* (SINTEF-Norway)
- OE11: *Preliminary Review of Carbon Dioxide Disposal and Utilisation Options*
- OE12A: *Carbon Dioxide Utilisation Chemicals* (Battelle Institute)
- OE13: *Carbon Dioxide Disposal — Ocean Disposal Study* (Technomare UK)
- OE14: *Carbon Dioxide Disposal: An examination of aquifers for the disposal of carbon dioxide arising from power generation using fossil fuel* (Stanley Industrial Consultants).
- OE16A: Carbon Dioxide Utilisation: Evaluation of long term forestry and short rotation cropping as two schemes for compensating or avoiding the carbon dioxide emissions from a 500 MWe coal-fired power station (VTT Finland).
- *Carbon Dioxide Capture: An Examination of Potential Gas-Solid Adsorption Technologies for the Collection of Carbon Dioxide and other Greenhouse Gases arising from Power Generation using Fossil Fuel* (MONENCO)
- A summary document entitled *Greenhouse Gas Emissions from Power Stations* is also available. Information concerning these reports and other activities of the IEA Greenhouse Gas Programme may be obtained from Dr. K.V. Thambimuthu of CANMET, 555 Booth Street, Ottawa, Ontario K1A 0G1 (Fax: (613) 992-9335).

Short Notes

- The cost of early decommissioning of nuclear reactors in the US is turning out to be higher than anticipated. Though most reactors had been assumed to last 40 years, some two dozen of the 107 reactors, which supply some 20% of the electricity in that country, are now due for closure within the next decade. In the past four years, six reactors have been retired long before the expiration of their operating licenses. The Congressional Office of Technology Assessment (OTA) predicted in a report issued in September of 1993 that the early retirement of aging and uneconomic reactors may result in substantial underfunding of decommissioning accounts. One economist, Geoffrey Rothwell at Stanford University in California, believes it will ultimately require as much as $33 billion to shut down all the nuclear plants over the next several decades. Early closings have made the disposal of radioactive wastes a more pressing problem. In Canada, the situation may be different as it is possible to extend the life of the CANDU reactors by tube replacement and other such measures. (Source: *Technology Review*, 97:1

(Jan.) 1994, p.20)

• A commitment in principle has now been reached between Ukraine and the US for the closure of the two remaining operating reactors at the nuclear power station in Chernobyl. The US is to assist Ukraine in finding alternatives for the energy lost involving conservation and the clean coal technologies, though there is still some doubt as to when this agreement will be implemented. Nuclear energy accounts for a third of Ukraine's electrical generation with the nuclear fuel supplied from Russia.

• The New Brunswick Electric Power Commission inaugurated its coal-fired 450 MW Belledune Generating Station on October 15, 1993. This $1 billion station is equipped with the utility industry's first flue gas desulphurization system in Canada. The wet limestone scrubber is designed to remove at least 90% of the SO_2 emissions. Ontario Hydro will inaugurate the second scrubber in Canada which is also of the wet limestone type on a 510 MW unit at its coal-fired 2040 MW Lambton Generating Station in May of 1994. A second scrubber will begin operation at this station in July. It now appears that the other two 510 MW units at Lambton will be mothballed as part of the utility's recently announced retrenchment policy.

• On December 16, 1993, the US Environmental Protection Agency announced its preference for the use of reformulated gasolines and ethanol blends in several metropolitan areas not in compliance with air quality standards. Large investments will be required in the refinery industry to produce gasoline to this formulation. It is also anticipated that a large market for corn will be established in the alcohol fuels industry.

• A pressurized water nuclear reactor has been placed in service in China only 50 km from crowded Hong Kong.

• On December 13, 1993, Atomic Energy of Canada Ltd. and the major Korean utility KEPCO signed a US$270 million contract for heavy water to be produced by Ontario Hydro at its Bruce Nuclear Generating Station. KEPCO operates CANDU reactors of Canadian design.

