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DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

REPORT ON OVERSEAS VISIT
OCTOBER-NOVEMBER 1980

BY

R.K. JOHNS
DEPUTY DIRECTOR-GENERAL

DECEMBER 1980

RB. 81/14

6th February, 1981.

Hon. E.R. Goldsworthy,
Minister of Mines and Energy,
Parliament House,
ADELAIDE. 5000.

Dear Mr. Goldsworthy,

I have much pleasure in forwarding a "Report on overseas visit, October-November 1980" which has been prepared to document technical details and non-confidential aspects of the matters canvassed during discussions and inspections on our visit to Canada, England, Sweden, Holland, France, Israel, Japan and Hong Kong.

Yours sincerely,

(R.K. Johns)
DEPUTY DIRECTOR-GENERAL

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REPORT ON OVERSEAS VISIT - OCTOBER TO NOVEMBER 1980

SUMMARY

The writer was privileged to travel overseas in the company of the Minister of Mines and Energy, Mr. E.R. Goldsworthy and his Press Secretary, Mr. R.G. Yeeles during the period 5th October to 23rd November, 1980 to study a wide range of energy issues and aspects of energy resource development and management, particularly with regard to uranium. Discussions were held with Ministers of Mines and Energy, senior Government officers and members of Government agencies, electricity generating authorities and utilities, atomic energy authorities and company representatives in the countries visited; Australian Ambassadors, Embassy staff, trade officers and counsellors also assisted and arranged appropriate visits. Inspections were made of several mining and processing operations in Canada and to industrial nuclear centres and processing sites in England, Holland, France and Japan.

This report has been prepared to document technical details and non-confidential aspects of the matters canvassed during discussions and inspections. An appreciation of overseas mineral and energy resource developments will find immediate application in planning for similar undertakings which have been foreshadowed in South Australia, including the mining and processing of uranium, management of radioactive wastes, exploration and exploitation of hydrocarbons and coal resources, and petrochemicals and alternative energy modes.

Demand for procurement of uranium supplies is expected to expand by the next decade and great interest was displayed, everywhere, in the progress of development at Roxby Downs. It seems likely that production from Olympic Dam which might be anticipated within that time will also coincide with forecast improvements in uranium price. Great interest was also evinced in possible participation in enrichment of uranium in Australia; promotion of South Australian initiatives is seen as timely since lead times for delivery would equate with what are perceived as increased requirements by 1990 in the U.K., Europe and Japan.

In connection with possible establishment of a petrochemical industry in this State, opportunities for development were promoted in Canada, Europe, Japan and Hong Kong.

The Canadian scene is of particular interest and has great relevance to the situation in Australia since populations and political systems are similar, and there are common problems of distance and concerns for mineral development and future energy supply; as in Australia, the Provinces have responsibility for mineral ownership and development but also have taxing powers not available to the Australian States. The Canadian Federal Government is involved with formulation of national energy policy, which conflicts with Provincial objectives, and seeks a larger share of energy based resource revenues. The energy rich Western Provinces, in particular, derive enormous financial benefits, from profit-based royalty arrangements and taxation revenues and have established 'heritage funds' for local welfare promotion.

Canadian uranium deposits vie with those of Australia for markets and rigorous programmes of exploration and development are being progressed; subject to strict health, safety and environmental safeguards.

Recent inquiries relating to uranium mining in Saskatchewan and to nuclear power generation in Ontario have found that these activities are acceptably safe. At a Toronto Energy Conference, attended by over 500 delegates representing Governments, energy authorities, industry and associated special interest groups from North America, Europe and Japan, several speakers urged the expansion of nuclear generating capacity in advanced nations to spare conventional fuels for the developing and under-developed nations and expressed concern for the absence in some countries of the political will to proceed with uranium mining and nuclear power. There are 11 nuclear reactors in operation in Canada, generating 5475 MWe, with a further nine under construction having an additional capacity of 5600 MWe.

U.K. experience in nuclear power generation and uranium conversion, enrichment and reprocessing of spent fuels has earned a reputation for safe and responsible involvement in the nuclear industry. The British have pioneered nuclear reactor developments and in conjunction with Netherlands and West Germany an alternative enrichment process based on gaseous centrifuge. The U.K. is self-sufficient with regard to oil and gas and, while there are large coal reserves defined, coal is becoming increasingly expensive to mine and use in conventional power stations. There are 16 nuclear reactors in operation, including a fast breeder, which generate 7100 MWe or 13% of Britain's electricity requirements; by 1985 this will rise to 20% and by the year 2000 this is expected to be 40,000 MWe or 30% of output. It is proposed that one new plant of 1500 MWe capacity will be commissioned each year from 1982. The cost of electricity generated by this mode is substantially lower than that from coal-fired stations.

France is committed to development of nuclear energy through lack of alternatives and is involved with all phases of the nuclear fuel cycle - mining, milling, processing, conversion, enrichment, fuel fabrication, reactors, reprocessing of spent fuels and disposal of radioactive wastes. There are 23 nuclear reactors in operation, including a fast reactor which generate 25% of electricity output and having an installed capacity of 13,000 MWe; by 1985 this will comprise 50% (40,000 MWe) and by 1990, 73% (65,000 MWe).

Japan, likewise, has no real alternative but to expand its nuclear energy programme. The nuclear electricity generation capacity is presently 15,000 MWe or 11% of the total output; by 1985 it will comprise 30,000 MWe (16%); by 1990 it is expected to be 53,000 MWe (23%) and by 1995 to be 80,000 MWe (28%). There are 21 nuclear power plants in operation and seven units under construction.

Of the countries visited, expansion of enrichment capacity is being progressed in England, Holland and France; new facilities are being installed in Japan; and new different chemical processes are under investigation in France and Japan.

Radioactive wastes resulting from reprocessing of spent fuels are generally being stored on site. In France, vitrification of wastes has been undertaken successfully at Marcoule since 1978. Final storage of high-level radioactive waste has been researched in Sweden where it is envisaged that a repository will be put into operation through deposition of encapsulated waste containers in granite when required, about year 2020. Nuclear energy from six reactors now provides about 25% of the electricity produced in Sweden and this share is expected to rise to 40% in the late 1980's, following a national referendum on the risks and acceptability of nuclear energy.

Alternative energy sources were investigated in Israel where a 150 Kw pilot solar electrical power station is in operation using heat collected in a solar pond adjacent to the Dead Sea. Harnessing of the Dead Sea through further development of this system and a re-establishment of water levels through connection of the Dead Sea by construction of a canal to the Mediterranean are imaginative concepts which are envisaged for the future.

Discussions with the Japanese Electric Vehicle Assosiation suggest that high costs and short range make electric vehicles an unattractive proposition in Japan and on a per capita, per car basis, the effort in this area would appear to be less than in South Australia.

CANADA

OTTAWA, 15th-16th October, 1980

Hon. Judy Erola, Minister of State (Mines)
Jack Masters, M.P., Parliamentary Secretary to the Minister
Gustyna Kuryllowicz, Special Assistant to the Minister
Margo Langford, Special Assistant (Press) to the Minister
Mrs. Autochi, Parliamentary Relations Secretariat
H.E. Barrie Dexter, Australian High Commissioner
Richard Bush, Counsellor (Resources) Australian High Commission
John Groves, Director, International Energy Policy Division, Department of External Affairs

Department of Energy, Mines and Resources

Jean Paul Drolet, Senior Assistant Deputy Minister, International Minerals
Bob Hutchinson, Acting Assistant Deputy Minister, Minerals Section
Charles Smith, Senior Assistant Deputy Minister
Paul La Fleur, Mineral Attaché
Dick Williams, Advisor, Uranium
Bob Lyman, Energy Strategy Group

Department of Industry, Trade and Commerce (Resource Industries Branch)

John Patterson, Senior Commercial Officer, Non-Ferrous Metals Division
George Nash, Director, Metals and Minerals Group

Atomic Energy Control Board

John Jennekens, President
David Smythe, Member
John Viljoen, Member

TORONTO, 13th-14th October, 1980

Hon. Robert Welch, Minister of Energy and Deputy Premier of Ontario
George Jewett, Deputy Minister, Ministry of Natural Resources
Andrew Frame, Ministry of Energy
Arthur Porter, Chairman, Royal Commission on Electric Power Planning
Ian MacDonald, President, York University, Toronto
Norm Olsen, President, British Columbia - Hydro
Eric Ruttley, Secretary-General, World Energy Conference (London)
Llewellyn King, "The Energy Daily" (Washington D.C.)
Dr. Carroll Wilson, Director, The World Coal Study (M.I.T. - Mass., U.S.A.)
Dr. David Drinkwater, Chief Economist, Ontario Hydro, Ontario
Patricia Moessinger, Vice Consul and Trade Officer, Australian Consulate General

MONTREAL, 15th October, 1980

Neil Phillips Q.C., Phillips and Vineberg
Ivan Phillips, Phillips and Vineberg

Canada is locked in one of the gravest constitutional crises in the history of the country's 113 years of federation and a battle is being waged in the courts and in TV commercials; at stake is the unity of the country according to some observers.

The struggle is about oil, power and natural gas. Prime Minister Trudeau is fighting to keep the country together and as a measure of the battle's intensity the Canadian Government's propaganda now makes it the single biggest advertiser on TV. The Provinces seek to control their own destiny and, in particular, of oil and gas in the Western Provinces. Trudeau can get no consensus on how power should be shared between the Federal Government and the ten rebellious Provinces.

At present the British North American Act of 1867 is Canada's constitution and the Canadian Prime Minister has sought to transfer the Act to Canada from Westminster, along with the power to make changes.

Alberta produces 90% of Canada's oil and wants world prices for the 1.6 million barrels it produces daily. Trudeau wants the cost of Canada's oil kept down and seeks a bigger slice of the tax revenues for the Federal Government. He wants the same from natural gas. His recent budget made it law and Alberta has rebelled. The Alberta Premier, Peter Loughheed, appeared on TV and told the Province to choose between "Peter and Pierre". Assured of public support he then announced that he would be cutting off the oil. Trudeau backed down saying that he was prepared to reopen negotiations.

Another revolt is simmering in Newfoundland, the poorest of the Provinces, but which has recently discovered offshore oil.

The Minister for Energy, Mr. Lalonde has announced that the Government's goals under its new energy programme were three-fold:-

(1) A 50% Canadian stake in the country's oil and gas industry by 1990;

(2) Canadian control of a significant number of the larger oil and gas firms;

(3) the Government's retention of a 25% interest in federal Canadian lands.

Mr. Lalonde said that 72% of oil and natural gas revenues went to foreign-controlled companies last year.

Australian mining and energy stocks are likely to benefit from the fallout from the Canadian Government's new harsh tax and energy policies and a decline in exploration activity in Canada might be anticipated. The Budget imposes new and heavy taxes which will be borne largely by producers, thus reducing cash flow and profits. More dangerous to Canada, however, is the new national energy policy introduced at the same time. The new policy will result in a drastic depression of exploration activity in Canada, a decrease in jobs in central and western Canada, and complete elimination of any possibility of self-sufficiency in oil at any time in the future according to one Canadian exploration company.

Energy Resource Developments

Canada is a net exporter of energy overall. In 1979, Canada's trade surplus in energy commodities was over $2.1 billion, with exports of natural gas, electricity and uranium partially offset by net imports of crude oil and coal.

Current energy problems primarily relate to the necessity for continued oil imports due to the slowness in finding frontier oil and in developing oil from tar sands. The oil and gas reserves are located in the western Provinces, principally Alberta, while the largest domestic markets are located in Ontario and Quebec. Federal energy policies are geared towards co-ordinating the supply/demand imbalance and attacking the current import requirement of 320,000 barrels a day for consumption in eastern Canada. Energy strategies are aimed at increasing the domestic supply of oil (and substituting other forms of indigenous energy, such as natural gas, for oil) through improved recovery from established reserves, production of non-conventional crude, and frontier and offshore development.

Canada has a 75% oil self sufficiency; 12% of requirements are imported from Venezuela, 12% from Saudi Arabia and 1% from Iraq.

Developments in the Beaufort Sea and off Canada's east coast augur well for Canada's attempt to become self-reliant in oil. Dome Petroleum is optimistic about the long term potential for the production of oil and gas from the Beaufort Sea and oil is expected to be flowing from the Beaufort area by the mid 1980's. Off the east coast of Newfoundland, up to 10 new exploratory wells are planned by three different groups. If further drilling proves the discovery to be commercial, Mobil, the Hibernia operator with Chevron and Petrocan, estimates that production could begin by 1985. Until more is known, the Board does not include these frontier and offshore resources in any estimate of recoverable reserves.

The natural gas situation in Canada is more secure than that of oil. Rather than having to rely upon technological breakthrough or potential discoveries to meet Canadian requirements, current natural gas supplies from established reserves, currently estimated at 71.8 TCF, are more than adequate to meet domestic demand. As well, frontier areas and as yet non-commercial sources provide a further backstop to these estimates. However, before these potential reserves can contribute to the current surplus situation, deliverability must be assured. It is for this reason that the Board's estimated established reserves of 9.2 TCF for the Arctic Islands and 5.3 TCF for the MacKenzie Delta cannot be considered surplus to Canadian requirements until appropriate means of bringing them to market are established, taking into account economic and environmental considerations.

Included among current proposals to bring these reserves to market is the Arctic pilot project which calls for the liquefaction of 6.4 million cubic metres of gas daily from Melville Island. Ice-reinforced tankers would carry the LNG year-round to a port on the St. Lawrence River or in the Maritimes for gasification. The proposed project calls for 2 TCF of natural gas to be delivered to eastern Canada over a 15 year period with initial deliveries as soon as 1983 and an equivalent amount to be exported by displacement from western Canada. Participants in the project are Petro-Canada (37.5%), Nova (25%), Dome Petroleum (20%) and Melville Shipping (17.5%).

Another similar project is the Polar Gas 'Y Line' project for transporting both Arctic Islands and MacKenzie Delta gas to eastern Canadian markets via large-diameter pipeline (much of this gas would be destined for the export market). Four different routes for the line are being considered and another transportation alternative is the Dempster Lateral which would link the MacKenzie Delta reserves to the Alaska Highway gas pipeline near Whitehorse.

The deep basin area of Alberta and British Columbia is another potential source of natural gas. However, the gas cannot currently be economically recovered from the very low permeability rocks given conventional production technology.

Canada has measured and indicated coal reserves of approximately 16 billion tonnes. Of these, approximately 6 billion tonnes with an energy value of 48,500 petajoules, are recoverable under conditions of current prices and technology. British Columbia and the Yukon account for 1.4 billion of these currently recoverable reserves with 900 million tonnes being metallurgical coal and the balance thermal. Most of Canada's coal exports originate from the coal fields in south eastern British Columbia.

Uranium resources in Canada are reviewed by a committee formed within Energy, Mines and Resources to ensure that reserves are adequate to satisfy domestic nuclear fuelling requirements. It requires that any exports of uranium be used for peaceful purposes and that uranium processing be as advanced as possible, before export.

Canada is a major supplier of uranium to Japan and a long-term contract has been signed with Denison Mines. Foreign investment is welcomed if it is found to be in the Canadian interest.

Canada's Policy vis a vis the Export of Energy Resources

The National Energy Board is charged with the responsibility of ensuring that reasonably foreseeable Canadian requirements for oil, natural gas and electricity are protected before exports are allowed. Only if there is an excess of the energy form after current and reasonably foreseeable Canadian requirements are met, is a surplus found to exist. Once it is determined that a surplus exists, exports are still only allowed if they are found to be in the Canadian public interest, and if the price is found to be just and reasonable.

Canada does not produce enough light crude oil to satisfy domestic requirements and therefore current exports are restricted to heavy crude, all of which is not needed as a feedstock for Canadian refineries. In the absence of a surplus of oil and pending a technological breakthrough such as those being pursued in Alberta, there is little likelihood that new exports of light oil would be approved.

However, the prospects for further exports of natural gas and liquefied natural gas are favourable if Canada's potential reserves continue to be proven up, if a transportation system can be put in place, and if the proposed exports are surplus to Canadian requirements.

The installed electricity generating capacity in Canada is 77,000 MW; by 1990 it is scheduled to be 100,000 MW. The Federal Government fixes the amount and price for electricity exported to the U.S.

A new U.S. line for Canadian natural gas is being planned by a group of 14 northeast U.S. utilities at a cost of $200 million for the supply of 185 million cub. ft. of gas per day. It will displace about 3 million barrels of oil a year in New England.

The U.S. currently imports 5.1% of its 12.3 trillion cub. ft. a day total gas consumption, mostly from Canada, whose $4.47 per 1,000 cub. ft. paid to U.S. producers. Canada had planned to raise its border price to $5.14 per 1,000 cub. ft. but postponed the increase recently because of competition from cheaper U.S. gas and fuel oil. As a result of the competition, Canada's gas exports to the U.S. fell to 51% of contracted volumes in August 1980.

Petroleum, pricing, taxation policy

The Federal Government was reported to be considering the imposition of a production tax on petroleum produced in Canada as a way of providing new energy revenue for its coffers.

Such a production tax has further angered Alberta since the Province is opposed to a Federal natural gas export charge. The tax was designed to prevent a significant amount of oil and gas revenue from ever getting into the hands of the Alberta Government by way of royalties. It is similar to the wellhead tax which the former Canadian Federal Government was planning to drop in favour of a windfall profits tax on the petroleum industry.

The production tax is understood to be as high as 5%; at this level it would represent about 83 cents a barrel on oil and add $500 million to Federal coffers. Revenues from a similar tax on natural gas production could provide an extra $200 million.

Alberta has control over production rates and seeks a voice in pricing; as one commentator put it "no one expects Ontario to sell gold to Alberta for $35 per ounce - why should the price of Alberta oil to Ontario be $16.75 per barrel, equivalent to 45% of the world price?" Albertans maintain that they have subsidised industry in eastern Canada to the tune of $30 billion and now seek prices for their petroleum products more in keeping with world prices.

The use of drilling rigs in Canada is expected to drop to 59% of available capacity over the next 15 months from full utilisation in 1980. A recent survey of 61 drilling contractors (representing 90% of rigs available) showed that the equipment market is over-supplied and, as a result, 49 rigs will move to the U.S. in the same time period.

There are 572 rigs in western Canada and 475 are drilling or preparing to drill, representing 83% deployment. There are enough rigs in Canada to drill 11,000 wells a year, based on the 1979 average depth - an earlier forecast was for a total of 8,900 wells to be drilled this year.

The Federal Government has adopted a policy of relating Canadian prices for oil to costs of exploration in Canada, and not to world prices. The price of oil was fixed through an agreement with the Provinces in 1974 and this expired in August 1980.

Uranium

Canadians were particularly interested in new and projected uranium developments in Australia, including that at Roxby Downs, since Australia looms as a strong competitor for markets, capacity for new resource development and potential for further discovery; Canada and Australia each have about 12% of the world's assured resources.

Canadian mine shipments (tonnes U) are as under:-

1976	1977		1978	1979	1985 (forecast)
5438	5787		8211	6956	14400 (20% of world production)
domestic consumption				690	1620

Projected uranium production levels anticipate that appropriate Federal export approvals will be forthcoming and that contracts will be secured.

Exports are made to the U.K., U.S.A., Germany, Spain, Italy and Japan subject to satisfaction of safeguards provisions, assurance on reprocessing for peaceful purposes and assurance on availability of domestic needs for 30 years. Audits are undertaken regularly to assess supply and demand and market stability to establish guidelines for sequential development of deposits. Contracts are approved only for 15 years (the last five of which are subject to variation).

Depression of price to \$US30/lb U_3O_8 is considered to be due largely to unloading of stockpiles by utilities to reduce interest payments; price is expected to fall to perhaps \$25/lb and a soft market to persist at least to 1985 or even 1990. However, problems relating to disruption of Middle East oil supply and the election of Mr. R. Reagan as U.S. President were seen as factors influencing a turn about.

There are six producers of uranium in Canada; four underground mines in Ontario, in the Elliott Lake district (Rio Algom, Denison Lake, Mattiwaska Bancroft, and Agnew Lake) and two in Saskatchewan, Uranium City (Eldorado) and at Rabbit Lake (Gulf/Uranerz). Discoveries of large deposits have been made in Saskatchewan at Cluff Lake, Key Lake and Collins Bay - these are now being prepared for production following the Cluff Lake Enquiry, which took two years to give a favourable determination.

There is an ownership objective of 2/3 Canadian, 1/3 foreign in uranium development (cp. 50/50 for oil and gas) on new projects.

Mineral resources are owned by the Provinces and, thus, tenure, exploration and development are provided for under Provincial legislation.

Uranium, however, has overall Federal jurisdiction through the Atomic Energy Control Act, administered by a Board which issues licences for extraction of more than 10 kg of uranium/year, in a concentration exceeding 0.05%, development licences, production licences and export licences.

The Federal Government Crown Company, Eldorado Nuclear Ltd., is engaged in exploration and development of uranium, production of hexafluoride and fuel fabrication.

Atomic Energy Control Board

The Board employs a staff of 190, including engineers and scientists, concerned with control and regulation of all aspects of atomic energy. Current regulations require a licence to mine, refine, process or use prescribed substances; to export such substances; or to produce deuterium or nuclear energy - these require that acceptable health and safety standards will be met and maintained and that any wastes will be stored or disposed of in a satisfactory manner. Relevant Acts and Regulations relating to standards, monitoring and audits are administered in conjunction with Provincial Government Departments (Health, Environment, Transport, Natural Resources, Transport, Labour) through co-ordination or designation.

Mining and milling of uranium ore

The Board has imposed a requirement for a full personal dosimetry programme to monitor gamma exposure in mines. Gamma radiation constitutes the principal hazard in recovery of high grade ores from open pits in Saskatchewan; whereas, in the underground mines of Ontario, radon daughters are the principal problem requiring adequate ventilation.

Refining and conversion facilities

Eldorado Nuclear Ltd. operate a refinery at Port Hope, Ontario for conversion of yellowcake to UO_2 (fuel for CANDU reactors) and UF_6 (for export, to be enriched and used in reactors requiring enriched fuel). There are no enrichment facilities in Canada.

Fuel fabrication facilities

Pellet production and fuel assembly is undertaken at eight locations but the principal plant is operated at Port Hope by Eldorado Nuclear Ltd. and having a capacity (tonnes/year of uranium) as follows:-

5,700 as UF_6; 7,700 as UO_3; 1,500 as U; and 2,000 as UO_2

Heavy water plants (for production of water enriched in the natural isotope deuterium oxide - a neutron moderator and coolant in the CANDU power reactor)

While production of heavy water from the six plants presents no radiological hazard the process uses large quantities of highly toxic H_2S. It is essential that plants are well engineered, constructed, operated and maintained to contain the gas and provide adequate safety and emergency systems.

Nuclear reactors

There is only one type in operation in Canada, the CANDU which uses natural uranium in the form of UO_2 pellets as fuel.

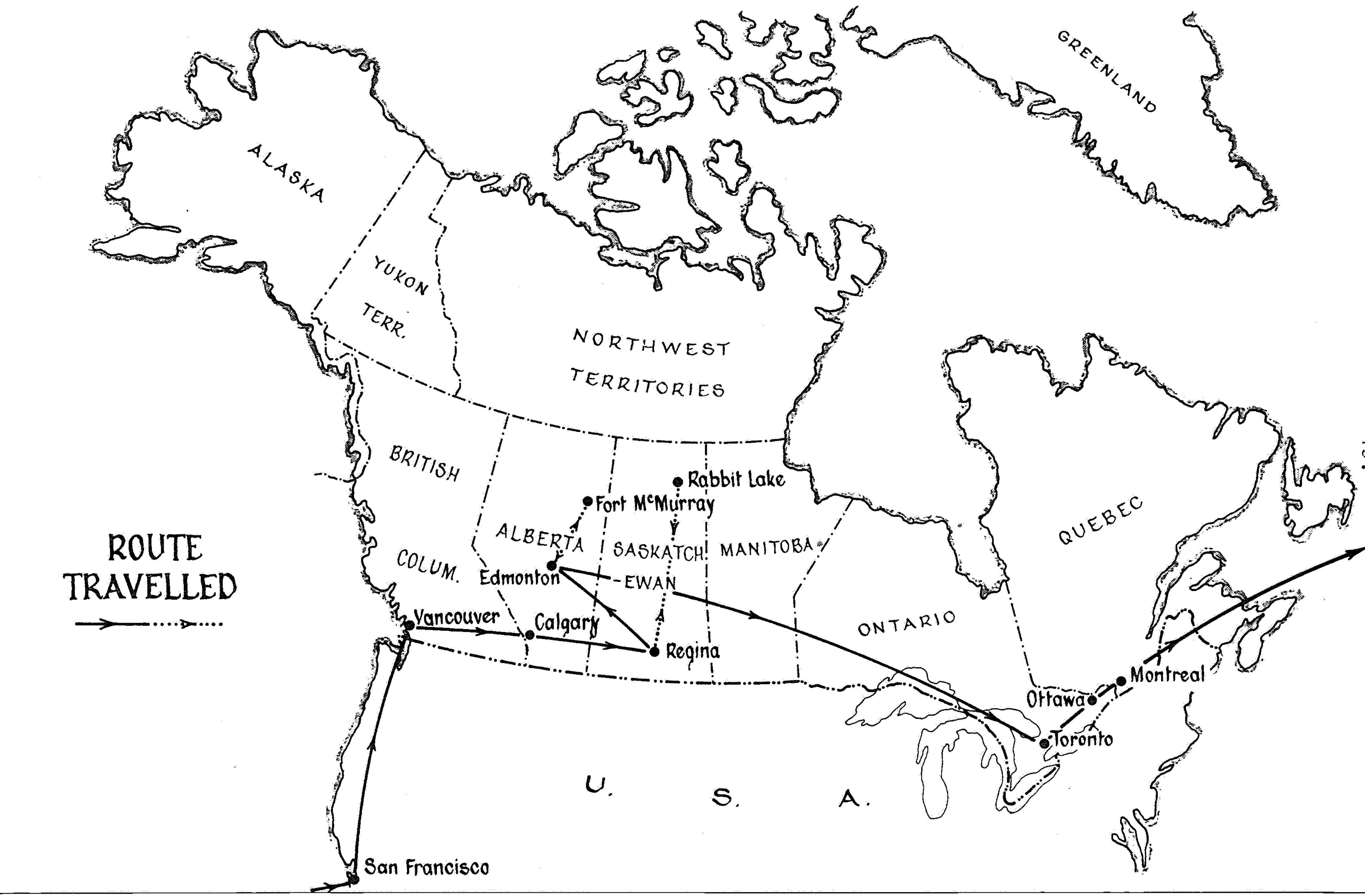
Power reactors licensed and planned are as follow:-

Facility	Operator	Capacity (MWe)	Status
Rolphton	Ontario Hydro & AECL	25	Start up 1962
Douglas Point	" " " "	200	" " 1966
Pickering 1 to 4	Ontario Hydro	2,000	" " 1971
Bruce 1 to 4	" "	3,000	" " 1976
Pickering 5 to 8	" "	2,000	Planned 1982
Bruce 5 to 8	" "	3,000	" 1983
Darlington 1 to 4	" "	3,400	Construction site accepted
Gentilly	Hydro Quebec & AECL	250	Start up 1970
Point Lepreau	New Brunswick EPC	600	Planned 1982

Radioactive waste management

Large volumes of waste rock and mill tailings, which have low level activity, are produced at uranium mines and are contained within natural and engineered barriers.

Low-level refinery and reactor wastes are being stored on site and high-level wastes from reactors are held in storage bays under water.



Department of Mines and Energy - South Australia.

BRITISH COLUMBIA - VANCOUVER, Monday 5th October

John Tait, Australian Consulate
Allan Poole, Mining Engineer, Director of Safety and Compensation
Miller Mason, Counsel (The Mining Association of British Columbia)

The Mining Association of British Columbia is a private organisation representing the interests of the operating mines in B.C. and Yukon and is concerned with legislation and taxation, health and safety, labour relations, pollution control. The following data were obtained during discussions with Association officers.

Mineral discovery/development in British Columbia

Coal was discovered on Vancouver Island in 1850 with mining started soon after. In 1858 gold placers were discovered on the Fraser River and the search for gold led to the discovery of base metals - mines based on base and precious metals developed in the Kootenays, adjacent to the U.S. border and along the coast. The advent of rail led to the opening of coal mines at the turn of the century.

In the late 50's and early 60's low grade deposits of copper based on open pit mining were developed to meet increased demands of the Japanese market. This gave rise to great exploration activity and many new finds were made and it is now estimated that proven undeveloped reserves equal the present reserves being mined; and that there are a further 300 signifciant new deposits requiring further investigation.

Before 1960, mining was mostly by underground methods but today almost 90% of the tonnage of ore mined comes from open pits.

Increases in world mineral prices, a stabilisation of Federal and Provincial tax policies and some moderation in inflation in 1978 created an optimism in the industry which was said to have been notably absent in the previous six years.

In 1979 the British Columbia mining industry set new records in revenues, earnings, expenditures, wages and salaries, tax contributions and capital invested and benefited greatly from substantial price rises in copper, molybdenum and lead; the increased value of exports and higher wages and taxes had a strong positive effect upon the British Columbia economy. Investment in exploration, development and capital expenditures also reached new record highs in 1979, reflecting the renewed optimism in the industry in the last two years. Major developments in progress, which are estimated to cost some $1.2 billion by completion, had a notable effect on expenditures in 1979 and will generate further large increases in production over the next few years, with consequent positive impacts on jobs, wages and taxes.

Total earnings of the industry after taxes exceeded $500 million, over 80% of which was directly reinvested in the form of exploration, development and capital expenditures during the year. This compares with earnings of $185 million in 1978 and $119 million in 1977. However when inflationary factors are considered the picture is not quite so bright and the industry looks to higher metal prices in the future, particularly where new mines are concerned.

While the return on investment for the industry in 1979 was 35.2% the average over the last ten years was only 14%.

The main minerals produced in order of net sales revenue were copper, coal, molybdenum and zinc. The total net sales revenue amount to $2 billion (42% of sales are to Japan, 17% to the U.S., 10% to the U.K., 12% to Canadian markets and 18% to others).

Total exploration and development expenditures were a record $102 million in 1979 (as compared with $65 million in 1978 and $59 million in 1977). Substantial increases were recorded for exploration, development on non-producing properties, and development costs on producing properties. There are 13 major projects underway or announced costing over $1.2 billion; these include new mines, old mines being reopened and expansions to existing plants.

Mining industry expenditures in 1978 had an estimated income multiplier effect of $1,500 million on the Province of B.C., about 5.4% of the gross Provincial product, and on Canada as a whole of $3,300 million. In addition to the 15,600 direct employees in the industry, mining expenditures were estimated to support a further 40,000 employees in other B.C. industries and, in Canada as a whole, a total of 110,000 other employees.

As at end of 1978, the major operations in B.C. were estimated to be 59% beneficially owned by Canadians and 55% controlled by Canadians.

Advantages enjoyed by the mining industry in British Columbia were given as:-

- significant ore reserves and the potential for discovering more since the success ratio is high
- stable political climate
- industrial capacity nearby in eastern Canada and the U.S.A.

- a well educated and motivated work force.
- adequate energy reserves.

Their disadvantages were listed as including:-

- rugged mountainous topography
- relatively severe climate
- poor access to much of the Province
- a need for more skilled workers at this time of expansion; the chronic shortage of skilled workers has led to very high wage rates.

Their concerns included:-

- ever increasing Government bureaucracy
- the trend to more public involvement in decision making
- over reaction to environmental protection
- Native Indian claims
- the division of power (Federal vs. Provincial).

There is pressure exerted to have more domestic processing of mine production. This has not been economical as long as the Japanese need feed for their smelters and as long as B.C. wages and construction cost remain high.

Energy Resources

Hydroelectric power serves a large proportion of electricity generation and has not been developed to full capacity. Surplus electricity is supplied to the U.S.

There is small production of oil from the Peace River area and natural gas production surplus to requirements which is piped to the U.S.

Coking coal is exported to Japan while a new large deposit of lignite is being developed by the Hydroelectricity Corporation.

The Provincial Government invoked a seven year moratorium in April 1980 on exploration for and development of uranium (the moratorium was imposed before a Royal Commission had reported its findings - and these are still awaited).

SASKATCHEWAN - REGINA, 6th-8th October, 1980

Michael Jackson, Director of Protocol
Hon. Norman Vickar, Minister of Industry and Commerce
Jeff Bugera, Deputy Minister, Department of Industry and Commerce
Trevor Apperley, Consultant, Trade and International Projects Division, Department of Industry and Commerce
Dale Christianson, Vice President, Resource Development, Saskatchewan Oil and Gas Corporation
Bill Douglas, Vice President, Exploration (Saskoil)
Fred Ursel, General Manager, Saskatchewan Power Corporation
Vergil Nelson, Vice President, Energy Supply and Planning, SPC
Mike Allan, Director of Coal Supply and Environmental Programmes, SPC
Hon. John Messer, Minister of Mineral Resources
Robert Moncur, Deputy Minister of Mineral Resources
Howard Leeson, Deputy Minister of Intergovernmental Affairs
Hon. Allan Blakeney, Premier of the Province of Saskatchewan

Saskatchewan's economic structure is undergoing profound changes. From an almost entirely agricultural economy it is changing to one in which the mineral industry now contributes almost 50% of the Province's commodity production. The population totals approximately 1 million and the unemployment rate in 1979 was 4.2%.

The changeover started slowly in the post war era with the discovery of oil and grew as service and supply industries developed to support this find. This was followed by the discovery of potash and the production of natural gas. Recently uranium has been recognised as being important to development of the sparsely settled northern part of the Province. Production of uranium was stepped up in 1976 with the opening of the Rabbit Lake open pit mine and with Eldorado's underground operations at Uranium City. Expenditure related to uranium exploration exceeded $80 million in 1979 and is expected to total $100 million in 1980.

The value of mineral production in 1979 totalled $1,795 million as under:-

	$ million
petroleum	720
potash	695
uranium	218
coal	31
natural gas	15.5
sodium sulphate	24
salt	12
copper	0.8
other metals	0.6
cement	35
sand, gravel, clay	21

With the discovery and development of oil, gas, uranium, coal and other resources the prairie provinces (Saskatchewan, Alberta and Manitoba) have become somewhat more affluent than the rest of Canada and their economies are expanding at a much faster rate than the nation as a whole - thus the centre of economic influence has moved west.

Energy resources, more than anything else, assure Saskatchewan's long term economic success and there are huge reserves, as follows:-

lignite - 7,500 million tons
crude oil (light and medium) - 770 million barrels (recoverable at current prices and technology)
heavy oil - 14,000 million barrels (in place)
natural gas - 1.3 trillion cub. ft. (39 billion m^3)
potential hydroelectric capacity - 2238 MW
uranium oxide - 200 million pounds

However, it remains one of the least industrialised provinces.

The New Democratic Party (NDP) (Premier Allan Blakeney) has introduced a special brand of socialism where wheat pools, crown corporations and co-operatives work in tandem with private enterprise. Its philosophy towards new investment is stated thus - "the public sector wants the starring role in the control, development and extraction of resources - to return to the people the maximum value from resource extraction, while enabling private enterprise to realise a reasonable rate of return on investment. Too often in the past the products have been shipped out of the province for processing, leading to a substantial denial of jobs, locally. Investors in the energy resource sector must be prepared to enter joint ventures with government agencies in the exploitation of those resources."

An important instrument of Government strategy to gain benefits for Saskatchewan residents from resource development has been direct investment by the Province in the economy, through wholly owned commercial entities called Crown corporations - in 1979 their assets totalled $3,449 million - these include:-

- Potash Corporation of Saskatchewan (PCS)
- Saskatchewan Oil and Gas Corporation (Saskoil)
- Saskatchewan Mining Development Corporation (SMDC)

Based on its ownership of minerals, the Province has developed royalty and tax arrangements which maximise returns to the Province while remaining sensitive to the economics of the industry. The uranium royalty system applied by the Province provides for a base royalty of 3% of gross revenue together with an additional graduated royalty based on profitability. This royalty structure, established in 1976, provides for a short pay-back period (five years for write-off) on investments and so is said to be attractive to the mining industry.

A company with a rate of return of 15% on capital invested in a mining property would pay no graduated royalty. However, royalties escalate from 3% to 5%, 7%, 9% etc. above that level to cream off what are regarded as windfall or excessive profits. Further, royalties are not deductible (since 1974) for purposes of Federal income tax assessment.

Uranium

Possible softening of world uranium markets in the early 1980's may slow the rate at which new orebodies are brought into production. In the longer term, world demand for uranium is expected to increase substantially, and the industry in Saskatchewan continues to grow. Saskatchewan producers are considered to be in a strong position to take advantage of market opportunities in the next decade - advantages cited include the nature of the deposits which permit economical open pit mining techniques to extract high grades of ore (average 2% U_3O_8) and Canada's reputation as a reliable mineral supplier.

As most of the production is expected to be sold under long term contracts, short term price fluctuations should not be critical to future growth. It is the Government's policy to schedule the rate at which new deposits are developed to maintain industry stability. This will ensure that products from established mines are marketed at reasonable prices, prior to approval of further expansions. Sales of uranium are expected to approach $1,000 million/year by 1990.

Key Lake mine is expected to be brought into production in 1983 and Mid West Lake mine in the period 1986-1989.

The unions accept uranium mining as being a safe occupation and do not oppose development. There is community acceptance of the industry and opportunity is provided for comment through normal EIS procedures. There is, however, said to be real opposition to all mining development from "environmentalists".

Coal

About 70% of Saskatchewan's electrical energy or 2,000 MW is produced from lignite. This percentage will increase over the next two years as two new 300 MW generating units are brought onstream. It is the Government's policy to minimise the use of oil or gas for the generation of electricity from the existing gas-fired turbines; the balance of requirements are provided by hydro.

Coal reserves recoverable at current prices are put at 7,500 million tons - annual production is about 8 million tons, of which almost 1 million tons are exported (cf. production at 2 million tons per year in 1969).

Lignite with 0.5% sulphur content in seams averaging 15 ft. in thickness is mined under overburden cover ranging in depth from 70 ft. to 110 ft. using electric shovels and draglines. To overcome slagging of ash due to problems occasioned by sodium content, lime (chicken coop lime) is blended with the coal with conventional blow-in boilers.

Saskatchewan has a 400 MW interchange capability with Manitoba Hydro and negotiations for a similar arrangement are in progress with Alberta; an exchange of 100 MW capacity with a U.S. grid is being considered.

Potash

Saskatchewan possesses over 40% of the world's economically recoverable potash reserves; provincial reserves are put at 100,000 million tons. Production is highly mechanised and low-cost because of the regularity and thickness of seams. Steady growth in production was accompanied by a three-fold increase in prices during the 1970's and the value of shipments increased from $109 million in 1970 to $695 million in 1979.

There are 10 producing mines which are owned by several companies - the largest being the Crown corporation, Potash Corporation of Saskatchewan (PCS), which purchased three potash mines and an interest in two others between 1976 and 1978, and now owns 40% of the Province's productive capacity. Solution mining is being undertaken at the Kalium mine, 30 miles from Regina.

In January 1976 the Province legislated for Provincial power to acquire effective control through ownership of some or all of Saskatchewan's potash mines - the vehicle being the Potash Corporation of Saskatchewan (PCS) - in keeping with the principle that Government should control the economy and, particularly, the resource industries which were almost totally foreign dominated.

Laws and regulations previously passed to allow taxation of private companies and to have control over resource development met opposition from potash producers. Significant tax concessions had been made to several companies when development of the industry was taking place and a very low royalty rate of 2½% of the value of the potash was granted on crown lands and guaranteed until 1981. In addition, Federal corporate tax regulations allowed generous concessions during start up, on top of which a three year mine holiday or tax free period was added, during which time depreciation was held back. This was followed by a period in which accelerated depreciation was allowed. The result was that many of the potash companies paid no Federal income tax for the first 10 to 15 years.

In 1972 they paid less than 6% of their total gross income in Provincial royalties and taxes and municipal income taxes; they paid no Federal income tax that year.

By 1975 the price of potash had risen (from $36 per tonne in 1972) to $75 per tonne. Since potash was produced at a cost of about $25 per ton, the rising prices meant windfall profits for the companies. The Province introduced new taxes, as it had in the case of oil, to ensure that a fair share of these profits came to the people of the Province.

There are a number of studies underway examining the possibility of moving potash and other solids through pipelines.

Metallic Minerals

The Flin Flon mine, on the Manitoba border is a major producer of gold, silver, copper and zinc.

Sodium Sulphate

Eight plants are in operation, producing about 500,000 tons of natural sodium sulphate valued at over $20 million annually.

Saskatchewan Heritage Fund

This Fund was established on 1st April, 1978 to ensure that a share of the benefits from development of the Province's non-renewable resources would be preserved for future generations. It has three main purposes:-

- to invest in assets that will provide a base for future economic vitality
- to finance capital projects which will contribute to the long term economic and social development of the Province
- to stabilise yearly fluctuations in the resource revenues used to finance general Government programming.

All non-renewable resource revenues are deposited in the Fund and in 1980-81 the total revenues of the Fund are estimated to be $645.5 million. Each year, a portion of the revenues is transferred to the Consolidated Fund to finance ongoing Government programmes and services.

All other resource revenues are allocated to three divisions of the Heritage Fund:-

- the Resources Division, which finances the general activities of the Fund, as well as those related to non-energy mineral developments

- the Energy Security Division, which finances the Fund's efforts to develop the Province's energy resources and encourage energy conservation

- the Environment Protection Division, which acts as a contingency fund against unforeseen environmental problems which may arise after a uranium mine has ended production and site reclamation has been completed.

In 1980-81, $47 million have been provided to assist the petroleum industry to explore for oil and gas, through subsidies on seismic surveys and drilling; a further $135 million will be loaned to or invested in Crown corporations.

The Saskatchewan Heritage Fund draws its revenue principally from royalties levied on petroleum, natural gas, potash and uranium. During 1978/79 the 60 million barrels of crude oil produced in Saskatchewan plus 42 billion cub. ft. of natural gas generated $351 million (or 70%) of Heritage Fund revenues.

Rising world demand and higher prices for potash produced $140 million revenue for the Heritage Fund in 1978/79 (28% of the total). Revenues from uranium production amounted to $5 million.

Other contributors to the Fund included production on coal ($842,000), sodium sulphate ($868,000) and other minerals $1.8 million.

The Provincial Government plans to expand activities in energy exploration, research and conservation to secure future supplies of energy resources. It believes that in the development of a national energy strategy, the Federal Government should establish a "Canada Energy Security Fund" to siphon off a large share of the oil and gas profits going to the multinationals for investment of the proceeds under Canadian control in the development of Canada's energy resources. The Provincial Government is concerned that the increased oil and gas revenues have been used to reduce the Federal deficit, and not to find new oil supplies. Further, that an increasingly unfair share of the cost of subsidising the consumers of imported oil in eastern Canada is borne by Saskatchewan. The Federal Government levies an export tax on oil sold to U.S.A. and the proceeds are used to subsidise the costs of imported oil in eastern Canada. The Province is paying an unfair share of the burden considering that natural gas exports from Alberta and British Columbia are not taxed.

The Federal Government currently collects $21 per barrel from exported oil while Saskatchewan and the oil producers must split the remaining $14.75 (i.e. $575 million for the Federal Government and $375 million for Saskatchewan in oil revenues per year).

Energy Resource Management in Saskatchewan

An important element of energy resource management in the Province is the contribution made by the three energy Crown corporations (the Saskatchewan Power Corporation, the Saskatchewan Oil and Gas Corporation and the Saskatchewan Mining Development Corporation). These are seen as a useful (and sometimes the only) means of appropriately managing the social, economic and environmental aspects of energy. Because they are not so restricted by short term profitability considerations, they can explore for and discover energy resources without necessarily having to produce them at an early date (e.g. SPC has been exploring for and acquiring natural gas and coal reserves since the 1960's).

Provincial Government revenues from energy resource development in 1976-77 were as follows (this does not include Provincial corporate income tax or dividends from energy crown corporations):-

crude oil	-	$200 million
natural gas	-	$820,000
coal	-	$600,000
uranium	-	$430,000
electricity	-	$510,000

Saskoil (Saskatchewan Oil and Gas Corporation)

Following the discovery of petroleum in Alberta and, later, in North Dakota and Manitoba, oil was discovered in the early 50's in Saskatchewan in Mississippian carbonates, Jurassic and Cretaceous sands. Today, it produces some 15% of Canada's total output (second only to Alberta) in the form of a heavy crude; peak production of 93.2 million barrels was attained in 1966. In the past decade minor discoveries have been made in Ordovician, Devonian and Cambrian sediments. Incentives for exploration are provided through subsidy on drilling dependent on stratigraphic targets.

Saskoil is the third largest producer of oil in the Province at 13,000 barrels per day for export to the U.S. at world parity price and to Ontario. Saskoil is a Crown corporation operating as a private company joint venturing where appropriate (though funded in part from Heritage Funds derived from profit based royalty up to 35% - dependent on 'old' oil/'new' oil). Most of Saskatchewan's crude oil needs are satisfied by Alberta.

Saskoil is responsible for distribution of natural gas for domestic and industrial use - 50% of requirements are imported from Alberta and Saskoil is involved directly in exploration and production in Alberta. Gas is purchased at a price fixed by the National Energy Board at the Alberta border for $1.80 per thousand cub. ft. of which the producers receive 80 cents, the Alberta Government 90 cents in royalty and 10 cents is for transportation (as compared to price of $4.00 per thousand cub. ft. when exported across the U.S. border) - 50% of requirements are imported. "Associated" gas (5% of production) and "non-associated" gas reserves are assured for 25 years requirement for the Saskatchewan Power Corporation and other users. Domestic natural gas producers receive 44 cents per thousand cub. ft. and pay 2 cents royalty.

In 1962 the first artificial underground storage cavern for natural gas was created through solution of Devonian salt beds - storage has thus been provided near Regina and Saskatoon.

Over 250 companies involved in the petroleum industry spent $545 million on exploration and development in 1978/79 and directly employed 1,750 persons. There were 999 new wells (of which 822 were successful) resulting in a total of 7,850 wells in operation at the end of that year. Saskatchewan is second to Alberta in oil production, accounting for some 15% of the national output.

Saskatchewan Mining Development Corporation (SMDC)

SMDC formed in 1974 and established under the Crown Corporations Act in 1977 is empowered to explore for, develop, mine, refine and market all minerals found within the Province, with the exception of oil and gas, potash and sodium sulphate. Under the Saskatchewan Mineral Resources Act, companies must offer the Crown up to 50% participation in any exploration project where expenditures exceed $10,000 per year. The Corporation is required to exercise its option within one year.

Most of its projects lie within the Precambrian Shield of Northern Saskatchewan. It is actively engaged in exploration on more than 200 projects in search of uranium and other minerals through joint venture agreements (with overseas publicly-owned companies or private sector companies).

Key Lake Project (SMDC 50%, Eldor Resources 17%, Uranerz Exploration and Mining Ltd. 33%)

High grade uranium mineralisation was discovered by the joint venturers at Key Lake in 1975, and in 1976 an equally rich deposit was discovered nearby. Diamond drilling has disclosed 155 million pounds U_3O_8.

An EIS on the proposed $200 million mine and mill have been completed for production scheduled for late 1983 at a rate of 12 million pounds U_3O_8 annually.

Cluff Lake Project (SMDC 20%, Amok Ltd. 80%)

During 1979, SMDC acquired a 20% interest from the French group, Amok, over identified mineable deposits of uranium in several distinct orebodies. The open pit mine will come into production in late 1980.