• A major advance in the field of fusion power was announced by the Princeton Plasma Physics Laboratory. On December 9, 1993, the experimental fusion reactor first generated 3 MW of energy and went on to generate 5.6 MW the next day. Typically each experiment lasted five to seven seconds, including the one-second burst of fusion power, with the temperature inside the reactor reaching between 300 and 400 million °C. In the next nine months the reactor is expected to generate 10 MW. By that time the usefulness of the $1.4 billion Tokamak-type reactor, will be exhausted. Construction began on this reactor in 1976 and the fusion program began in 1982 and is now reaching a successful conclusion. A more powerful unit is planned and it is thought the first commercial reactors could be operation by 2035. In Europe, the Joint European Torus is in operation near Oxford in England.

• Total expenditures on fusion research in Canada are estimated at $20 million per year. They are coordinated for the National Fusion Program by Atomic Energy of Canada. There are two main activities. The Tokamak at Varennes, Quebec, operated by Hydro Quebec, is largely devoted to studies in the field of plasma physics, while Ontario Hydro, a producer of tritium, coordinates studies in the field of fuelling systems. There have been some recent successes in the latter efforts.

• The Japanese fast breeder program is causing concern on the part of those responsible for the control of nuclear proliferation. Japan is a large importer of energy and there is a continuing worry about the security of energy supply in that country. The first fast breeder reactor (reactors that produce more plutonium than they consume) is expected to begin service within a year at the Monju Reactor at Tsuruga. More such reactors are expected to follow. The British government is expected to license a plutonium separation facility at Sellafield which will contract for the recovery of the plutonium and the Japanese industry will be its biggest customer. This development is a matter of concern for Canada since the uranium generally originates here, though there is no official stance on the issue of plutonium production or stockpiling by allied countries to serve civilian nuclear energy programs.

• Japan has reached a bilateral climate accord with the US to cooperate on the development of technologies capable of reducing greenhouse gas emissions. In the US, the EPA and the Departments of Energy and Commerce will be responsible for carrying out the agreement and on the Japanese side the New Energy Development Organization will be involved.

• A company in the Ottawa district, Thermal Energy International Inc., is now offering an improved system for the recovery of energy from flue gases under the trade name *Flu-Ace*. The system is designed to replace existing smoke stacks so that up to 90% of the flue gas waste heat may be recovered. This energy is used to heat water to 54-65°C, which is then circulated to provide heat for such purposes as space heating and air conditioning. Annual fuel savings are claimed in the range of 15-25%. Emissions are

reduced in two ways: less fuel must be used; and gases such as NO_X and CO_2 may be partly removed in the water. The process is basically a direct contact gas-to-liquid heat exchange and mass transfer device. The chemically-treated primary water, after contact with the flue gases, transfers its energy to re-circulating heating water in an exchange step. The emissions dissolved in the primary water may be removed by subsequent chemical treatment for disposal. The largest of the seven installed to date is at the Ottawa Civic Hospital. Previous efforts of this kind have encountered corrosion problems, which the company claims have been overcome through improved design and the selection of superior materials. Nearly all commercial and industrial heating plants now burn natural gas in the regions served by the pipeline network and there is little in this fuel to raise concern about releasing flue gas at low heights.

• A company based in Bellevue, Washington, American Flywheel Systems, Inc., has demonstrated a flywheel system for powering vehicles it claims is superior to batteries. The advance has been made possible by the development of high-strength carbon fiber composites and magnetic bearings. The system meets most goals specified by the US Advanced Battery Consortium. It is claimed the flywheel system can propel a GM Impact Electric Vehicle 480 km on one re-charge.

• Progress continues in the field of electric vehicles. An American company, Electronic Power Technology has devised a technique that permits the fast re-charging of batteries. A pick-up truck converted to battery operation by Solectria Inc. of Arlington, Mass. has established a new record for the distance travelled in 24 hours for an electric vehicle by using the new device. The technique permits charging times as short as 20 minutes, with less damage to the battery claimed than conventional slow charging. This latter company has sold some 70 electric vehicles since 1991 and has orders for 50 more. Many of these have been conversions of the General Motors Geo Metro car.