Other uranium exploration

Uranium is the prime target of most projects in which SMDC is participating. Over 60% of the total diamond drilling in Canada in 1979 occurred in Saskatchewan - most of this was for uranium.

The most favourable geological environment is at or near the contact between older graphite-bearing basement rocks of the Canadian Shield and the overlying Athabasca Sandstone where uranium may be present in highly altered zones (cf. Alligator River region of the Northern Territory). Thus, encouraging results were reported in SMDC joint ventures at Asmera (with Occidental), Russell Lake (with Getty Minerals) and Wheeler Lake (with Union Carbide) - 265 rotary and diamond drill holes were completed on SMDC operated uranium exploration projects for a total of 233,430 ft. (a further 1,964 holes were drilled, aggregating 729,250 ft. on partner-operated uranium exploration projects) in 1979.

It is estimated that Saskatchewan accounts for 50% of total Canadian uranium reserves.

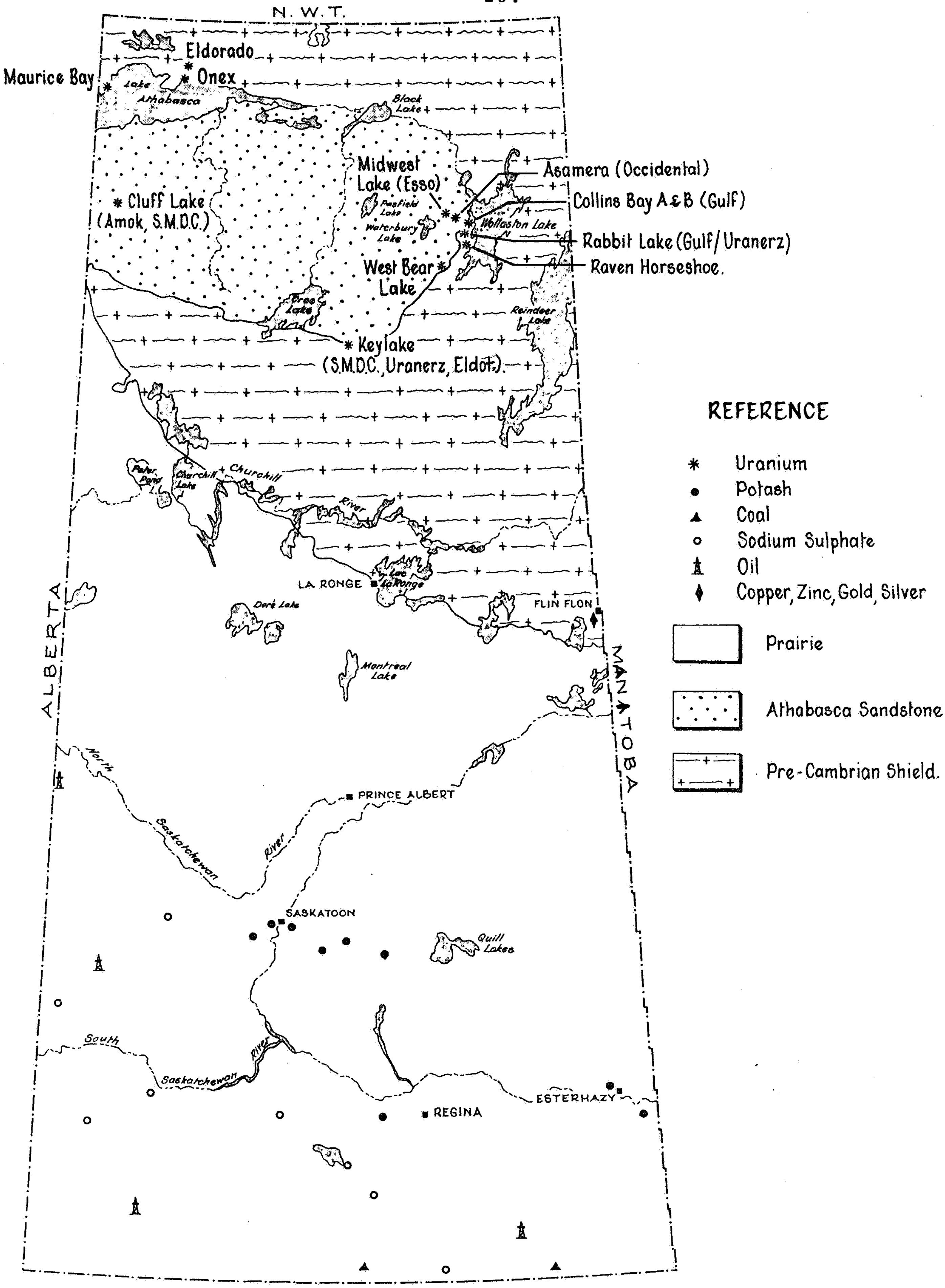
Rabbit Lake Mine (Gulf Mineral Resources Co. 45.9%, Gulf Canada Ltd. 5.1%, Uranerz Canada Ltd. 49%) - 8.10.80

Fred Thode Hamilton - General Superintendent
Brenda Beug - Ministry of Intergovernmental Affairs

The Rabbit Lake mine and mill complex began production of yellowcake in 1975 - during its projected 10 year life, an estimated 40 million pounds of yellowcake will be recovered from the 5 million tons of pitchblende ore. Discovery of the deposit in 1968 was based on airborne radiometric surveys (followed by drilling) and radioactive float on the shore of Rabbit Lake after acquisition of 3.5 million acres of mineral exploration permit in the Wollaston Lake area of northern Saskatchewan. Since then, 130,000 ft. of core drilling was undertaken; site preparation was initiated in 1972.

The Rabbit Lake uranium deposit consists of pitchblende and other uranium minerals in a conical fault-bound mass of fractured gneisses and calcsilicates of the Wollaston Group (age 2,000 m.y.). Mineralisation is localised by faulting below the surface of unconformity of the flat lying Athabasca Sandstone (1400 m.y.) - (comparable to the Kombolgie Sandstone (N.T.)) - a thin conglomerate is developed at the base.

Some 165 employees work at the mine and mill complex, around the clock on a 2 x 11 hour shift basis (commuting on a 7 days on-7 days off schedule by air from Saskatoon, Prince Albert and Uranium City).



MINERAL DEPOSITS OF SASKATCHEWAN

Department of Mines and Energy - South Australia.

Rabbit Lake Uranium Mine (Gulf Minerals)
Aerial view of open pit in foreground

Rabbit Lake Uranium Mine (Gulf Minerals)
Aerial view of mill in foreground and open pit in background, right

Ore averaging 7½ lbs U_3O_8/ton is mined from an open pit with shovels and front-end loaders and requires removal of 2 million cubic yards of rock annually; ore is mined on 20 ft. benches and waste on 40 ft. benches. The ore is stockpiled according to grade after being scanned in the haulage trucks to give an instant radioactivity read out.

The ore is reduced in a jaw crusher, semi-autogenous mill and regrind ball mill for dissolution by sulphuric acid, sodium chlorate and steam in the leach circuit. Barren solids separated by counter-current decantation are neutralised with lime and pumped to a tailings dam while the pregnant aqueous uranium solution is fed to the solvent extraction circuit. There, amine and kerosene extract the uranium in agitated cells and is then pumped to the stripping circuit where ammonium sulphate is introduced.

Ammonium diuranate (yellowcake) crystallises on addition of anhydrous ammonia - this is settled in a thickener tank, washed with water, dried at 130^{o}F to drive off ammonia for packaging in 44 gallon steel drums.

Regulatory guidelines have grown increasingly stringent in recent years and the trend is expected to continue. Approximately 40 contaminants, variously radioactive or chemically toxic that are released in mining and milling are monitored and reduced to specified concentrations in the ore residue and process waste water. On-site air quality is also sampled and tested.

There is a programme of bio-assay mine analysis testing which ensures that internationally recognised exposure levels are not exceeded for employees working where radiation is present.

The mine and mill are inspected and monitored routinely for radiation levels by radiation-health-trained staff. After 5 years of operation there has been no case of injury from radiation or toxicity.

Federal Government codes of practice are monitored by the Province through its various Departments of Labour, Occupational Health and Safety and Environment.

Rabbit Lake Mine

Open pit exposes folded and steeply dipping metasediments; ore in pit floor

Rabbit Lake Mine

Flat-lying Athabasca Sandstone exposed in top bench at extreme right, faulted against and resting on Wollaston Group metasediments, beyond figure

ALBERTA - EDMONTON, 9th-10th October, 1980

Paul King, International Trade Director, Government of Alberta
Benito Fiore, Montedison Canada Ltd.
Hon. Frank Lynch-Staunton, Lieutenant Governor of the Province of Alberta
Myron Kanik, Assistant Deputy Minister, Policy Planning and Analysis, Department of Energy and Natural Resources
Norman MacMurchy, Senior Advisor, Special Projects, Department of Energy and Natural Resources
Hon. Merv Leitch, Minister of Energy and Natural Resources
Ken Broadfoot, Assistant Deputy Minister, Development and Trade Division, Department of Economic Development
Dallas Gendall, Deputy Minister of Development and Trade, Economic Development
Brigitta Lowe, Director, International Co-ordination and Policy, Federal and Intergovernmental Affairs
Dr. M. Maduro, Senior Intergovernmental Officer, International Division, Federal and Intergovernmental Affairs
Ken Patterson, Director of Finance and Administration, Executive Council
Doug Rankine, Manager of Government Affairs, Dow Chemical
Mike Sieweke, Trade Development Branch, Department of Economic Development
Graham Underwood, Royal Bank of Canada
Peter White, ATCO International
John Whalley, Chief of Protocol
Bob Cook, Energy and Natural Resources
Shiela Grace, Fort McMurray
Bruce Regensburg, General Manager, Syncrude, Fort McMurray
Frank Agar, Chairman, Coho Resources Ltd.
Ken Lambert, President, Coho Resources Ltd.
Ken Campbell, Director, Coho Resources Ltd.

National and international conditions affecting the petroleum industry have enhanced the value of Alberta's mineral production which exceeded $9.7 billion in 1978. Of this total, $4.7 billion represented the value of production of crude oil and $4.5 billion, that of natural gas. Coal production, though substantially lower than the contributions of those resources, shows considerable growth potential.

The written portion of the Canadian constitution, the British North America Act, limits the provinces to direct taxation within their borders in order to raise revenue for provincial purposes. Consequently the provincial Governments cannot impose indirect taxes unless they serve a regulatory purpose within their spheres of jurisdiction. Direct taxation is available to both the federal and provincial governments.

The Alberta tax regime is the most moderate in Canada - it places no tax on retail sales or petrol and imposes the nation's lowest rate of personal income tax - made possible by the large oil and natural gas revenues accruing to the provincial government in the form of royalties. Oil and gas revenues represent 50% of budget revenues (and this excludes oil and gas revenues that are allocated to the Alberta Heritage Savings Trust Fund).

Alberta Heritage Savings Trust Fund

This was established in 1976 "to ensure that the revenue flow which the Government currently receives from the depletion of non-renewable resources benefits future generations, helps strengthen and diversify the provincial economy and improves the quality of life in Alberta."

Upon approval by the Legislature, 30% of the non-renewable resource revenue received in a fiscal year is transferred from general revenue to this Fund. By September 1979 its assets totalled $5.46 billion.

Royalty on oil and gas production

75% of production is derived from Crown Lands, on which royalties are paid to the Crown; on the remaining 25%, deals are made with the freehold land owners and freehold taxes are imposed on them. On Crown Lands the levels of royalty are staged and are volume and price dependent ranging from 22½% to 50% - such that the average royalty on Crown natural gas approximates 40% or $2.65 per 1,000 cub. ft., less transportation. These are negotiated annually; at present 34% of the gross revenue is collected by the Province, 52% is retained by the producer and 14% is returned to the Federal Government as a tax (the producers pay income tax at the rate of 47% after certain deductions are allowed - but royalty is non deductible; this double taxation of the producers is a serious disincentive). The Federal Government is seeking a variation of these arrangements to increase their take and there has been no agreement since July when the Alberta Government made a unilateral decision to increase the price of oil 10% or $2 per barrel to bring the price to $16.75 per barrel, and gas by 30%.

Royalty on natural gas used in the Province is dependent on whether "old" or "new" (discovery since 1974 and being 10% lower).

Natural Gas

Total remaining recoverable reserves are presently estimated at 58 trillion cub. ft. with ultimate recoverable reserves estimated at over twice that volume. In 1979, 3.3 trillion cub. ft. of natural gas were produced - 21% were consumed locally, 43% were shipped to other Provinces and 34% were exported to the U.S. Uncommitted reserves total 10 trillion cub. ft. so that there is no incentive for further exploration for natural gas.

Many of the natural gas reserves are wet and/or sour, containing an abundance of butanes and pentanes plus and sulphur.

The price of gas is set by negotiation between producers and consumers within the Province with free market forces operating - this is 60-70% that of the Alberta border price. Exports across the U.S. border are determined by negotiation between the Provincial and Federal Governments. The border price to Saskatchewan is $1.80 per 1,000 cub. ft.

Two world scale Dow Chemical petrochemical plants are based in Alberta and have operated since 1970. Domestic ethane is being purchased on a 20 year contract signed with Dome Petroleum in 1974 to provide feedstock (with salt from Saskatchewan) for manufacture of caustic soda and chlorine (for timber, pulp industry) and ethylene for PVC, EDC (for export to U.S. and Japan although this market not as brisk as was anticipated), ethylene oxide, glycols, polyester fibre, styroform ($12 billion have been capitalised internationally by Dow with expansion over the past four years amounting to $1 billion per year).

Dow operates two methanol plants in Alberta and is in the process of doubling their capacity. Ethane, ethylene, propane and butane are exported to the U.S. in a common pipeline in "slugs". Gas is stored underground in cavities, artificially developed in salt formations.

Electric Power

Alberta's electric power grid is operated by private utility companies and municipalities. Total net generation of 19,083 GWh in 1978 was generated by hydro plants and plants fuelled by coal or natural gas.

Coal

Coal resources provide a massive potential source of primary energy or potential feedstock for synthetic fuels and chemicals.

Present coal production exceeds 16 million tons per year of which 75% is sub-bituminous, used mainly for thermal power generation, and 25% is high grade metallurgical coal destined for export, primarily to Japan, with some railed to Ontario.

Remaining recoverable reserves of thermal coal are put at 12 billion tons. A slurry pipeline is under construction to convey coal to the west coast for export.

Crude Oil

The largest and most prolific oil fields have been discovered during the past 30 years - recoverable reserves are put at 5.8 billion barrels; these are mostly of light and medium gravity with a low sulphur content and are produced in fields in the central and north-western parts of the Province. The potential for heavy oil development and production is considerable.

Natural gas fields contain some 507 million m^3 (3.2 billion barrels) of remaining recoverable reserves of propanes, butanes and pentanes plus.

The production of crude oil and equivalent liquids in 1978 was 443 million barrels. Of this amount, 20% was consumed locally, 64% by other Provinces (principally Ontario) and 16% was exported to refineries in the U.S.

Exploration is continuing at an extremely high level and present production represents 85% of Canadian output. Incentives are provided through seismic survey and drilling subsidy which are depth and zone dependent and have regard for separation from producing wells. However, pricing is seen as the most meaningful incentive.

Oil sands and synthetic oil

The largest deposits of oil sands occur in northeastern Alberta at Fort McMurray (population 28,000) where they outcrop or occur under shallow cover and contain some 717 billion barrels of oil in place (of which 4% or 30 billion barrels is recoverable using present open-pit mining and extraction technology.) Two plants are currently producing from these deposits.

The Syncrude plant has a capacity of 20,000 m^3 (129,000 barrels) per day and the Suncor plant (Sun Oil Co.) produces 7,150 m^3 (45,000 barrels) per day of high grade synthetic oil. Three additional oil sands mining projects have been proposed and are in the planning stage of which Alsands (Shell) is most advanced. Present estimates are that Alberta could produce 180 million barrels in 1985, increasing to 400 million barrels in 1995.

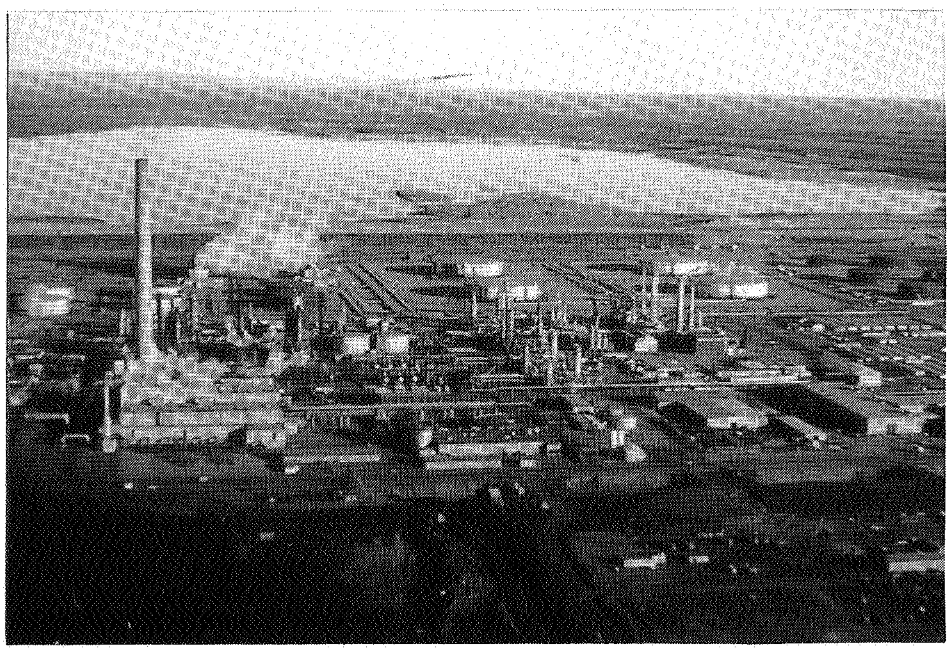
Deeper deposits (95% of reserves) contained in the Cold Lake, Peace River, Wabasca and Buffalo Head Hills areas must be developed by in-situ recovery techniques. These involve the injection of air to support underground combustion, or steam to mobilise the oil, enabling it to flow to the surface. Currently, one experimental in-situ recovery project is operating (Esso Resources) in the Cold Lake area, extracting 200,000 barrels of heavy oil annually.

Syncrude - Athabasca Oil Sands, Fort McMurray (Alberta)

The Athabasca oil sands were recorded in 1788 and geological studies made in 1875. In 1913 separation of bitumen from the sand was achieved by hot water flotation for testing as road-paving material, successfully but uneconomically, and the project was dropped. In the period 1920-1942, bitumen was produced (by the same process) for roofing and road surfacing. During the years 1936-1945 there was some production of diesel oil from the oil sands.

Syncrude Operations - Fort McMurray

Aerial view along open pit to refinery and tailings dams. Drag lines and bucket wheel reclaimers recovering tar sands



Syncrude refinery and tank farm, aerial view

Tailings dam in background

In 1948 the Alberta Government took over the small plant and by the next year was processing 450 tons of oil sand daily before the operation was closed. A pilot plant was then established and the first major production of oil began in 1967, which built up to 7,155 m^2 per day.

Clearing of the Syncrude construction site at Fort McMurray commenced late 1973 and was commissioned mid 1978 at a total cost of $2.3 billion; ownership is now as follows : Esso Resources Canada Ltd. (25%), Canada-Cities Service Ltd. (17.6%), Gulf Canada Resources Inc. (13.4%), Petro Canada Exploration Inc. (12%), Alberta Energy Co. (10%), Alberta Syncrude Equity (8%), Petrofina Canada Inc. (5%), Hudson's Bay Oil and Gas Co. Ltd. (5%) and PanCanadian Petroleum Ltd. (4%).

The production of synthetic crude oil from the Athabasca oil sands involves three phases, viz. mining, extraction of bitumen, refining of bitumen.

The Athabasca sands have attracted large scale commercial development because the deposits are extensive, readily accessible and amenable to open pit mining. Smaller developments have taken place in the oil sands of Venezuela, Trinidad, Albania, Rumania, USSR, U.S.A. and Malagasy.

The Athabasca deposits are the largest of several Alberta heavy oil deposits and account for over 100 billion m^3 in place. The other major deposits at Cold Lake (25 billion m^3), Wabasca (6 billion m^3) and Peace River (10 billion m^3) are too deep for open pit.

The Pre-Cambrian Canadian Shield is here blanketed by Devonian salt and limestone. On the irregular eroded surface of the latter the McMurray Formation (Lower Cretaceous), an oil-bearing quartz sandstone ranging up to 215 ft. thick (and averaging 140 ft.), was deposited along a shoreline as stream mouths were being flooded by the rising sea. They are succeeded by marine shales of the Clearwater Formation. The oil is generally considered to have migrated to its present site.

Pleistocene glacial gravels, sands and silts overlie and infill erosion scours in the Clearwater Formation - in the Syncrude mine area these are 40 ft. thick; they are overlain by muskeg 10 ft. thick in a region of forest, marsh, lakes and rivers.

80% of the oil in the Athabasca Oil Sands is located in only 50% of the total volume of the oil-bearing sediments. Between 55% and 80% of the available pore space between the sand grains is occupied by oil, with 1% to 30% taken up by water.

Bitumen saturation is expressed as a weight percentage which ranges up to 18%. Sands containing +6% bitumen by weight are considered to have recoverable potential; present production averages 10.5% bitumen. The major portion of the reserves will require an underground mining or other recovery technique, such as steam injection or fire flooding.

Suncor Operations, Fort McMurray

Aerial view of refinery and tank farm. Tailings ponds at extreme left

Suncor open pit, aerial view

Bucket wheel excavation of pit in foreground; Athabasca River in background

The Athabasca deposits extend over an area of 200,000 ha with less than 150 ft. overburden - in the mine area overburden averages 45 ft. in thickness with a maximum of 105 ft.

Where overburden thickness does not exceed 150 ft. and where saturated beds are 90 to 180 ft. thick, recovery by present techniques is economic where oil sand beds contain +6% bitumen saturation by weight.

While some consider that the oil was formed locally the commonly held belief is that the oil was originally conventional crude oil which migrated from the deeper Alberta Basin to the southwest, displacing water.

Quartz grains are surrounded by a film of water, which in turn is surrounded by bitumen. About 20% of the bitumen will distil at standard pressure without cracking; about 60% of the distilled fraction is light aromatics and the balance is an alkane mixture. The non-volatile fraction is about 40% resins.

The Syncrude mine is one of the largest open pits in the world, producing 92 million tons of oil sand per year and shifting 45 million tons of overburden and waste from an area that will extend over an area 3 miles x 5 miles in 25 years.

The mine area was depressurised by dewatering aquifers below the oil sand before operations commenced in mid 1978.

A single opening box cut three miles long has been created and the oil sands are excavated by four (two Marion, two Bucyrus Erie) draglines (360 ft. boom, 80 cub. yd. bucket) to a depth of 200 ft., two located on each side of the box cut, after the overburden has been removed. The oil sand is cast into single wind rows on the surface, parallel to the mining faces. Waste encountered in the oil sand ore section is selectively mined by the draglines and cast into the pit.

Four Krupp bucketwheel reclaimer systems reclaim the oil sand from the windrows and convey it to the 6 ft. wide conveyors which run parallel to the windrows and dump onto surge piles over bins.

There are four parallel production lines, each with the following:-

- tumblers - large horizontally-mounted rotating drums into which are fed water, heated by steam and waste heat from the fluid cokers, oil sand and caustic soda - while steam is added internally.

  The water film between the sand grains and the bitumen ruptures and the small globules of bitumen are aerated to form froth which is lighter than the water and is discharged as a slurry to pump boxes.

- primary extraction - where the bitumen is skimmed from the top of the froth and the heavy sand particles are removed from the bottom of the separation vessels.

- secondary extraction - flotation cells where the remaining bitumen is recovered.

- froth cleaners - centrifuge separation of sand after the froth is diluted with naphtha and tailings pumped to tailings ponds.

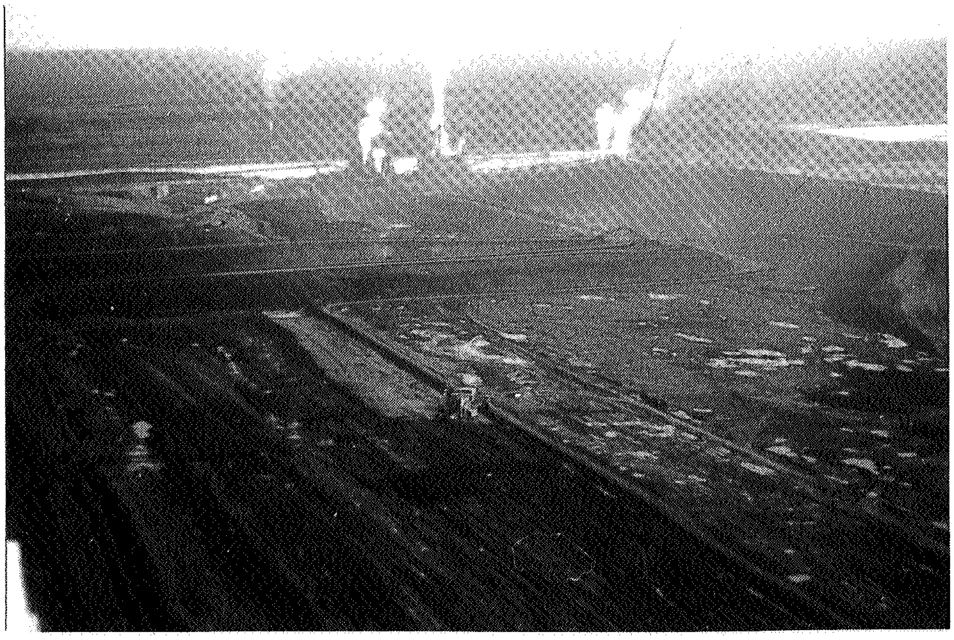
At full production, 260,000 tons/day of oil sand is processed for the recovery of 35,000 tons/day bitumen (93% recovery). Diluent naphtha and the remaining water are removed from the diluted bitumen in two diluent recovery units each of which consists of two preflash stages, a fired heater and a column. The resulting bitumen contains 0.7% solids and is ready for upgrading to a product refineries can use. Primary upgrading, where the bitumen is coked to break the molecules down (cracked by preheating and spraying on a fluidised bed of hot coke) and produce lighter molecules and coke. In a secondary upgrading stage, sulphur, nitrogen and heavy metals are removed in naphtha and gas-oil catalytic hydrotreating units - production of sulphur at full plant capacity is 1,000 tons/day. By-product coke (2,200 tons per day) has no present market.

The production of synthetic crude oil is approaching 70 million tons/year (20,500 m^3 or 130,000 barrels per day) - production by Suncorp is about 6,500 b.p.d.

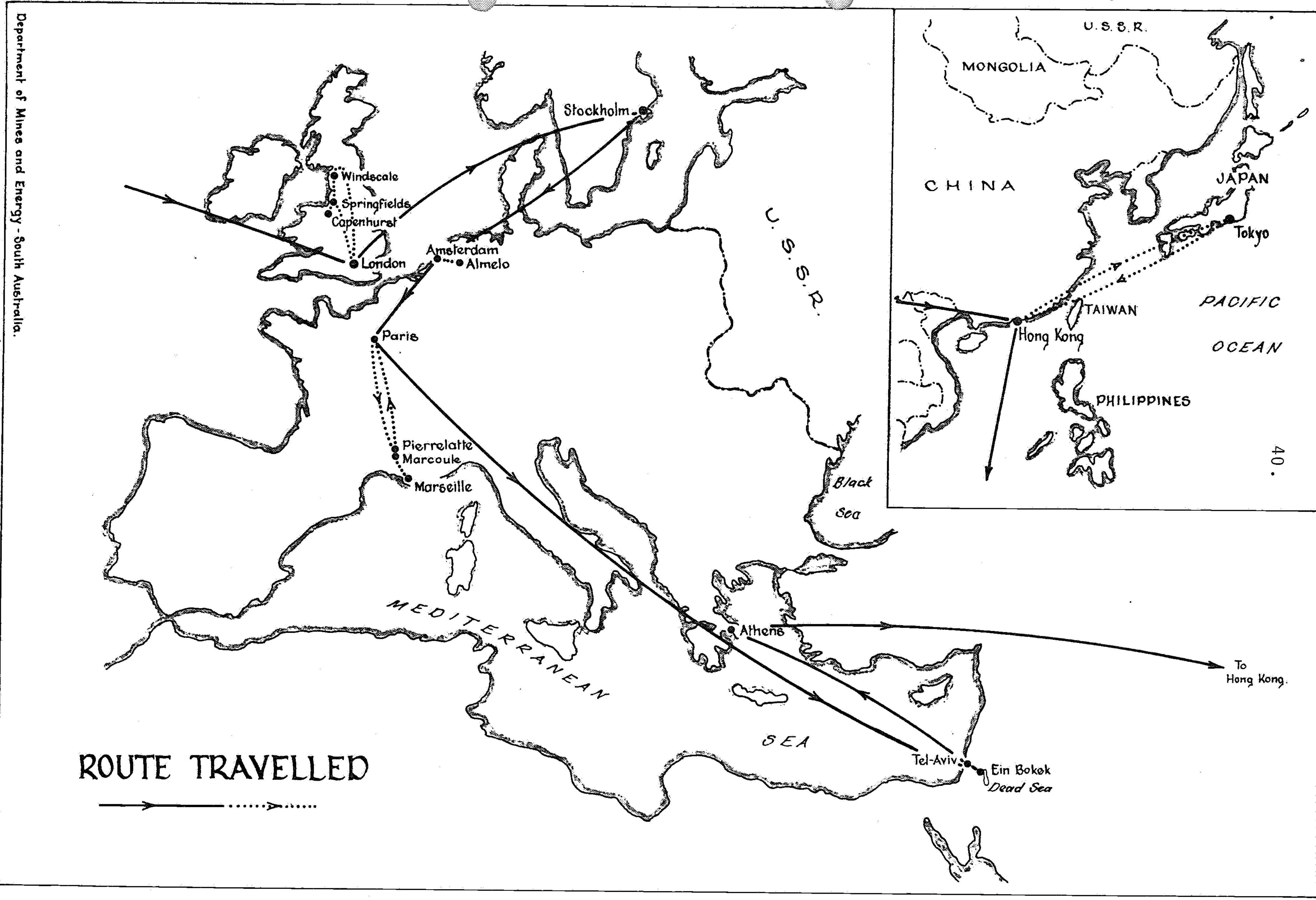
The Syncrude operations workforce on site totals 3,200.

To provide for reclamation of excavations and tailings ponds, replacement of muskeg and tree planting, 3 cents per barrel are paid in bond - rehabilitation will be undertaken progressively.

The cost of production per barrel was put at $25 in 1977 and, by 1979, at $20/barrel (before tax and royalty); this is expected to be as low as $15 in the future. Under a royalty agreement, 50% of profits are paid to the Alberta Government - the balance is subject to tax and represents a 15% return on investment ($2½ billion). Synthetic oil production from the Athabasca tar sands attracts, as an incentive, a price pitched at world parity, presently $38 per barrel.



Syncrude Operations


ROUTE TRAVELLED
Department of Mines and Energy - South Australia.
Windscale
Springfields
Capenhurst
London
Amsterdam
Almelo
Stockholm
U.S.S.R.
Paris
Pierrelatte
Marcoule
Marseille
Black Sea
MEDITERRANEAN SEA
Athens
To Hong Kong.
Tel-Aviv
Ein Bokek
Dead Sea
U.S.S.R.
MONGOLIA
CHINA
JAPAN
Tokyo
TAIWAN
PACIFIC OCEAN
Hong Kong
PHILIPPINES

UNITED KINGDOM - 18TH-27TH OCTOBER, 1980

LONDON

Mike Duff, Acting Agent-General for South Australia
Lord Glendyne
Norman Lamont, Parliamentary Under-Secretary of State, Department of Energy, Millbank
Sir Ben Dickinson, Consultant
Ron Wilmshurst, AMDEL
His Excellency Mr. Justice Fox, Ambassador-at-Large

U.K. Atomic Energy Authority - London

Sir John Hill, Chairman
Wilf Rooke, Secretary and Financial Director, URENCO
Tony Allen, Member for Finance and Administration

British Nuclear Fuels Limited (BNFL)

Capenhurst

Alan Avery, Works General Manager
Dr. Mike Horsley, Works Manager, Diffusion Plant
Joe Charnock, Works Manager, Centrifuge Plant
Alan Johnson, Executive Director, Enrichment Division
Frank Bamford, Chief Sales Manager, Fuel Division, Risley
Dr. Arnold Huggard, Chief Technical Officer (Policy), Fuel Division
Bob Connop, Principal Technical Officer, Fuel Division

Springfields

Gordon Steele, Deputy General Manager
Harry Page, Works Manager, Chemical Plants

Windscale

Roy Pilling, General Manager, North West Area
John Doran, Deputy General Manager, Windscale and Calder Works
Jack Creighton, Works Secretary
Les Tuley, liaison
Vernon Holroyd, Sella Park House

URENCO Ltd. - Marlow, Capenhurst, Statham Lodge (Lymm)

Jack Parry, General Manager
Dr. Brian Kehoe, Business Development Director
Ian Herriott, Director

BP Limited - Princes Gate

John Milward
Ted Hannington
Frank Rickwood

Nuclear Energy Programme

Nuclear energy generated by 16 reactors now provides 7,100 MW or 13% of Britain's electricity requirement and by the mid 80's this will rise to 20% and by the year 2000 this is expected to be 40,000 MW or 30% of output. It is proposed that a new plant a year will be built from 1982.

The U.K. reactor programme is as follows:-

Site	Type	Nominal Capacity (MWe)	On power
Calder Hall	Magnox	240	1958
Chapelcross	"	240	1959
Bradwell 1-2	"	250	1962
Berkeley 1-2	"	280	1962
Windscale	AGR	30	1963
Hunterston A-1-2	Magnox	300	1964
Trawsfynydd	"	390	1965
Dungeness A-1-2	"	410	1965
Hinkley Point A-1-2	"	460	1965
Sizewell A-1-2	"	420	1966
Oldbury 1-2	"	400	1968
Winfrith	SGHWR	90	1968
Wylfa 1-2	Magnox	840	1971
Hinkley Point B-1-2	AGR	1250	1976
Hunterston B-1-2	"	1250	1976
Dounreay	FBR	250	1976
Dungeness	AGR	1200	1981
Hartlepool 1-2	AGR	1200	1982
Heysham 1-2	"	1250	1982
Torness 1	"	625	1986
Heysham B-1	"	625	1986
Torness 2	"	625	1987
Heysham B-2	"	625	1987
PWR1	PWR	1100	1988

U.K. generating costs (p/kWh) are as follow:-

	1974/75	1975/76	1976/77	1977/78	1978/79
Coal	0.74	0.97	1.07	1.23	1.29
Oil	0.88	1.09	1.27	1.42	1.31
Nuclear (magnox	0.48	0.67	0.69	0.76	1.02
Nuclear (AGR	-	-	-	-	1.3

Thus, in the U.K. average cost of generating electricity in a nuclear power station has been historically much less than cost of generation in coal- or oil-fired stations.

NUCLEAR POWER STATIONS IN GREAT BRITAIN

Department of Mines and Energy - South Australia

Nuclear Fission

Uranium fuel in a nuclear reactor generates heat as the atoms split in the uranium. A coolant fluid, gas or liquid, flows over the hot fuel transferring the heat from the core of the reactor to boilers where water is converted to steam and used to drive turbo generators to produce electricity.

Uranium fuel in a reactor is surrounded by a 'moderator' (graphite, heavy or ordinary water) which slows down the flying neutrons derived from fission to ensure that the splitting process is carried out efficiently.

The fuel and the moderator are enclosed in a reactor vessel which is connected to a number of water boilers. Heat from a reactor is transferred by a coolant gas, carbon dioxide, to the boilers where steam is produced to drive turbines.

Magnox reactors

In 1956, Calder Hall at Windscale Works, Cumbria became the first large-scale nuclear power station to operate in the world. It is still operating and generates 240 MW in four reactors. However detailed plans are being prepared to dismantle the reactor as a complete exercise.

Based on this successful development, Britain pressed ahead with a programme of commercial "magnox" nuclear power stations, where the uranium metal rods are contained in a magnesium alloy (magnox) container or can. There are now nine of these stations in operation, each with two reactors; they have proved safe, reliable and economic and produce more than 11% of the electricity generated in the U.K.

Some idea of the energy available through atomic power can be gauged from the fact that a 3½ ft. fuel element as used in the Wylfa nuclear power station is equivalent to 150 tonnes of coal. Each of the two reactors at that site contain 49,000 fuel elements; and one fuel element can produce power continuously for the five years of its life in the reactor.

Nuclear power stations have a first class safety record. The operating experience of the Central Electricity Generating Board with magnox stations is now equivalent to over 200 years. During that time no harm has been caused by radiation to any of their workers or members of the general public.

Advanced Gas-cooled Reactors (AGR)

During the 1960's a further development of the magnox system led to the introduction of the AGR which operates at higher temperatures and efficiencies. The U.K. second nuclear power programme is based on this system and there are five stations in various stages of construction or commissioning.

The basic concept of the AGR is the same as for the magnox designs. A graphite moderator is used and carbon dioxide gas is the coolant. The fuel differs, however, consisting of enriched uranium oxide pellets encased in stainless steel tubes arranged in clusters.

Fast Reactors

A fast reactor is unique in that it can produce more fuel than it consumes. A blanket of uranium fits around the reactor core in a position where it absorbs neutrons from the fuel. Plutonium is formed in this blanket which can be used, after extraction, to manufacture more fuel for the reactor. Thus, as fuel is burned up in the core, more fuel is being manufactured in the blanket.

No moderator is used in a fast reactor and neutrons move around at high speed. Because there is no moderator the reactor core is small compared to other reactor systems and the fuel is highly enriched in fissile atoms, either with more U235 or Pu239, or a mixture of both.

Liquid sodium is used to transfer heat from the reactor core to the steam generators.

The Prototype Fast Reactor at Dounreay in Scotland produces 250 MW of electricity.

Fast reactors are in theory able to burn all the uranium (as U238) that is fed to them and in practice can produce more than 50 times as much energy from a given weight of uranium as current reactor designs. Further, they are capable of converting to useable nuclear fuel the 99% of U238 that the conventional nuclear power stations are unable to use. The 20,000 tonnes of U238 in stock in the U.K. would, if used in fast reactors, be equivalent to more than 40,000 million tonnes of coal.

Experience to date supports the view that the fast breeder reactor will be a safe, reliable and economic source of power for the production of electricity. The fact that such a system also produces sufficient fuel for its own needs makes it an incomparable system to fulfil the world's long term energy needs.

The term 'fast breeder reactor', although widely used, is misleading, as it takes about 20 years for a fast reactor of current design to produce enough plutonium to fuel a second similar reactor. Fast reactors can also be operated as nett consumers of plutonium, and there is no need for the system to generate more plutonium than is required.

Plutonium is formed in thermal reactors as an inevitable by-product of burning uranium. Unless it is burnt up in fast reactors it will accumulate in increasing quantities and will have to be stored safely, or satisfactorily disposed of in some other way.

A Magnox reactor generating 1,000 MWe produces about 750 Kg/yr. of plutonium.

British Nuclear Fuels Limited (BNFL)

BNFL is wholly Government owned and was incorporated as a private limited company in 1971. Before that time it was known as the Production Group of the UKAEA. The assets of the company and its subsidiaries exceed 370 million pounds. In 1979 turnover was 237 million pounds and export sales totalled 30 million pounds.

Principal activities include the conversion and enrichment of uranium, the manufacture of uranium and plutonium-based fuels and the provision of related fuel cycle services for all types of nuclear power stations including the transport and reprocessing of irradiated or spent nuclear fuel. The company also operates two nuclear power stations at Windscale.

Britain seeks to internationalise conversion, enrichment and reprocessing for economies of scale and seeks appropriate involvement for either licensing or minority participation in conversion and/or enrichment. United Processors involves the U.K., France and Germany with a requirement to provide services at the same cost to other members of the EEC. The group also has a 10 year contract to reprocess for Japan (and construction of a reprocessing plant is being considered by the Group in Japan).

Nuclear Fuels

BNFL has been Britain's sole manufacturer and reprocessor of nuclear fuels for over 25 years. In that time, many millions of fuel elements have been manufactured and, after use in the reactor, reprocessed for nuclear power stations in the U.K. and elsewhere.

BNFL operations are conducted at three main centres:-

- nuclear fuel elements are manufactured at Springfields Works, Salwick, near Preston
- fuel enrichment for reactors is carried out at Capenhurst Works, near Chester
- fuel reprocessing is done at Windscale Works, in Cumbria.

Uranium for use in nuclear reactors must be extremely pure because impurities can absorb neutrons and interfere with the nuclear fission, or atom splitting process.

Uranium ore concentrates (yellowcake) are imported by Springfields from Canada, South Africa, U.S.A. and Australia and are first dissolved in nitric acid. Pure uranyl nitrate is produced from which is formed uranium tetrafluoride (UF4). For metal-fuelled reactors this is converted to natural uranium billets from which rods are produced. It can also be made into uranium hexafluoride (UF6) for enrichment and conversion to the more efficient enriched uranium oxide fuel.

Enrichment

Nuclear fuel is enriched by increasing the fissionable, or fissile, content of the fuel (U235). Uranium consists of two isotopes U238 and U235, of which U235 is the more important since this is the fissile isotope on which the chain reaction depends. By increasing the U235 content in fuel it becomes more effective and economic : reactors are able to operate at higher temperatures and increased power, and can be built in smaller, more compact sizes.

The enrichment process is based on the use of uranium hexafluoride in its gas phase and is commercially carried out by gaseous diffusion or by the gas centrifuge process.

Gaseous diffusion process is a kind of molecular sieving operation in which the UF6 gas is pumped through filters with very fine openings which allow the U235 molecules to pass through more readily than those containing U238. Since each sieving operation increases the concentration of U235 only very slightly it has to be repeated in succession. The plant at Capenhurst consists of over 1,000 diffusion stages, each with a compressor, a gas cooler and porous barrier.

The *gas centrifuge* process is also based on the use of UF6 gas. The gas is fed into rapidly rotating centrifuges which spin the gas at high speed causing the heavier U238 to settle near the wall of the machine and the lighter U235 to settle near the centre, thus a partial separation of the two uranium isotopes is achieved in each centrifuge. By arranging for a flow of gas from the middle of one centrifuge machine to the machine "up" the plant and for a second gas flow from near the wall of the centrifuge to the machine "down" the plant, the separation process is repeated thus increasing the amount of separation achieved by a single centrifuge.

By further repetition of the process in a number of centrifuges connected in a series, a centrifuge cascade is formed which provides the degree of enrichment necessary (typically 4 to 5 times the natural abundance of U235) for nuclear fuel.

In comparing costs of enrichment by diffusion and centrifuge processes the following were provided : capital costs are approximately 50% for each; electricity costs for diffusion, 50% - and only 1/10 of that for centrifuge; running costs were put at less than 5% for both.

One of the world's first full-scale production plants for uranium enrichment by gas centrifuge has operated since 1977 at BNFL Capenhurst Works. The new plant is producing enrichment for nuclear fuels at a more economic cost than previous methods.

Most enriched reactor fuel is in the form of uranium oxide. Enriched uranium oxide is produced at Springfields in a plant in which enriched UF6 is reacted with steam and hydrogen to form uranium oxide in a powder form, from which fuel pellets are formed.

Nuclear fuel must be contained in a suitable cladding or canning material for several reasons. Radioactive fission products accumulate in the fuel and are contained inside the can which also supports the fuel while it is in the reactor core and protects it from the coolant. Easy movement in and out of the reactor and secure location of the fuel in the core are also made easier by use of fuel cans.

Magnesium alloy cans are used to contain the fuel of the first generation of (magnox) nuclear power stations operating in the U.K. The second generation of gas-cooled reactors (AGR) uses uranium oxide fuel pellets enriched to about 2% U235 canned in stainless steel.

Enriched uranium oxide is also used in the Steam Generating Heavy Water Moderated Reactor (SGHWR) which is an alternative design to graphite moderated reactors. The fuel pellets in this case are clad in a zirconium alloy.

Plutonium is the principal by-product obtained from spent fuel from a nuclear reactor. It is envisaged that this will be used for fuel in fast-breeder reactors being developed for commercial operation later this century.

Fuel Reprocessing

In a nuclear power reactor, U235, the fissile component of uranium fuel is slowly used up and must be replaced. After a period of four to five years fuel elements are removed from a reactor and replaced by fresh fuel.

Irradiated or spent fuel is transported to BNFL Windscale Works for reprocessing. Fission products which have accumulated in the fuel elements are removed for concentration and safe storage.

Unused uranium and by-product plutonium are separated and recovered for future re-use.

Most of the irradiated fuel consists of unused uranium (up to 99%), by-product plutonium (up to 2%) and fission product waste (up to 3%).

Irradiated nuclear fuel is highly radioactive. It is carried to the reprocessing factory in thick-walled steel transport flasks, weighing 50 tonnes and containing two tonnes of spent fuel.

Reprocessing of magnox fuel starts by mechanically stripping the fuel element can from the uranium metal fuel rod. The rod is then dissolved in nitric acid. Fission products are removed from this solution, leaving uranium, which is depleted in its fissile U235 content, and by-product plutonium. These are separated from each other chemically.

All handling processes involving radioactive materials are carried out remotely until the fission products are removed.

The concentrated fission product waste extracted during processing is at present stored in stainless steel tanks. The tanks are double-walled and are located in concrete vaults which are themselves lined with stainless steel.

The fission product waste that has accumulated in the U.K. over the past 25 years is stored in 74 stainless steel tanks at Windscale whose total volume is 750 m^3. There will be no need to seek a permanent repository for high level wastes before the end of this century.

The storage of liquid fusion product waste is well established and safe, but there are advantages in making it solid for more effective disposal. A process to convert this waste to a solid durable glass-like form for permanent disposal in stable rock formations as developed by the French will be installed at Windscale in due course.

The process comprises mixing the liquid waste with silica and borax and heating the slurry in a furnace to form glass. The glass is cast into cylindrical, stainless steel sealed containers which can be stored under water in ponds or in artificially cooled vaults. The glass is chemically inert and insoluble and thus the radioactive waste is permanently locked in.

Environmental

Most of the radioactivity (99.96%) arising from the reprocessing of irradiated fuel at Windscale is stored on the site. The remaining 0.04% is discharged to sea in dilute form or, in the case of gases, up tall stacks, under the independent supervision of the Ministry of Agriculture, Fisheries and Food and the Department of the Environment.

Regular environmental monitoring is carried out by BNFL and by a number of Government Departments. Air, milk, fish, shell fish, seaweed, grass, soil etc. are also collected and analysed regularly. The results of this monitoring have consistently shown that the levels are well below the limits laid down by the International Commission on Radiological Protection (ICRP).

The effectiveness of the safety measures may be judged from the nuclear industry's record - and no fatalities have been due to nuclear causes.

The annual radiation exposure of the U.K. population resulting from all activities of the nuclear industry (of which waste disposal is the most significant) amounts to less than ½% of their total annual radiation exposure from all natural and man-made sources. To an individual it is less than the radiation received from one diagnostic X-ray a year, and far less than the increase in natural background radiation that he would incur by moving house from, say, London to a granite area like Aberdeen.