• The April 1994 issue of *Technology Review* (Vol.97, No.3) includes a comprehensive article on the future of fuel-celled vehicles based upon hydrogen or methanol by R.H. Williams of Princeton University.

• The US Bureau of Mines has developed a hydrogen-powered internal combustion engine rated at 74 kW to replace diesels in underground equipment in mines. A spark ignition engine has been modified for independent feed of the hydrogen and air to the cylinders to prevent the backfires often encountered when hydrogen is used. The hydrogen is held in the form of hydrides, which are decomposed with the heat of the engine exhaust. Special safety precautions have been taken, such as separating the hydride fuel supply into independent modules and selecting alloys such that the equilibrium vapour pressure of hydrogen over the hydride is below atmospheric pressure at ambient temperatures.

• Recent studies of the world carbon balance are now placing more emphasis on the northern boreal belt of woodland which covers some 1.2 billion hectares in Alaska, Canada, Scandinavia, and Russia. It now appears that this vast belt acted as a sink for carbon from the atmosphere from about 1920 to 1970. In the late 1970s, however, the boreal and temperate forests began to lose wood rapidly and once again became a source of CO_2 to the atmosphere as world forestry operations intensified. It is proving difficult to reach an international consensus on ways of stabilizing these forests. (Source: *New Scientist*: 8 January, 1994, No. 1907.)

• Statistics Canada now publishes two continuing reports on energy data. The *Energy Statistics Handbook* provides detailed energy and energy-related statistics in one 256-paged binder with over 150 tables. Annual data is provided for the past 10 years. Updated information is provided every month. The *Quarterly Report on Energy Supply-Demand in Canada* provides 196 pages of data with 98 tables including a current year-to-date set of balance sheets in a standardized format for each province. Both these publications may be obtained from Statistics Canada, Ottawa, Ontario, K1A 0T6 (Fax: (613) 951-1584).

• Mr. Jack Siegal, Acting Assistant Secretary for Fossil Energy in the US Department of Energy stated in a recent speech that pressurized fluidized combustion of coal will be the technology of choice for utilities in the US to meet the requirements under Phase 2 of the *Clean Air Act* to take effect in 2000.

• In a major government reorganization in Alberta, two previously separate agencies, the Alberta Oil Sands Technology and Research Authority and Alberta Oil Sands Equity will be merged into a new oil sands division in the Energy Department.

• A Russian engineer, Alexander Gorlov, now associated with Northeastern University in the US, has devised a new method of obtaining hydropower from low-head sites, including possibly tidal power. The system works on the principle of the displacement of air by water, which in turn powers a turbine in a manner somewhat similar to the approach used in some wave power apparatus. The Central Main Power Company is studying the technique. (from *Technology Review*, April 1994,

pp.13-14)

• Research conducted at the Experimental Lakes Area in northwestern Ontario — a group of 47 pristine small lakes remote from population centres — indicates that the quantity of methane and CO_2 (both greenhouse gases) released when land is flooded behind dams is significant. Hydro power may not be a completely clean source of energy in respect of emissions of greenhouse gases.

• The Canadian Broadcasting Corporation, in its program *Witness*, devoted a further one hour to activities in the cold fusion field on April 4, 1994. (See *ESR* 5:1, p.76, for an account of the first such broadcast.) The two originators of this highly controversial field of research — Dr. Stanley G. Pons and Dr. Martin Fleischmann — are continuing their efforts in a laboratory in France financed largely by the Toyota group. There is now an international network of people working in this field, with the first signs of commercial activity including reports of the acquisition of patents and patent applications. There is still no coherent explanation for the evolution of "excess heat" reported by several experimenters but disputed by many.

• Edmund Storms has reviewed the current status of Cold Fusion in a balanced and comprehensive article appearing in *Technology Review*, Vol. 97, No .4 (May/June) 1994, pp. 19-29. This article includes a number of hypothesis for the explanation of this increasingly perplexing phenomenon.

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