BNFL currently employs 8,742 industrial and 6,227 non-industrial persons; at Windscale, Calder and Chapelcross (6,354), Springfields (4,500), Capenhurst (2,664), and Risley (2,221).

Fuel Division

Is centred on the Springfields Factory, near Preston, where some 9,000 tonnes of uranium are processed each year on a 2,000 acre site.

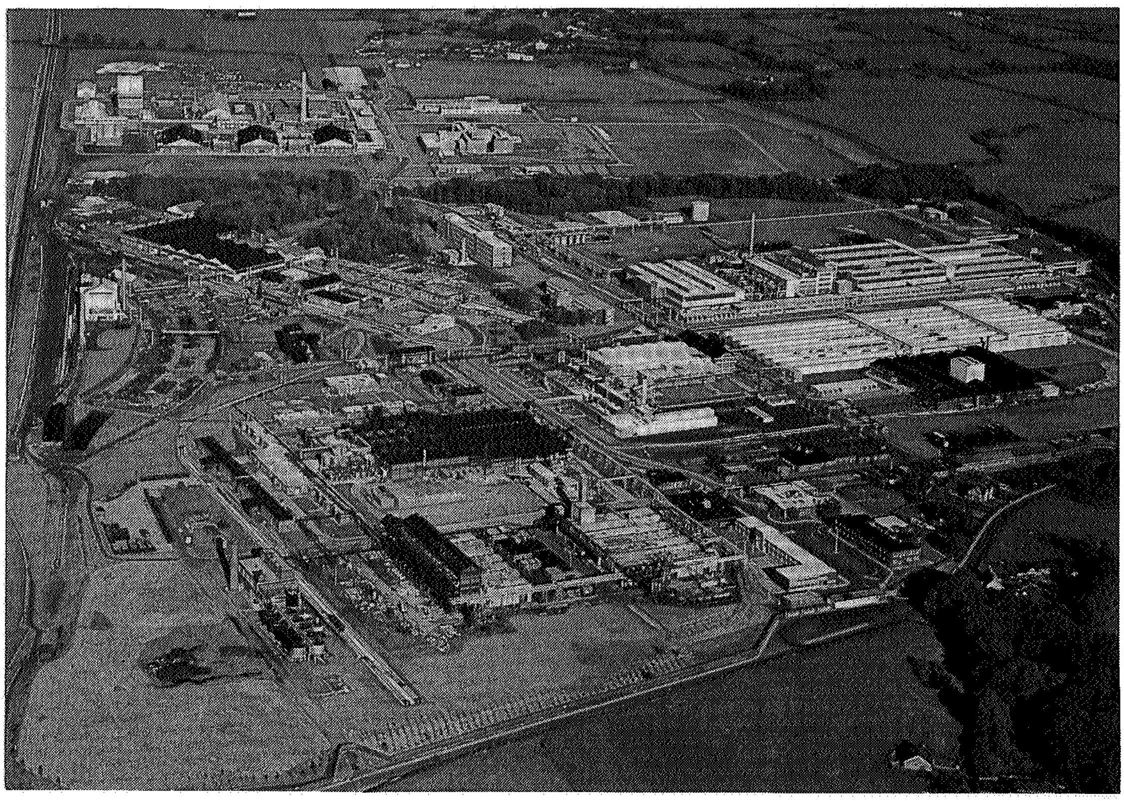
Over three million fuel elements of several different designs have been manufactured for Magnox nuclear power stations operating in the U.K., at Tokai Mura in Japan and Latina in Italy.

In addition, well over 1,000 tonnes of uranium oxide fuel has been produced for use in AGR now operating or under construction in the U.K. Oxide fuel has also been manufactured for PWR and BWR and as breeder fuel for Britain's PFR.

A wide range of uranium ore concentrates is received at Springfields for conversion to uranium hexafluoride. The plant capacity of 9,000 tonnes uranium per year produces extremely pure UF6 to meet the feed specification for enrichment plants throughout the world. BNFL has delivered over 20,000 tonnes of UF6 to enrichment plants on behalf of customers throughout the world.

BNFL offers a complete conversion service, arranging transport and conversion.

Ceramic grade uranium oxide (U02) powder is produced by BNFL by reaction of UF6 with steam and hydrogen. The process is licensed in Europe and is used, by agreement, by Westinghouse Electric, the leading U.S. nuclear plant manufacturer.



BNFL Springfields Works

Over 1,500 tonnes of uranium (of ceramic grade U02) have been produced by the Integrated Dry Route (a single stage process which has been in use for the last nine years) - six kilns are in operation with a total conversion capacity of 650 tonnes uranium per year.

Sintered U02 nuclear fuel pellets have been produced at Springfields for Belgium, West Germany, Italy and the U.S.A. as well as for British nuclear power stations. The pellet production plants have a capacity of 300 tonnes uranium per year; extendable to 500 tonnes and are used for the production of U02 pellets of varying specifications.

Enrichment Division

The enrichment of uranium is carried out at BNFL Enrichment Division factory located at Capenhurst, near Chester.

A gaseous diffusion plant has been in operation since 1950 - for defence purposes until 1962 and to meet British civil requirements for the AGR programme since that time.

At the same time BNFL is developing and building gas centrifuge enrichment plants. Britain's first production size plant, built at a cost of 60 million pounds began operation at Capenhurst in 1977 and provides 3% enrichment with 200 tonnes separative work/year capacity.

Construction of a second centrifuge plant costing about 90 million pounds began in 1979, to increase enrichment capacity by 600 tons/year SWU. Early in 1980 plans were announced for a high-enrichment centrifuge plant to be built on site to produce fuel for the propulsion of nuclear submarines.

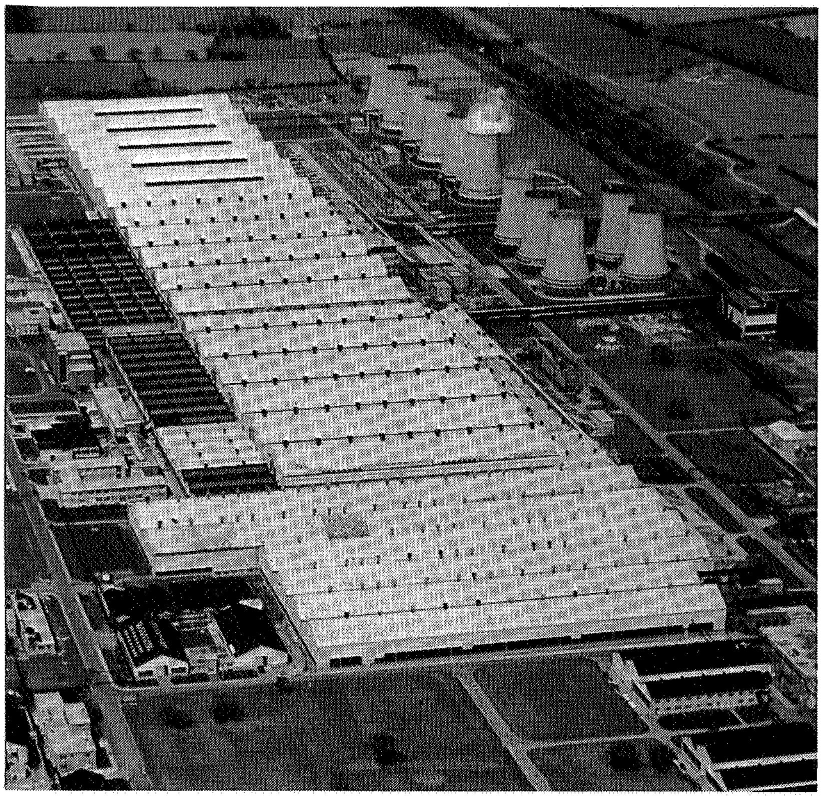
The gas centrifuge process is being developed commercially as a result of an agreement with the British, West German and Dutch Governments. A similar plant to that at Capenhurst is operating at Almelo in the Netherlands.

URENCO Ltd., on behalf of the three partners, is responsible for the marketing of enriched uranium and has obtained contracts worth 1,000 million pounds to supply enriched uranium to customers throughout the world over the next 15 years.

Reprocessing Division

BNFL spent fuel reprocessing factory at Windscale, Cumbria has dealt with about 22,000 tonnes of irradiated fuel, including 1,100 tonnes of fuel from overseas reactors.

Irradiated fuel is initially stored in ponds to allow short-lived radioactivity to die away. The fuel is then chemically reprocessed to separate uranium, plutonium and fission product waste.



BNFL - Capenhurst gaseous diffusion plant

(the adjacent centrifuge enrichment plant occupying less than one quarter of the area of diffusion plant is out of picture, left centre)

Recovered uranium is returned to the customer or sent to Springfields for re-use or storage. Plutonium is handled under international safeguards. Fission product waste is separated and concentrated for further treatment and storage.

Reprocessing facilities are being extended and a new reprocessing plant for irradiated oxide fuel from British nuclear power stations and from overseas reactors is being constructed.

Test drilling is being undertaken in the Cheviot Hills near the Scottish border to establish the nature of underlying basement rocks (this attracted a protest demonstration on 19th October).

BNFL - Windscale

Calder Hall Magnox reactor station, extreme left.
Reprocessing plants for irradiated fuel, plutonium fuel fabrication and storage ponds, centre.
Windscale gas cooled reactor (AGR), extreme right.

Western World Nuclear Fuel Cycle Services Supply

	1980	Projected 1990
Uranium (tonnes U)	49,000	112,000
UF_6 (tonnes U) conversion capacity		
Allied Chemical (U.S.A.)	12,700	12,700
Kerr-McGee (U.S.A.)	9,100	9,100
BNFL, Springfields (U.K.)	9,500	9,500
Comurhex (France)	11,000	15,000
Eldorado, Port Hope (Canada)	5,500	14,500
	48,000	61,000
Enrichment (tonnes Separative Work)		
U.S. DOE	10,500	29,600
Eurodif (Pierrelatte, Tricastin)	6,000	20,800
URENCO (Capenhurst, Almelo)	500	10,000
USSR (to Western World)	3,900	2,400
Brazil	-	200
Japan	20	2,500
South Africa (helicon process)	-	300
	21,000	66,000
Reprocessing (tonnes heavy metal)		
U.K.	-	1,200
France	400	2,500
Germany	40	500
Italy	-	500
	440	5,000

URENCO-CENTEC - the centrifuge process for uranium enrichment

A PWR of	1,000	MWE output requires
	200	tonnes of yellowcake/year containing
	180	tonnes of uranium valued at
	20	million pounds. Converted to hex it fills 21 containers.
For enrichment	120	tonnes separative work is needed, result-
ing in	30	tonnes of product at 3.2% U235 and
	150	tonnes of tails at 0.25%. The product fills
	20	international containers each worth
	1.5	million pounds. It is converted to oxide pellets
to make	14,000	fuel pins, which are assembled into
	60	fuel elements. After about
	3	years in the reactor they reach
	30,000	MWD/te burn-up; and are then replaced.

1	tonne of natural uranium equates to
16,000	tonnes of coal or
80,000	barrels of fuel oil or
12	million m^3 of natural gas.

SWEDEN

STOCKHOLM - 28th October, 1980

Erik Svenke, President, Swedish Nuclear Fuel Supply Co.
Thomas Eckered, Director, Nuclear Safety Board of the Swedish Utilities
Tonis Papp, Safety Analysis, Swedish Nuclear Fuel Supply Co.

Nuclear Power Stations

In Sweden six nuclear power reactors (total output 3,770 MWe) are in operation, four reactors (3,600 MWe) are ready to be fuelled and two reactors (2,000 MWe) are in an early construction phase. Nuclear energy now provides about 25% of the electricity produced and this share is expected to rise to 40% in the late 1980's. The reactors are located on the coast; those operating are as follow:-

Oskarshamn	1	BWR	450	MW	in operation	1972
"	2	"	580	"	" "	1974
Barseback	1	"	580	"	" "	1975
"	2	"	580	"	" "	1977
Ringhals	1	"	760	"	" "	1976
"	2	PWR	820	"	" "	1975

Two units are in a start-up phase:-

Forsmark	1	BWR	900	MW
Ringhals	3	PWR	900	MW

A further two will be started next year:-

Forsmark	2	BWR	900	MW
Ringhals	4	PWR	900	MW

The reason for the large number of new reactors waiting to go into operation is due to delayed granting of licences under a new law and a national referendum on future energy planning.

The Ringhals station is owned by the Swedish State Power Board which is also a 75% shareholder in the Forsmark Station. Barseback is owned by a private company (Syd Kraft) with large public shareholding. Syd Kraft is the main shareholder in Oskarshamn.

Uranium is purchased from foreign sources (discussions are taking place with regard to bilateral agreements with Australia for contracts to supply uranium from Ranger for 10 years, dating from 1982). Sweden prefers to buy natural uranium on the open market rather than procure enriched uranium (e.g. Canada requires that conversion of Canadian uranium be undertaken in that country). Conversion and enrichment is undertaken through foreign contracts, in U.S.A. or USSR. There are known low grade deposits of uranium in Sweden and prospecting is continuing; the cost of production would be twice that for which it can be imported.

Domestic stockpiles of reactor uranium are held. Fuel elements are fabricated locally as well as being imported.

Nuclear Safety Board

The four Swedish nuclear power utilities formed a Nuclear Safety Board in April 1980 to promote, co-ordinate and co-ordinate aspects of nuclear safety; to sponsor R and D in safety work through consultants, universities etc.; and to assess and analyse work. One of its main tasks will be to collect, assess and analyse information relating to incidents and accidents in Swedish and foreign nuclear power stations.

The work of the Board will be open to the public, politicians and the press so that they have an insight into its activities to build up a public confidence in the nuclear safety work of the Swedish utilities.

Radioactive wastes

Thirty reactor-years of operation in Sweden have accumulated 3,000 m^3 of radioactive waste (ion exchange resins and evaporator sludges) and spent fuel with existing storage capacity sufficient for a further 12 years. The utilities pay into a fund (1 ore per KWh electricity produced) to provide for handling, treatment and deposition of waste.

After spent fuel has been taken out of the reactors it is stored in spent fuel storage pools at the reactor sites. To date only limited amounts of Swedish fuel have been contracted for reprocessing, 140 tons with BNFL at Windscale and 720 tons with Cogema at La Hague.

A central spent fuel storage facility (CLAB) is being established to serve all the Swedish nuclear power stations, in parallel tunnels excavated at a depth of 50 m in crystalline rock; containment barriers will comprise 50-70 cm concrete surrounded by 1-1.5 m bentonite. Construction commenced in May 1980 and it is scheduled to be operational by 1985.

The fuel is to be transported to the facility in special containers by sea; these will be unloaded in a reception building after they have been cooled down and cleaned. The fuel assemblies will be transferred to racks for lowering into the storage tunnel through a vertical shaft.

Final Storage of high-level radioactive waste

High-level waste consists mainly of fission products present in spent fuel. The final repository being considered in Sweden is in crystalline rock at a depth of 500 m and, to this end, experiments have been conducted since 1977 in the Stripa Mine, 217 km west of Stockholm, as a joint project involving the U.S. Department of Energy, the Lawrence Berkeley Laboratory (University of California) and the Swedish Nuclear Fuel Safety Project organised within the Swedish Nuclear Fuel Supply Co.

When the Stripa iron ore deposit was mined out to a depth of 430 m the mine was made available for experimentation. Drifts were excavated into the granite adjacent to the abandoned workings to study heat transfer through conduction, fracture hydrology, geochemical and geophysical characterisation of the fracture system, stress measurements in rock, migration testing and investigation of backfill materials to verify the barrier function of bentonite and mixtures of sand and bentonite.

It is envisaged that a final repository for spent fuel will be put into operation about year 2020 when a number of parallel tunnels are excavated in granite at a depth of 500 m. In the tunnel floor, deposition holes will be drilled to accept an encapsulated waste container about 5 m in length and the surrounding space packed with bentonite.

Results to date show that final storage of spent fuel or high-level reprocessing waste is feasible within the constraints of the technology of today.

The Nuclear Referendum

On 23rd March, 1980 a national referendum on nuclear energy was held in Sweden. For many years an intensive debate has raged in Sweden on the risks and acceptability of nuclear energy and this developed into a political issue.

The Three Mile Island incident on 28th March, 1979 triggered a parliamentary decision to re-evaluate safety aspects of nuclear energy in Sweden and to hold a referendum with choices as follow:-

Choice 1 - "Energy for Sweden" - proposing a replacement for nuclear energy only if safer and cheaper alternatives were found.

Choice 2 - "Phase out with common sense" - stressing that the 12 reactors in operation, ready to be fuelled or under construction were to be operated for their economic life. No subsequent development of nuclear energy was to take place.

Choice 3 - "Nuclear power - no thanks" - campaigned to turn off the reactors as soon as possible, at the latest in 10 years.

The referendum returned support as follows : alternative 1 - 18.7%; alternative 2 - 39.3%; alternative 3 - 38.6%. The immediate consequence was that permission was granted to start the four reactors that were ready and for construction of the central fuel storage facility. The permission to operate existing and future reactors may well be tied to the progress of development and demonstration work within the area of radioactive waste management.

Papp, Tonis : "Radioactive waste management in Sweden".

A paper presented at the Annual American Nuclear Society Meeting in Las Vegas, June 1980.

THE NETHERLANDS

ALMELO - 29th-30th October, 1980

URENCO-CENTEC

Dr. Brian Kehoe, Business Development Director
Douglas Kell, General Manager, Almelo
Prof. Borman, Director

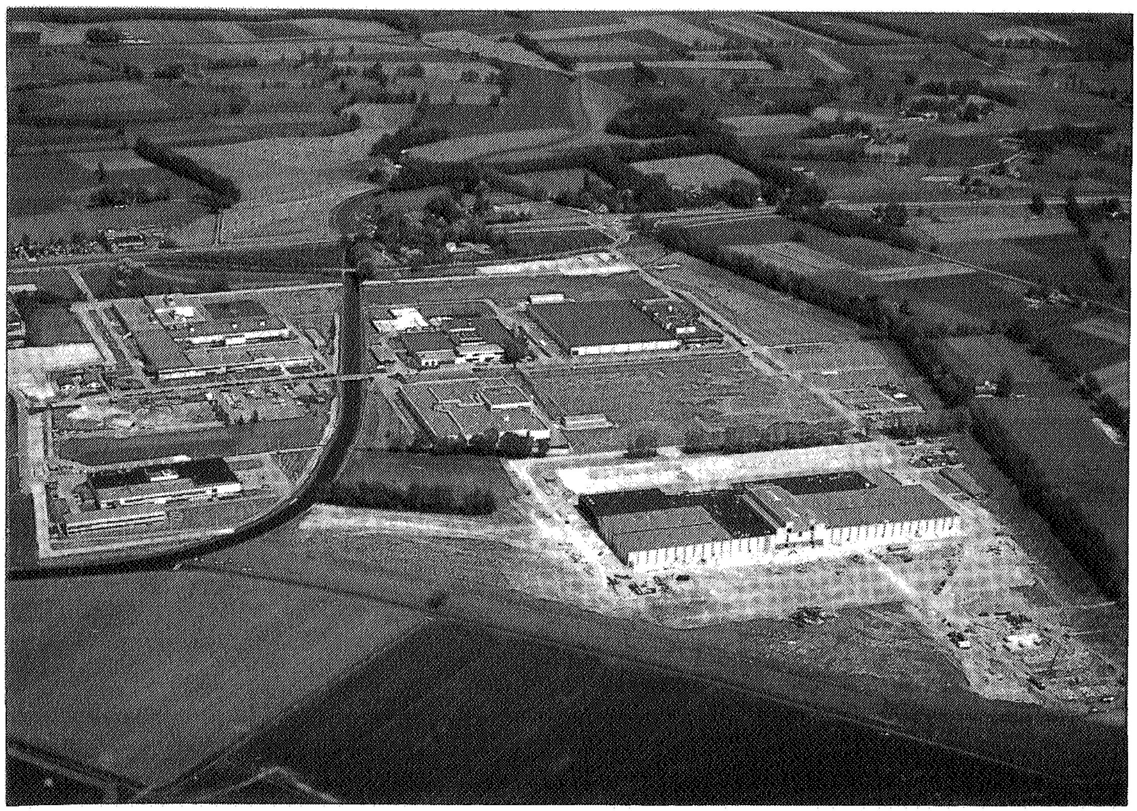
The enrichment plant which has been operational since 1972 is situated 1½ miles from the centre of the city of Almelo (population 50,000), and is less than ¼ mile from the built up suburban area. Approximately 350 are employed in fabrication on the site adjacent to the centrifuge hall.

Hexafluoride is received by road from BNFL (Springfields), Comurhex (France) or Eldorado (Port Hope, Canada) in 12 tonne cylinders. It is gasified at a temperature of 60° to 70°C in an autoclave to transfer to inter-connected banks of cascade units 4 ft. long and 9 inches in diameter. The plant has a total capacity of 200 tonnes per year SW. The power requirement for this plant is 4 MW. A 12 tonne cylinder of uranium hexafluoride valued at $40/lb results in two tons of enriched product valued at $1½ million.

A new building under construction will comprise 10 cascade halls, each 100 x 25 yards; the extended plant will have a capacity of 1,000 tonnes per year SW.

Almelo centrifuge enrichment plant

The centrifuge hall



Almelo works, aerial view

200 tonne centrifuge hall, lower right
Centrifuge Manufacturing Centre, upper left

FRANCE - 31ST OCTOBER-8TH NOVEMBER, 1980

PARIS

Ian Lincoln, First Secretary, Australian Embassy
John Rowland, Australian Ambassador to France
Andre Giraud, Minister for Industry
M. Tridon, Ministry of Industry
Henri Boccaccio, Director-General, Technip
Daniel Gilbourne, Business Development Manager, Oil and Gas Technology RCG Division, Technip
Jean Delafont, Senior Vice President, Technip
Peter Sorensen, First Secretary (Commercial), Australian Embassy
John Trotter, Minister, Australian Embassy

Commissariat a L'Energie Atomique (CEA)

Michael Pecquer, Administrator General
Georges Vendryes, Director of Industrial Nuclear Applications
Philippe Girard, Director-General of Nuclear Materials
Bertrand de Gelassus, International Relations Division
Jean-Claude Guais, Chemistry Division
Jean-Paul Devilliers, Delegate for Nuclear Materials
Michel Mezin, Representative in Australia
Jean-Hubert Coates, Assistant to Director, Nuclear Materials Division

Comurhex, Pierrelatte

Jean Bourque, Directeur de l'usine de Pierrelatte
M. Loppion, General Manager
Andre Ducouret, Chef des Fabrications
Jean Richez, Assistant Plant Manager

Cogema, Marcoule

M. Savineau, General Manager, Phenix
Denis Martin, Assistant Director, Phenix
M. Chottin, Manager, Vitrification Plant
M. Meffre, External Relations
Michel Berville, Assistant Manager

Commissariat à L'Énergie Atomique (CEA)

The CEA comprises scientific, industrial, national defence and other technological activities under the authority of the Ministry for Industry and Research and is concerned with production of nuclear materials, reactor development, research, transfer of technologies, military applications, radiological protection and nuclear safety.

Discussions with the Minister for Industry in Paris centred on possible French involvement in mineral development projects in South Australia, including uranium enrichment, a petrochemical project, coal for petrochemicals, Stuart Shelf development, mineral exploration and petroleum exploration interest, offshore and onshore.

The French energy outlook and programme for nuclear power generation were discussed with officials of the CEA and Comurhex in Paris; aspects of enrichment, conversion, nuclear power reactors, reprocessing and vitrification of waste were discussed with officials of CEA, EDF (Electricite de France), Comurhex, Cogema and Eurodif in the south of France; and inspections were made of the Comurhex conversion plant and EDF installations at Pierrelatte, stage 4 enrichment by gaseous diffusion at Eurodif Tricastin plant and the Tricastin 4 nuclear reactor, the prototype fast reactor Phenix and the vitrification of high level radioactive waste facility at Marcoule.

Electricité de France - nuclear power programme

In 1979, primary energy use in France was made up as follows:-

- petroleum 56%
- nuclear 4.5%
- coal/gas 30%
- hydroelectric 8%
- other 1.5%

Electricity generation in 1979 comprised the following:-

- nuclear 21%
- lignite/gas 5.4%
- oil 24.6%
- coal 25%
- hydro 24%

During the early period of nuclear power development from 1954 to 1973, eight gas cooled reactors (GCR) and three prototype facilities (Monts d'Arree HWGCR, Chooz PWR and Phenix FBR) were constructed. This was followed by a period of pressurised water reactor (PWR) development when the nuclear power units committed since the end of 1969 linked the national utility (EDF) and the French reactor vendor (Framatome) - these units consist of two standardised series of 900 and 1300 MWe reactors.

Fast breeder reactor (FBR) development followed construction of a 250 MWe demonstration facility (Phenix) which was connected to the grid in 1973. The Super-Phenix, a 1200 MWe commercial prototype facility, is under construction at Creys-Malville with Novatome as the general contractor; connection to the grid is scheduled for 1983 and four 1200-1500 MWe units are planned to come on line between 1989 and 1995.

At the end of 1979 the French nuclear power plant construction programme was as follows:-

- 16 operational units with a net installed capacity of 8300 MWe.
- 32 units under construction with a net capacity of 31,500 MWe and scheduled for commissioning in the period 1980-1986.

Continuation of this construction programme calls for implementation of:-

- phase 1, start of construction on nine units by the end of 1981 (10,700 MWe) to be commissioned in the period 1986-1987.
- phase 2, start of construction on five units in 1982 (6000 MWe) to be commissioned in 1987-1988.

To provide for anticipated electricity consumption beyond 1987 will involve start-up of:-

- one to three 1300 MW standard PWR units every year,

and

- four 1500 FBR during the period 1989-1995.

Commercial operation and projected nuclear power capacity is as follows:-

Year	% of total electricity output	Net installed capacity of nuclear reactors (MWe)
1978	13	4,700
1979	16	8,300
1980	25	13,000
1985	50	40,000
1990	73 (15% by FBR)	65,000

The installed and projected power reactors are as follow:-

Start Construction	Plant	Type	Electric capacity (MWe)	Commercial operation
1954	Marcoule G1	GCR	2 (to be	1956
1955	Marcoule G2	GCR	38 (dismant- (led (through (obsoles- (cence)	1959
1956	Marcoule G3	GCR	38	1960
1957	Chinon 1	GCR	70	1964
1958	Chinon 2	GCR	210	1966
1961	Chinon 3	GCR	480	1967
1962	Chooz 1	PWR	310	1970
1962	Monts d'Arree	HWGCR	70	1967
1963	St. Laurent 1	GCR	480	1969
1965	Bugey	GCR	540	1972
1966	St. Laurent 2	GCR	515	1971
1968	Phenix	FBR	233	1974
1970	Fessenheim 1	PWR	880	1977
1971	Fessenheim 2	PWR	880	1978
1972	Bugey 2	PWR	920	1979
1972	Bugey 3	PWR	920	1979
1973	Bugey 4	PWR	900	1979
1974	Bugey 5	PWR	900	1980
1974	Tricastin 1	PWR	920	1980
1974	Gravelines B1	PWR	920	1980
1974	Dampierre 1	PWR	900	1980
1974	Tricastin 2	PWR	920	1980
1975	Gravelines B2	PWR	920	1980
1975	Dampierre 2	PWR	900	1981
1975	Tricastin 3	PWR	920	1981
1975	Gravelines B3	PWR	920	1981
1975	Dampierre 3	PWR	900	1981
1975	Tricastin 4	PWR	920	1981
1976	Gravelines B4	PWR	920	1981
1976	St. Laurent B1	PWR	880	1981
1976	Dampierre 4	PWR	900	1982
1976	St. Laurent B2	PWR	880	1982
1976	Le Blayais 1	PWR	920	1982
1977	Le Blayais 2	PWR	920	1982
1977	Chinon B1	PWR	870	1982
1977	Chinon B2	PWR	870	1982
1977	Le Blayais 3	PWR	920	1983
1978	Le Blayais 4	PWR	920	1983
1978	Cruas 1	PWR	880	1984
1978	Cruas 2	PWR	880	1984
1979	Cruas 3	PWR	880	1984
1979	Cruas 4	PWR	880	1985
1977	Paluel 1	PWR	1285	1984
1977	Paluel 2	PWR	1285	1984
1978	Paluel 3	PWR	1285	1984
1979	St. Maurice 1	PWR	1275	1985
1979	Flamanville 1	PWR	1285	1985
1980	Paluel 4	PWR	1285	1986

Start Construction	Plant	Type	Electric capacity (MWe)	Commercial operation
1980	St. Maurice 2	PWR	1275	1986
1980	Flamanville 2	PWR	1285	1986
1976	(Creys-Malville) (Super phenix)	FBR	1200	1984
1979	Gravelines C5	PWR	920	1985
1980	Gravelines C6	PWR	920	1986
1981	Chinon B3	PWR	870	1986
1982	Chinon B4	PWR	870	1987
1979	Cattenom 1	PWR	1275	1986
1980	Cattenom 2	PWR	1275	1986
1981	Belleville 1	PWR	1275	1987
1981	Nogent 1	PWR	1275	1987
1981	Belleville 2	PWR	1275	1987
1982	Cattenom 3	PWR	1275	1987
1982	Nogent 2	PWR	1275	1987
1982	Golfech 1	PWR	1275	1988
1982	Chooz B1	PWR	1275	1988

The construction period for a 1000 MW reactor is 5½ years and from time of completion to connection to grid on full power occupies 1½ months. The cost is put at 3,800 francs/KWe, equivalent to $1,000 million per reactor.

Tricastin nuclear power plant, in the Rhone valley on a lateral canal with a dam, comprises four units, adjacent to the Pierrelatte Comurhex enrichment plant. Fuel buildings are attached to each.

The plant comprises turbine holds with 940 MW generating sets each; the first unit was brought on line in May 1980, the second in August 1980, the third will be completed in December 1980 and the fourth, in May 1981.

The three metre thick concrete cladding around the reactor, 50 m high and 40 m in diameter, fabrication workshop and site installations were inspected.

<u>Sodium cooled fast reactor Phenix, Marcoule</u>

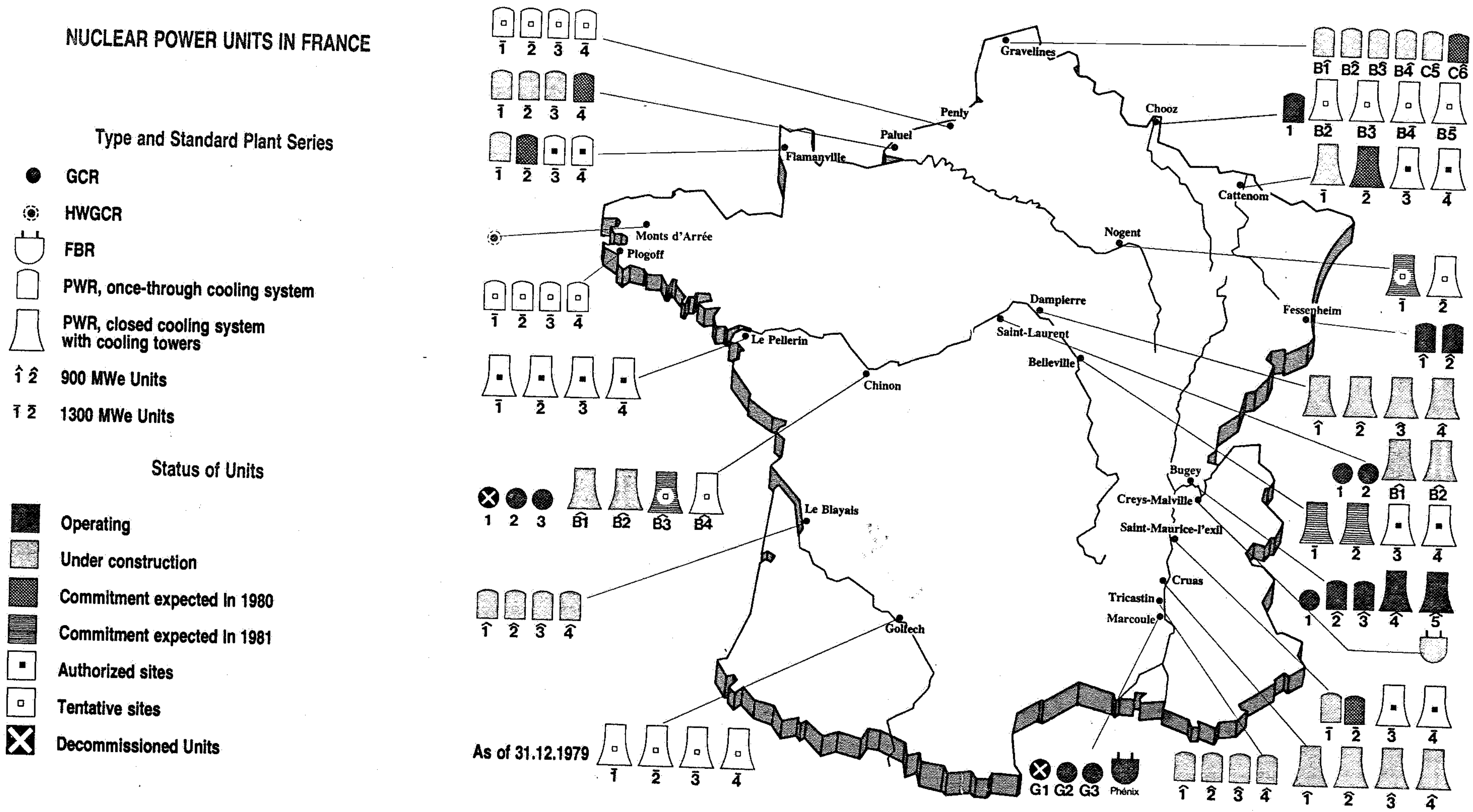
Phenix has been operational since 1973 and has a rating of 250 MWe. The essential advantages of the fast neutron-breeder reactor include:-

- utilisation of plutonium and otherwise expended fuels (PWR use 1% of the energy available from natural uranium and 99% of contained potential energy is discarded as unexpended fuels).

- utilisation of plutonium from reprocessed spent fuels and the isotope U238 which derives plutonium in the reactor.

- production of more plutonium than graphite and light water moderated slow reactors for the same output power level.

NUCLEAR POWER UNITS IN FRANCE

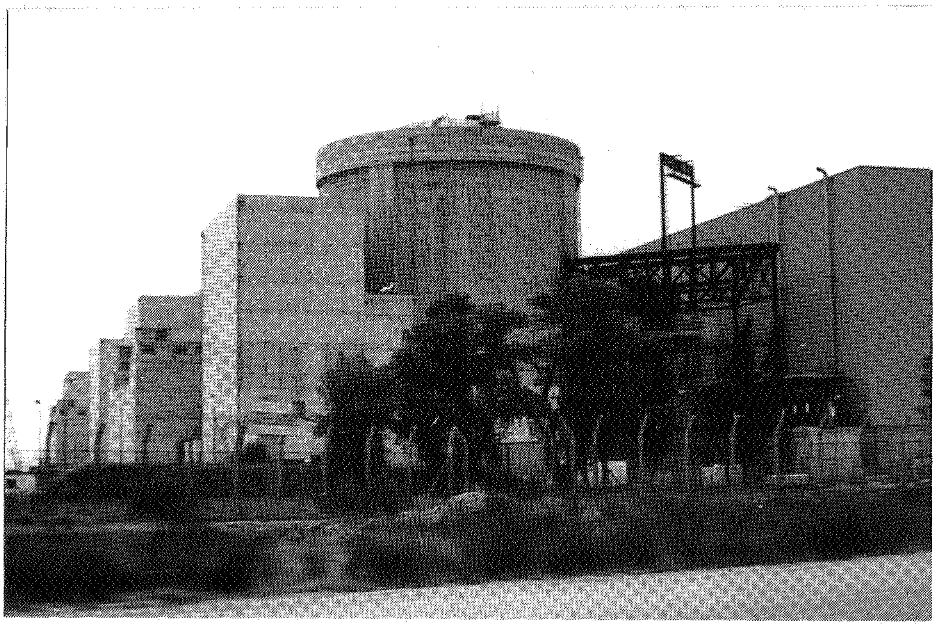


Tricastin - Centrales EDF and Usine EURODIF

Four nuclear power reactors on River Rhone canal (foreground of 1 square mile site)

Two cooling towers adjacent to water treatment plants (middle ground)

10.8 million SWU/year capacity diffusion plant housed in four buildings in background



Tricastin nuclear power station - Pierrelatte

- the quantity of fissile matter generated ("bred") in a fast reactor is greater than the quantity consumed in generating power; thus, obtaining a power yield from natural uranium reserves that is very much greater than at present.

- high temperature attainment in the core.

The fuel developed for the fast reactor is a mixed U238-Pu239 oxide, sintered into the form of cylindrical pellets which are assembled as fuel rods in compact hexagonal frames with spacers and clad in stainless steel. The fuel cycle is now closed which means that, with reprocessing included, the Phenix reactor requires no more fissile material than it produces.

Heat generated in the reactor core is transferred by molten sodium through heat exchangers to the steam generators. Steam is fed to a turbo alternator at 510^{o}C.

Fast breeders have to be developed progressively since fuel is dependent on production of plutonium in PWR and one FBR is under construction as compared with 40 new PWR. It is envisaged that fast breeders will contribute 12,000 to 15,000 MWe of the projected 100,000 MWe output in year 2000.

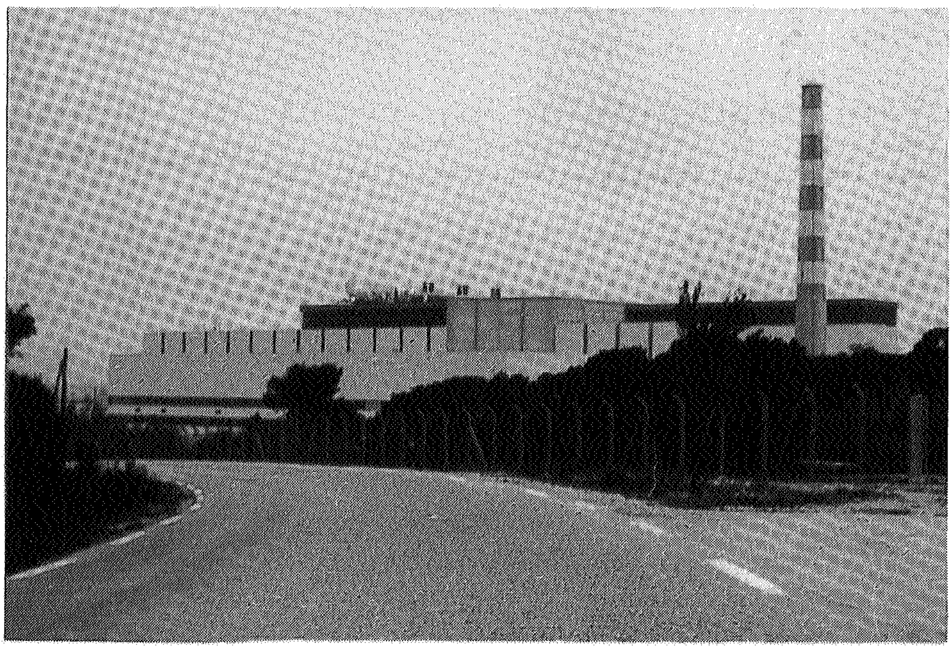
The Phenix reactor is operating at designed capacity at an efficiency twice that of the PWR. Radiation doses received by the operatives is low (less than 1/100th the authorised limit).

Construction of the 1,200 MWe Super Phenix at Bugez was initiated in late 1976 and is at present 50% completed; start-up is scheduled for December 1983. Its cost is twice that of the investment in PWR of similar power output since it is a prototype, it is the only plant on the site and it is being built in a multinational framework. The cost of Super Phenix (1977 prices) is put at FF10,000 million.

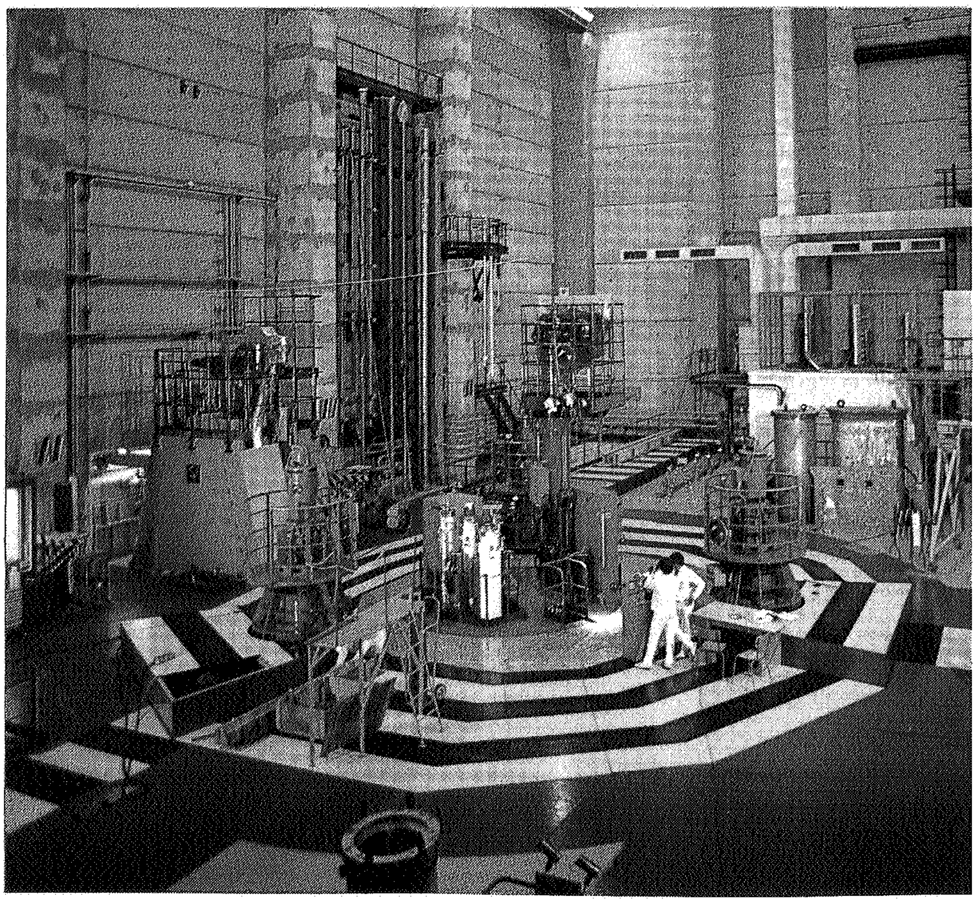
COGEMA (Compagnie Generale des Materieres Nucleaires)

Cogema, created in 1976 by the CEA to operate the fuel cycle plants formerly controlled by CEA, is engaged in uranium mining, enrichment and fuel reprocessing.

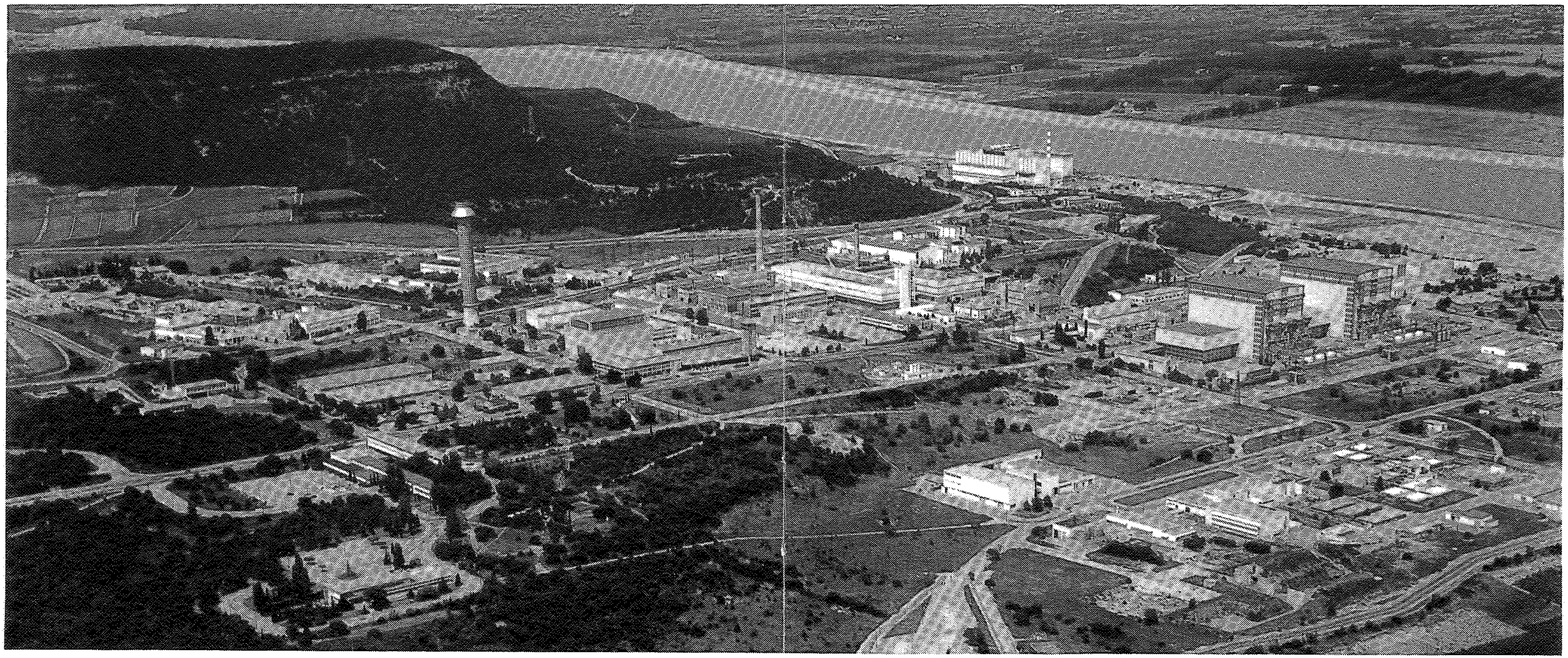
The company now produces 2,000 tonnes of domestic uranium per year and has contractural access to a further 3,000 tonnes from foreign sources, worked by its subsidiaries or partners. Reserves at its disposal include 50,000 tonnes of contained metal in France (Vendee, Limoges and Provence) and 60,000 tonnes abroad. By 1990, France will import a large proportion of requirements - these will total 10,000 t.p.a. before 1995 and rising to 14,000 t.p.a. by year 2000 and 18,000 t.p.a. by year 2010. Imports of yellowcake are now made from Niger and Saskatchewan (Cluff Lake, 1,500 t.p.a.) and there is speculation that Australia might provide the fuel required by 1990.



Prototype fast reactor station Phenix - Marcoule



Phenix, reactor hall



Marcoule, Industrial Nuclear Centre

Tritium extraction plant (lower left centre)

Spent fuel hold-up pool, fuel decanning workshop, chemical reprocessing plant - UPI (centre)

Reactors G2, G3 (housed in high rectangular buildings) and Celestin I and II (centre, extreme right). Phenix, on bank of River Rhone

Marcoule is the site of the first nuclear industrial units created in France including the first plutonium producers (G1, G2 and G3), the first nuclear power generators, the first spent fuel reprocessing and plutonium extraction plant (UP1), the industrial irradiation reactors (Celestin 1 and 2), analysis and product control, effluent processing equipment decontamination, fission products disposal and is the site of the first breeder reactor power station, Phenix.

The company operates three mining divisions, the isotope enrichment facility at Pierrelatte (40%) and Malvesi and the fuel reprocessing plants at Marcoule and La Hague.

Cogema employs 8,000 people and has a turnover in excess of 4.5 billion francs.

Comurhex - Pierrelatte Plant

Comurhex (Company for Conversion of Uranium in Metal and Hexafluoride) was created in January 1971 by joining the forces of CEA and of industry and now includes Uranium Pechiney Ugine Kuhlmann (51%), Cogema (39%) and Compagnie de Mokta (10%). The company operates the Malvesi plant in Aude and the Pierrelatte plant in the south of France, adjacent to the Cogema and CEA industrial development site of Tricastin and the Eurodif enrichment plant.

At Comurhex-Pierrelatte (where about 400 persons are employed) uranium tetrafluoride is received in tanks in the form of a green granulate from the Malvesi plant near Narbonne (where processing comprises dissolution of uranium oxide concentrate with nitric acid; purification of uranyl nitrate by solvent; precipitation of ammonium diuranate and calcination to U03; reduction of U03 to U02 and hydrofluoration of U02 to UF4). The UF4 is combined with fluorine produced on the Pierrelatte site by electrolysis of hydrofluoric acid in reactor towers and condensed as white crystals in "cold traps". The production line operates under negative pressure to obviate leakage of F, HF or UF6 in the process. The UF6 retained in the crystallisers is melted at 80°C and poured into containers at a charging station for delivery to the enrichment plant.

Residual gases are washed in columns and discharged to the atmosphere. Liquid effluents are treated for the recovery of uranium.

Comurhex conversion of U_3O_8 to UF4 in Australia and export of UF4 to France was raised as a possibility of interest.

Enrichment - Eurodif plant, Tricastin (Usine Eurodif du Tricastin)

Uranium enrichment by gaseous diffusion was developed by CEA in the 1950's. Enrichment was initiated in France at a military plant which existed at Pierrelatte.

Eurodif was created in 1973 and production of enriched uranium at Tricastin from the first production unit put in cascade dates from February 1979. The third production unit will be commissioned late 1980 to give an installed capacity of 7,000 tonnes SW. The fourth unit will be completed in late 1981 to give a capacity of 10,000 tonnes SW or 25% of world enrichment capacity. Sales of enriched uranium contracted for the period 1979-1980 represent 110 million SWU. The annual feed will be 18,000 tonnes of natural uranium (as UF6) per year when completed in 1982 and will produce 2,670 tonnes of enriched uranium per year at 3.15%, the tails assay is 0.25%.

Eurodif is among the largest commercial suppliers of enrichment services in the world and was the first to operate a large scale enrichment facility capable of meeting world-scale requirements.

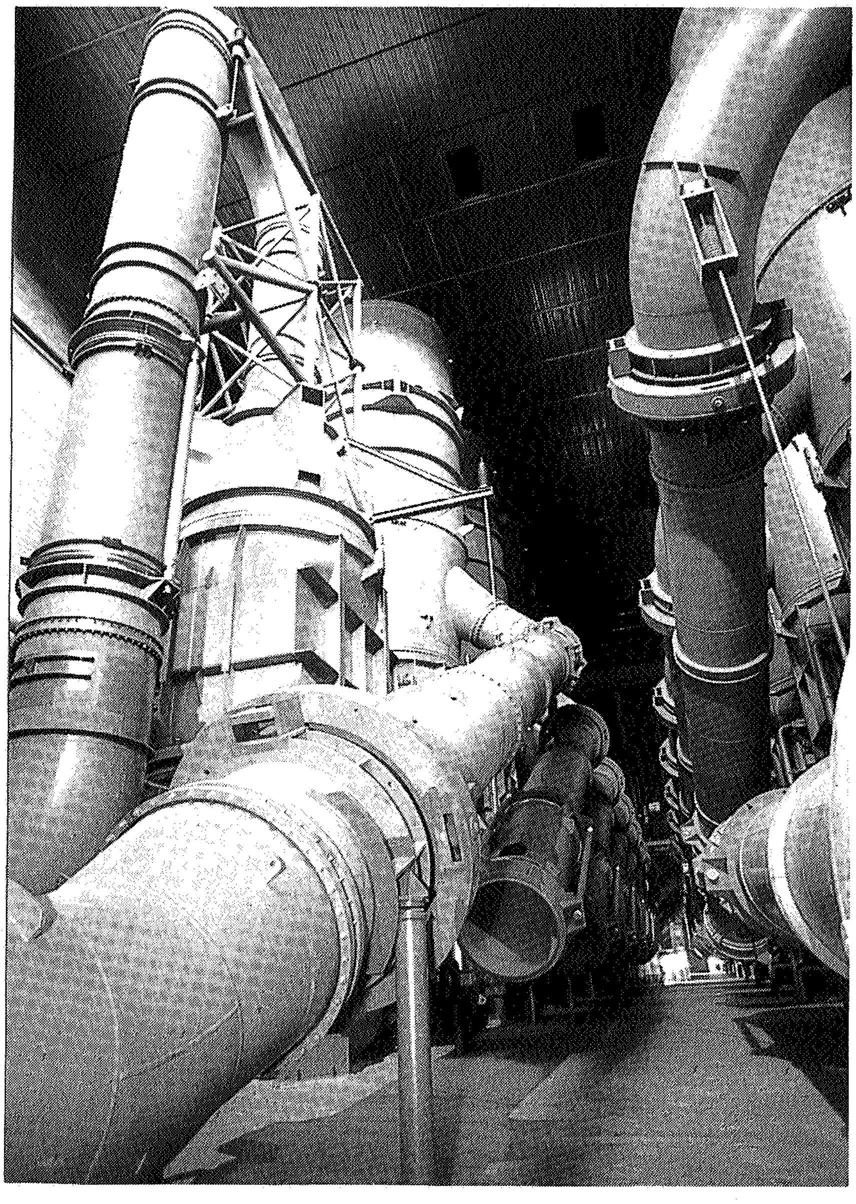
Uranium enrichment raises the natural 0.7% concentration of U235 to approximately 3%. This stage in the fuel cycle occurs after the natural ore has been concentrated as yellowcake and converted to uranium hexafluoride.

The gaseous diffusion process has been used for over 30 years, in U.S.A., USSR, U.K., China and France and it accounts for 98% of the enriched uranium currently produced. The process is based on the diffusion of UF6 gas through porous membranes or barriers in 1 metre long ceramic tubes - the gas passes through a diffuser housing the barriers which separate the isotopes and comprises columns 25 m high. The lighter U235 moves more rapidly, hits the barrier more frequently than the heavier isotope U238 and has an enhanced opportunity for passing through the barriers. Thus a gas with a higher proportion of the U235 isotope than its original 0.7% content collects on the other side of the barrier.

Since the enrichment obtained at each passage is low, the operation has to be repeated a great number of times through barriers arranged in a series of diffusers installed in "cascade" to provide the necessary degree of enrichment, with 0.2% enrichment being achieved in each staged phase. Circulation of the enriched gas and the recycling of the depleted gas through a succession of 1,400 identical stages are accomplished by compressors for which the power requirement is 3,000 MW (derived from the Tricastin stations on site).

The gas is circulated at a temperature of 100^{o}C through the cascades and is cooled down in heat exchangers for processing in the succeeding stage through compression. Enriched gas is withdrawn at the top and the depleted gas at the bottom.

A gaseous diffusion enrichment facility is composed of a cascade of diffusion stages, each stage containing an assembly of one diffuser with a large number of barriers, one compressor and one heat exchanger which cools the gas flow. The industrial process is essentially static, the compressors



Diffusers, Eurodif, Tricastin

and their motors being the only moving parts. Thus, the facility has a long life and is reliable. The diffusion cascade consists of 1,400 diffusion stages, as 70 groups of 20 stages, housed in four buildings. The process annexe feeds natural uranium to the facility and draws off the enriched and the depleted uranium. The control building houses all the process controls, technical, logistic and safety systems associated with producti9n. Staff employed total 775 and there are currently 2,000 construction personnel on site.

The largest electric switch yard in Europe, covering 40 acres feeds power to the facility.

Two cooling towers evacuate excess heat; auxiliary units include water treatment plant. Nickel coating of equipment in contact with process gas is done on site - the total surface so treated exceeds 550,000 m^2.

An EDF power station with 4 x 930 MWe nuclear units, located near the enrichment facility, provide power to the Eurodif plant - the average power requirement will be 3,100 MW.

The facility cost 9.553 billion 1974 francs (equivalent to $A2 billion and approximately 15.5 billion current francs).

Eurodif has six shareholders - SOBEN (Belgium), AGIP NUCLEARE (Italy), CNEN (Italy), ENUSA (Spain), COGEMA (France) and SOFIDIF (Franco-Iranian). Relations between the partner countries are defined in agreements, particularly concerned with commitments to peaceful use under the control of the IAEA. The structure is that of a commercial corporation which seeks return on investment, free from political constraint. Original shareholdings are as follow:-

- Spain ENUSA 11% - utilities
- Belgium SOBEN 11% - state commission/utilities
- Italy CNEN 12.5%) AGIP 12.5%) of which 9% has since been sold to COGEMA
- France COGEMA 42% (plus 9% of above - 51%)
- Iran OEAI 11%

Contracts have been written with 25 electric utilities, who will have a total nuclear generating capacity of 140,000 MWe in 1990, to provide 90% of their enriched uranium needs; 11 contracts taking 10% of throughput are with non-member countries : Japan (nine utilities), Germany (one utility) and Switzerland (one utility). Enrichment work, as elsewhere, is performed on a toll basis and the natural uranium feed remains the property of the client throughout the enrichment process.

Given the current nuclear reactor construction programme, world requirements will rise from 20 million SWU in 1980 to approximately 45 million SWU by 1990 (a 1,000 MWe reactor uses approximately 120,000 SWU per year). Demand is expected to grow at a somewhat slower pace during the following decade.

Eurodif enrichment capacity is sufficient to 1990. After that time the options include:-

- Additions to existing plant.

- New plant elsewhere in Europe

- New plant in Australia. Interest has been maintained since the 1972/73 visit of a French mission to Australia - a 3,000 SW tonnes plant with enrichment to say 2% and requiring 1,000 MWe power station for operation is envisaged - since the Pacific Basin (Japan, particularly) is regarded as a favourable centre for such development. France would seek to take 20% to 40% of production and share in financing, construction, electric power generation, coal mine development etc.

- Such plants would be based on the gaseous diffusion process. However, there would be flexibility with regard to technology, components, degree of enrichment and procurement of natural uranium. Components might be built partly in Australia (cf. construction of heat exchangers in Spain and large scale compressors in Italy, for Tricastin). The pace of development is unknown; lead times are put at 6 to 7 years with a further two years for full output capacity.

- The centrifuge process was studied when the diffusion process was being developed but was considered to be not economically attractive and was, accordingly, rejected.

- Laser technology, if successfully developed, would provide the ultimate solution and is seen to be the technology of the future.

- Experiments are being pursued in centrifuge, diffusion, chemical exchange, laser and other dynamic processes.

- A chemical isotopic enrichment process based on separation of different sized elements is being progressed. Research has continued for 13 years and, while the compounds are classified, the process is said to be applied in petrochemical and pharmaceutical industries. This is not a resin process as is being developed in Japan.

Chemical Enrichment Process

In 1978, the CEA developed a new method of isotope enrichment based on chemical exchange by which it would be virtually impossible to produce highly enriched weapon grade uranium in less than a decade or two, thus reducing risk for spread of nuclear weapons. Consideration is being given to construction of a demonstration plant in co-operation with other companies. The process is said to have potential for high output with 3,000 SWU for individual columns and, therefore, no requirement for a large number nor high degree of automation. It may be readily inserted because of the modular nature of installation in parallel as required; thus 200,000 SWU/year would be readily established having a power requirement 25% that of gaseous diffusion - a plant with 1 million SWU/year capacity would require 100 MWe and low grade heat.

As the UF6 step is eliminated it would be possible to match design and scale to reactor requirement.

The process is highly confidential and the nature of the chemical reactants has not been divulged ... "the interacting compounds are not usual and ... enter into two liquid phases, one aqueous, the other organic. ... The isotopic exchange zone is an iterative counterflow contact structure in which the two non miscible liquid phases are successively made to mix and separate".

The Marcoule Vitrification Facility (AVM)

At the backend of the uranium fuel cycle, waste management and storage of highly radioactive fission products have received great attention in France. Vitrification of wastes has been undertaken successfully at Marcoule since June 1978 where irradiated natural uranium fuel rods and graphite moderators are reprocessed. (Cogema at La Hague reprocess LWR fuel rods where current capacity of 250 tonnes/year is being enlarged to reprocess 600 t.p.a. of spent fuel by 1990, equivalent to the needs of 60 operating LWR of 1,000 MWe output).

The Marcoule Vitrification Facility is based on a continuous vitrification process developed by CEA on behalf of Cogema.

The system comprises a rotary kiln calciner, heated by a resistance furnace, fed with slurry waste, coupled to a continuous metallic melter, heated by an induction furnace, in which calcine from the kiln and glass frit are continuously melted, then batch dumped through a freeze valve into a receiving canister. Once filled, the canister is capped, seal welded, decontaminated and moved to air cooled storage.

"France's chemical enrichment process" (Jean-Hubert Coates, CEA). Paper presented at the International Conference on the Nuclear Fuel Cycle in Amsterdam, September 1980.

The process condensate and off-gas wash solutions are returned to the reprocessing plant for concentration prior to being fed back with the concentrated high level waste.

Three different compositions of borosilicate glass are utilised to accommodate the three different types of fuels received at AVM. The choice of glass is made to fulfil requirements of low leachability, thermal stability, stability of the structure under irradiation and physical properties. Glass for commercial spent fuels has the following composition (weight %) : SiO_2 (42.5), Al_2O_3 (8.5), B_2O_3 (17.5), Na_2O (14.0), MgO (1.0), Fe_2O_3 (1.6), F (1.4), NiO + Cr_2O_3 (0.5), FP oxides (13.0).

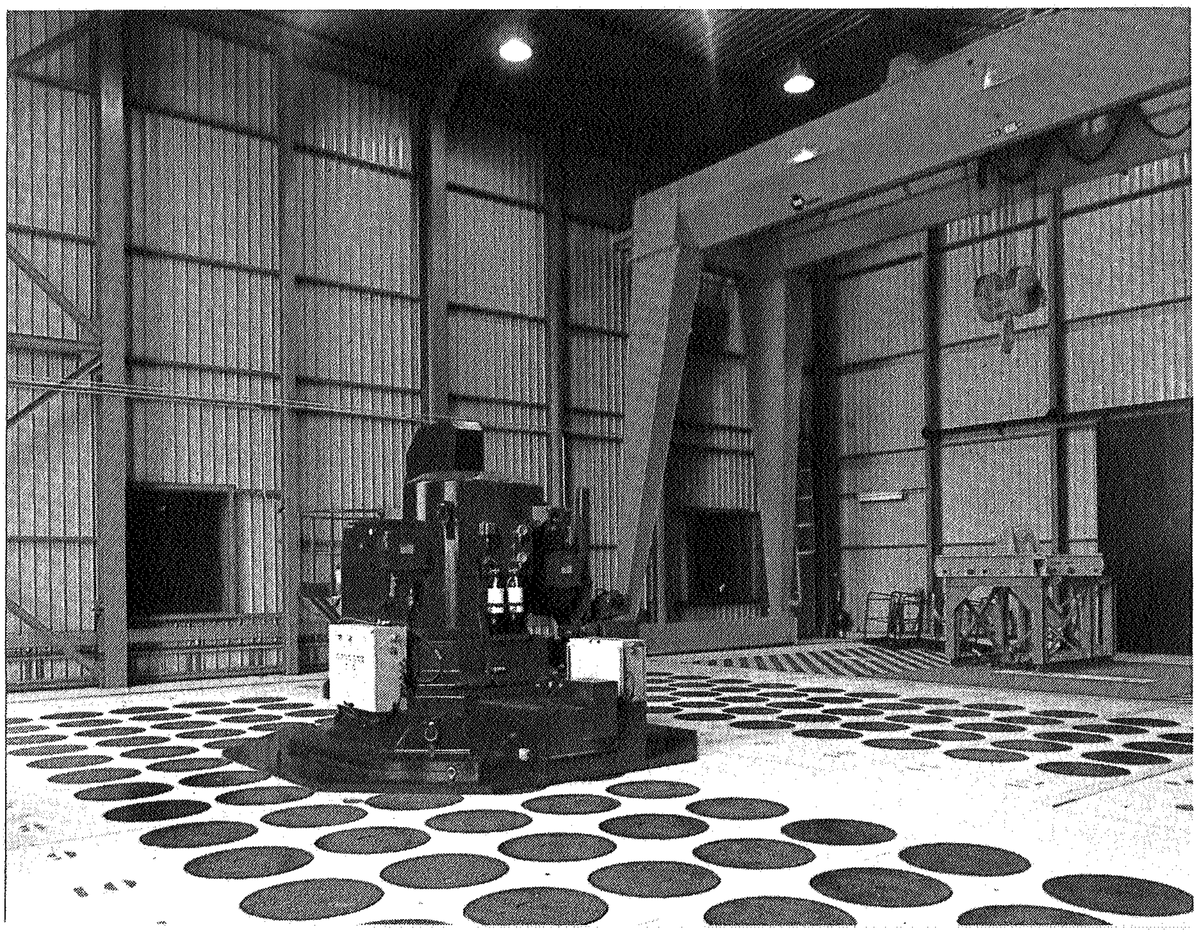
The vitrification cell is lined with stainless steel and contained equipment is operated and maintained through remote control.

The throughput of the melting furnace is about 15 Kgh^{-1} of glass melted at 1100 °C/1150 °C. Every eight hours 120 kg of glass are cast in a canister which receives three successive casts. A few hours after filling, the canister is shifted to the welding area where it is capped and seal welded. Decontamination takes place one day later by washing the surface with water jets.

The glass storage unit comprises three engineered underground concrete vaults. The canisters, 1 metre long and 50 cm diameter, are piled up in the 10 m high pits fitted in the vaults. There are 220 pits to meet requirements to year 2000.

To date, 106 m^3 of concentrated solutions of fission product equivalent to waste from 2,00 tonnes of fuel from the Marcoule metal fuel reprocessing plant have been transformed in 48.5 tonnes of glass. Forced air cooling maintains temperature in the storage vaults. There are no plans for permanent disposal of the canisters.

"Vitrification of high level waste solutions at Marcoule, France". Paper presented at European Nuclear Conference, Session Waste Management at Hamburg, May 1979 by J.A. Coste, A.F. Jonan, C.C. Papault and C.M. Porteau.



The Marcoule vitrification facility (AVM) - Glass Storage Hall

Canisters sectioned to illustrate storage simulation of vitrified fission products (AVM)

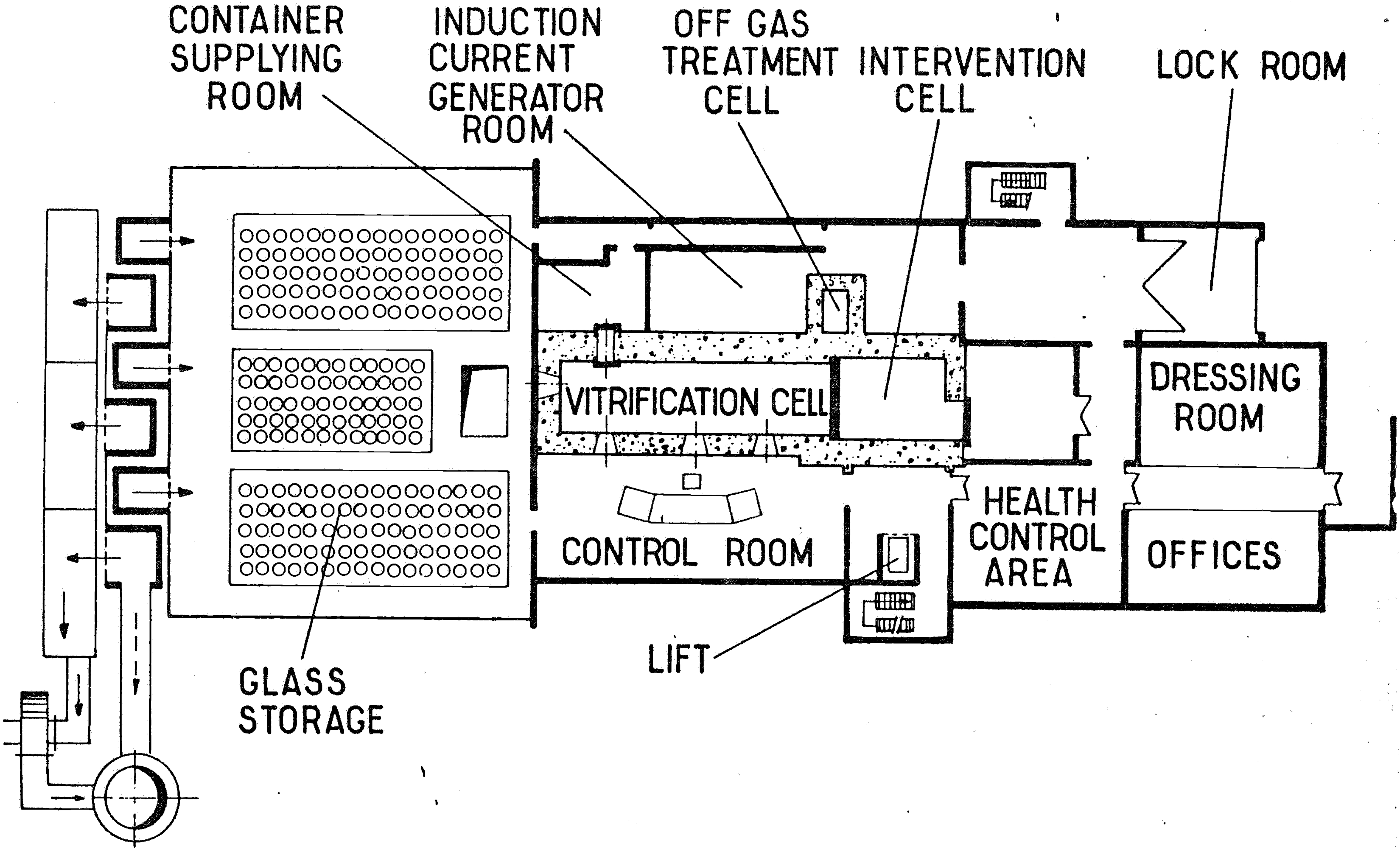


FIG. 3 AVM HORIZONTAL SECTION

ISRAEL - 10TH NOVEMBER, 1980

Solar Ponds

Aharon Lopez, Israeli Foreign Relations, Ministry of Foreign Affairs
Michael Gill, Manager, Agri-Systems Division, Ormat Turbines Ltd.
S. Solly, Ein Bokek, Ormat Turbines Ltd.
Joseph Tulipman, Managing Director, The Israel Electric Corp. Ltd., Haifa
Eric Meadows, First Secretary, Australian Embassy, Tel Aviv
John Gutteridge, Trade Commissioner, Australian Embassy
David Goss, Ambassador of Australia, Tel Aviv

Ormat Turbines Ltd. have developed energy converter systems, based on the Rankine power cycle, ranging from 200 watt-3 kw output for a variety of purposes where long life, reliability and minimum maintenance are of prime importance e.g. to provide power for telecommunications on the Trans-Alaskan pipeline and the Moomba-Sydney pipeline and some 2,000 units operate in 43 countries. Because they rely on external heating they operate on a range of fuels, diesel oil, kerosene, natural gas, alcohol, LPG or biogas which are used to vapourise an organic fluid in a boiler for propulsion of a turbogenerator (the only moving part). The spent vapour is condensed and returned through heat exchangers to the boiler. Industrial waste heat has also been harnessed to drive turbines to generate electricity and 300 kw units are commercially available.

The energy converters were developed for solar applications in the 60's but as little interest was evinced attention was given to their development in sealed units using conventional fuel. Research has now switched to low temperature, solar applications and has extended to solar ponds at Ein Bokek adjacent to the Dead Sea where 150 kw are generated from a solar pond 100 yards square and 21 feet deep - 80% of electricity used in Israel is for heating and pumping of water, thus, peak usage in summer.

A solar pond depends for its effectiveness in trapping and storing heat of the sun in a bottom layer of highly saline brine under a layer of low salinity water.

In a shallow unstratified pond the temperatures measured at the top and the bottom might approximate 22°C due to constant stirring to equilibrium through convection streams. In a solar pond the saline layer at the bottom readily attains temperatures of up to 80°C because of gradient in salt concentration and hence gravity, downwards. The layers, accordingly, do not mix and heat is trapped at the bottom. Energy storage at night is a built-in element of the system itself.

A 150 kw pilot solar electrical power station is in operation at Ein Bokek using heat collected in a multilayered rubber-lined 70,000 sq. ft. pool of water in which the lower, highly saline layer (pumped from the Dead Sea, 30% salt content) absorbs and retains the heat. Water from the lower layer is piped into an evaporator in which an organic working fluid is heated and transformed into a gas which is piped into the fan of a turbine. This in turn activates a generator for production of electricity. The installation is being monitored for technical and economic valuation.

This is the first step towards generation of electricity sufficient for one third of Israeli requirements by the end of the century.

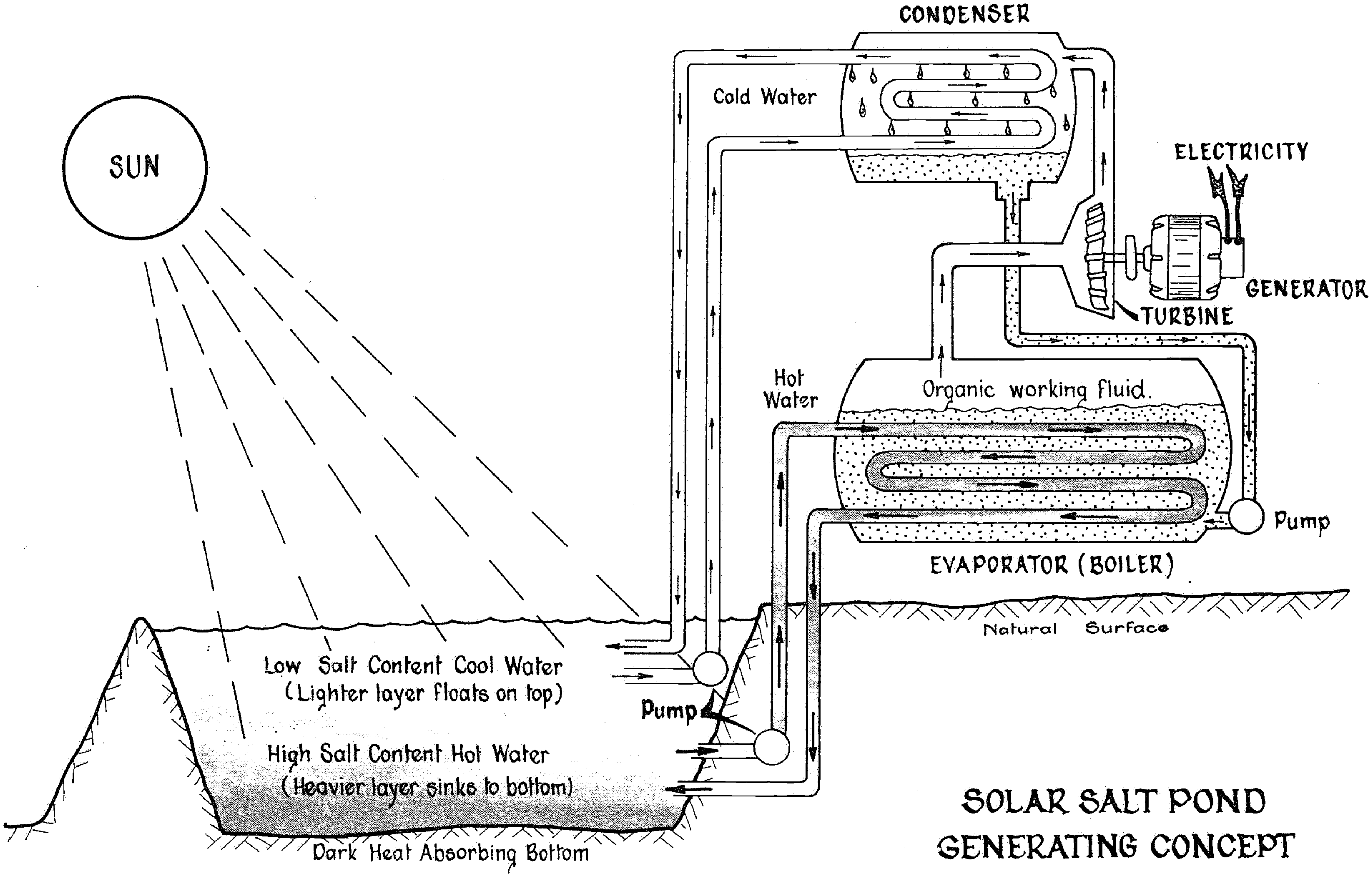
Plastic wind barrier materials float on the surface to keep down convection currents.

Ormat Turbines Ltd. is working on a 5,000 kw power station to be operational by 1981. It will be the first module of a system with total capacity up to 2,000 MW from the Dead Sea!

A solar pond project has been proposed for California and design and engineering studies are under way to convert a section of the Salton Sea into a solar pond which will result in 600,000 to 800,000 kw of electrical generating capacity. Funding is being provided by DOE ($300,000), Department of Defence ($50,000), State of California ($100,000), Southern California Edison ($100,000) and Ormat Turbines Ltd. ($100,000). Phase 1 comprises conception, design, feasibility and cost studies and if these are approved it is planned to construct and test a 5 MW pilot plant module in phase 2. Phase 3 will involve construction of a 600 MW plant in modules of 30 to 50 MW to serve a population of ½-1 million. Feasibility studies are to be completed by April 1981. The cost of a 5 MW pond of 1 km^2 area is put at $20 million i.e. cost of electricity generation would be 12-13 cents per KWh. However costs are expected to be much lower with larger solar ponds.

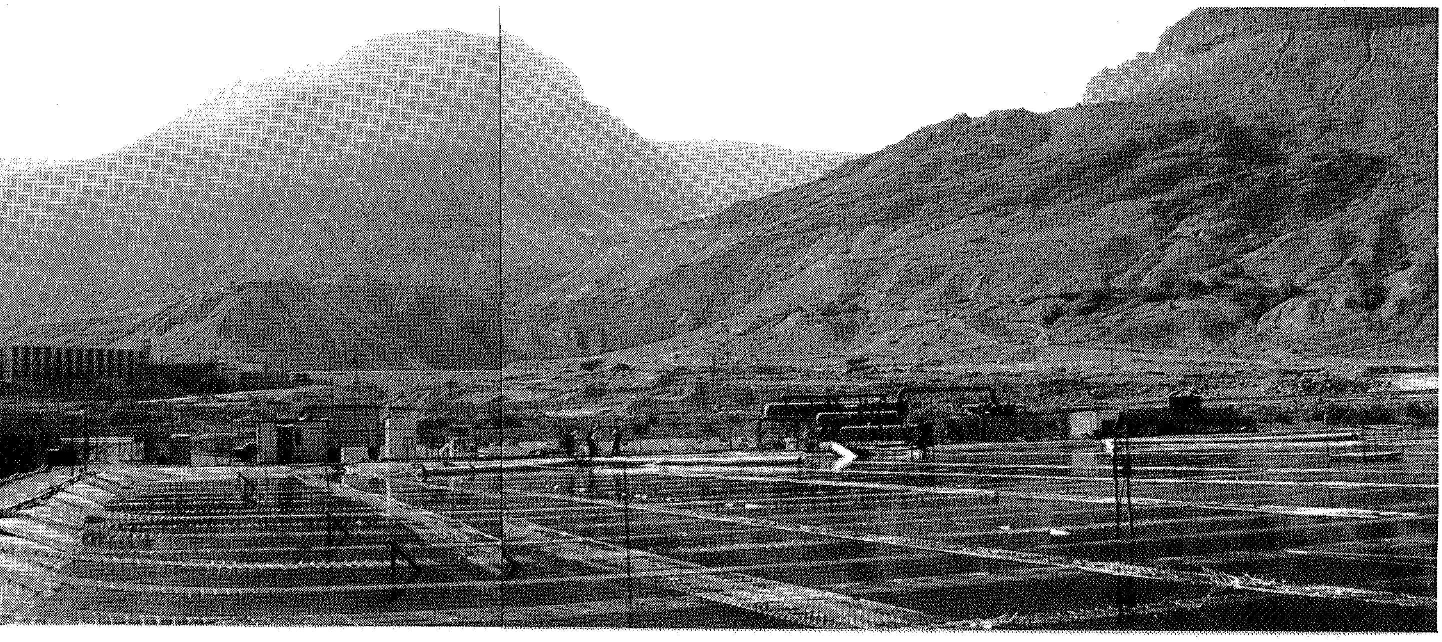
The level of the Dead Sea, 1,320 ft. below Mediterranean sea level, has fallen 21 feet over the past 25 years as a consequence of diversion of water from the River Jordan for irrigation at its northern end by the Israelis and the Jordanians. This has necessitated the excavation of channels beyond the Lissan Peninsula to the Dead Sea Works Ltd. at Sdom. Serious consideration is being given to excavation of a channel from the Mediterranean to the Dead Sea to restore water level and to generate hydroelectricity.

A unanimous decision by the Israeli Cabinet has been given to the project which, if implemented, will provide half of Israel's energy needs by the end of the century. The fall of 400 m from the Judean Hills into the Dead Sea would supply 600 MW of electrical power during the six hours of peak demand each day - additionally, the water may be stored in reservoirs for use in the power grid as required.



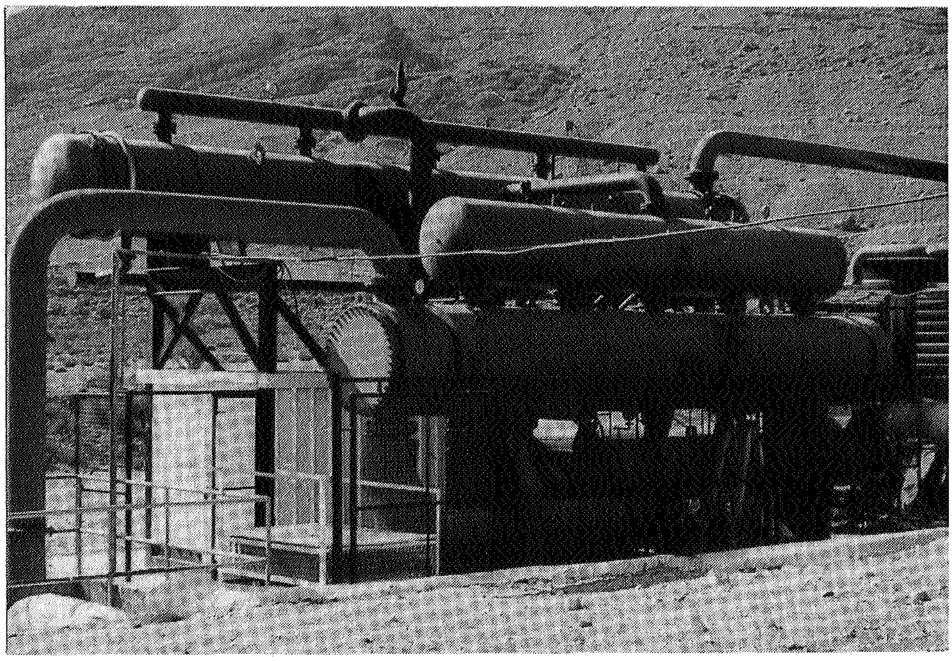
SOLAR SALT POND
GENERATING CONCEPT

Department of Mines and Energy - South Australia.

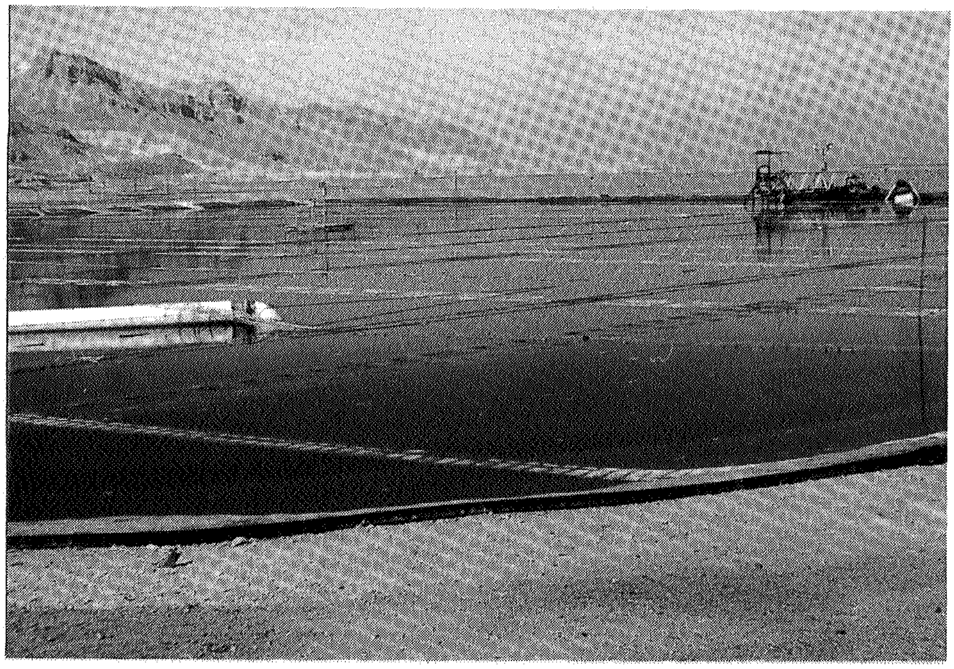


Solar pond, Ein Bokek

Solar pond with plastic strips overlaid (in foreground), with energy converter and instrumentation sheds beyond



Ormat Turbines Ltd., energy converter, Ein Bokek



Solar pond, Ein Bokek

Dead Sea in background beyond pump platform
Inlet pipe to energy converter, left centre

Solar pond, Ein Bokek

Dead Sea in background beyond fence

The estimated cost of the canal project at current costs is put at $685 million; the decade needed for completion includes one year for site testing, two to three years for detailed planning and five to six years for construction.

The northern sector of the Dead Sea is 500 ft. deep while the southern part is only 10 feet deep - the aim of the planners is to use the canal to restore the 1955 level of 1,297 feet below sea level within 20 years of project completion by accession of 1 billion m^3 of Mediterranean water. The preferred route across the Negev Desert from Katif to Ein Bokek involves a 6 km tunnel from the western intake point, followed by a 22 km open canal 10-15 m wide, and then 80 km of tunnel (5 m wide) to the Dead Sea terminus.

Reservations on the project relate to cost (?50% higher than that quoted, plus maintenance and operation, including fuel to operate the pump and power plant) and to ecological consequences.

As a solar lake, the Dead Sea could generate 2,000 MW through use of energy converters - and this is the Ormat goal for year 2000.

In consideration of development of this system it would be a pre-requisite to undertake a feasibility on site selection - is a natural lagoon available? Is there salt available? Is there water for topping? - thus pond cost will depend on the site. Its advantages include no fuel requirement, no pollution and low maintenance. However, electrical output is limited and the cost of power generation plus costs of energy converter, condenser and heat exchangers is unfavourable ($300,000 f.o.b. Israel) for 300 kw unit (i.e. $1,000 per kw). To serve a population of 10,000, the generation of 5 MW would require a 1 km^2 pond, the cost of which is put at $20 million.

Canal constructed across Lisan Peninsula to connect shallow southern arm to main deep sector of Dead Sea

JAPAN - 14TH-17TH NOVEMBER, 1980

TOKYO

Rowan Osborn, Charge d'Affaires, Australian Embassy
Neil Davis, Counsellor, Resources, Australian Embassy
Bob Davis, Counsellor, Resources, Australian Embassy
Jeffrey Scougall, Counsellor, Resources, Australian Embassy
Paul Potter, First Secretary, Australian Embassy
Dr. Bob Cairns, Counsellor, Atomic Energy Commission

Ministry of International Trade and Industry (MITI)

Keiya Toyonaga, Deputy Director-General
Katsuomi Kodama, Councillor, Director-General's Secretariat, Agency of Natural Resources and Energy
Toshiaki Yamamoto, Deputy Director, Nuclear Energy Division
Hirotoshi Inaba, Deputy Director, Nuclear Industry Division

The Tokyo Electric Power Co. Inc. (TEPCO)

Ichiro Hori, Executive Vice-President
Toshio Fukuda, Managing Director, Nuclear Power Development Operation
Hiroshi Kisaki, Manager, Nuclear Fuel Planning Division, Nuclear Fuels Department

Power Reactor and Nuclear Fuel Development Corporation (PNC)

Yoshiro Kanaiwa, Vice President
Mikio Isetani, Director
Giichi Nishikido, Assistant General Manager, Uranium Enrichment Development Project
Yoshikazu Hashimoto, Acting Director, Raw Materials Division
Chikao Kinoshita, Manager, International Co-operation Office, Project Planning and Management Division

Japan Atomic Energy Commission

Kinya Niiseki, Commissioner
Takehisa Shimamura, Commissioner

Kanematsu-Gosho Ltd.

I. Matsuura, President
K. Oda, Executive Director, General Manager, Fuel Division
S. Hori, Manager, Energy Resources Department
S. Takizawa, Assistant Manager (Nuclear Fuel) Energy Resources Department
H. Ejiri, Deputy Manager (Coal Development and Marketing) Energy Resources Department
Takashi Haseo, General Manager, Non-Ferrous Metals Division

Asahi Chemical Industry Co. Ltd.

Dr. Maomi Seko, President Director and Executive Vice President
Yasumichi Yamakoshi, General Manager, Planning and Control Department, Technology, Research and Development Administration
Mr. Miyazaki, President
Tebuya Miyake, R & D Division, Kawasaki
Tetsuo Takada, Executive Vice President
Hidenori Yaoi, Advisor
Keita Tsuzuki, Executive Vice President
Seiji Azuma, General Manager, Planning and Control Department, Chemicals and Plastics Administration

Japan Electric Vehicle Association

Hajume Inoue, Director-General
M. Saito, Chief, Research Department
M. Takori, Research Manager

C. Itoh & Co. Ltd.

Masao Takaya, Director, Overseas Liaison, Japan Australia Uranium Resources Development Co. Ltd.
Makota Takada, Nuclear Energy Department
Kay Ohmina, Deputy Manager, Nuclear Energy Department

Australian Chamber of Commerce in Japan

Ted Weatherstone, Chairman

Energy Policy

Japan relies on energy imports for approximately 90% of its domestic energy requirements with oil contributing 73%, coal 13%, LNG 2% and nuclear 4%; domestic sources, largely hydro-electricity (conventional and pumped storage) provide the balance. Security of supply problems are aggravated by the fact that the sources of imports are unevenly distributed; current imports of crude oil are from Saudi Arabia (33.6%), Indonesia (14.4%), United Arab Emirates (10.5%), Iran (9.9%), Kuwait (9.4%), and Iraq (5.6%). Japan is particularly sensitive to the deteriorating world oil situation both in terms of price and supply since it has a dependence on oil for energy the highest among industrial nations; and any proposed energy solutions depend to a large degree upon international co-ordination and co-operation. Japan's energy consumption is second in the free world after the U.S.; however, per capita energy consumption is one third that of U.S.A. and Canada.

The basic direction of Japanese energy policy as outlined in an August 1979 report by the Advisory Committee for Energy included securing stable supplies of oil, promoting the development of nuclear power, utilising domestically produced energy, and diversifying supplies of foreign energy.

Although the contribution of foreign oil to energy requirements will gradually decrease in percentage terms, it will continue to be the primary energy source in the 1980's. Oil, therefore, remains Japan's first energy priority. In an attempt to reduce the risk associated with reliance on foreign oil, Japan hopes to diversify its sources of crude as well as routes of supply. By 1990, plans call for 30% of crude requirements to be provided from Asian sources, with Chinese deliveries to increase substantially. Strategic oil storage is to be increased substantially and experimental plants concerning new storage modes are to be developed.

Japan hopes to secure a more stable supply of oil through participation in overseas petroleum development, is interested in overseas exploration and development, and has participated in the Middle East since the 1960's. A target of 1.5 million barrels a day, or 20% of requirements, by 1990 has been set for the contribution of such overseas developments. To this end, Japan and China have agreed to a joint project to develop oil fields in the Bay of Po-Hai. Japanese groups are also engaged in development in Canada.

Even if Japan is successful in ensuring access to oil, alternative energy sources will also have to be developed, of which nuclear energy is considered to be the most reliable.

By 1990, nuclear power capacity will be increased to 53,000 MWe to meet 23% of demand (nuclear currently accounts for 11%). Japan's nuclear programme presently includes 21 light water reactors (Boiling Light Water Reactors (BWR) and Pressurised Light Water Reactors (PWR)) and a prototype Heavy Water Reactor (Advanced Thermal Reactor (ATR)) is being tested.

Japanese imports of coal are expected to increase from 13 to 14% of energy requirements by 1990 despite problems relating to berthing of colliers, dust, pollution and disposal of ash. Canada currently ranks third among suppliers with approximately 19% of the market, behind Australia with 46% and the U.S. with 22%. Associated with the increased use of coal are the related technologies in coal liquefaction and coal gasification which Japan expects will be developed in co-operation with other countries or international organisations. In this regard, Japanese interests are currently involved in a $4 billion joint venture with Victoria to develop a coal liquefaction plant in Australia and production is scheduled for the late 1980's. Japan, the U.S. and Germany are involved in a pilot plant for a coal liquefaction project in Houston, Texas.

During this same period the contribution of LNG imports is expected to increase significantly from the current level of 2% of energy requirements to 8% by 1990. If a viable means of transporting Canada's Frontier resources to market can be developed, LNG from Canada should be able to compete for this larger market.

With policies designed to reduce the requirement for foreign crude, Japan has found it necessary to promote energy conservation programmes such that consumption of energy has been reduced 7% during the period 1973 to 1977.

In the industrial sector, policies include rationalisation of energy use in factories, consultation services and financial incentives. Conservation standards for housing and improved energy efficiency of consumer products are targets in the residential and commercial sector. Transportation sector policies include improving the energy efficiency of motor vehicles.

Nuclear Energy - MITI

There are 21 nuclear power plants in operation with an electricity generating capacity of 15,000 MWe; there are seven units under construction (capacity 5,839 MWe) and seven units (capacity 7,090 MWe) have been authorised by the Electric Power Development Co-ordination Council.

The nuclear electric generation capacity is presently 15,000 MWe or 11% of the total output; by 1985 it will comprise 30,000 MWe (16%); by 1990 it is expected to be 53,000 MW (23%); and by 1995 to be 80,000 MW (28%).

As a nation poor in indigenous resources, Japan places its greatest expectations on nuclear energy as the alternative energy source for the future.

With 21 nuclear power plants (15,000 MW) in operation, makes Japan second in the free world after the U.S. (71 power plants; 54,300 MW). Japan is promoting the construction of nuclear power plants as fast as possible and, to attain these goals, efforts are being made to secure an independent fuel cycle, plant safety and improved plant reliability.

The Atomic Energy Commission was established in 1956 for implementing national policy on atomic energy research, development and utilisation with the main responsibilities being:-

- determine policy for atomic energy utilisation
- co-ordination of atomic energy utilisation activities
- regulate and control nuclear fuels and reactors
- safety measures
- research
- collection of data on atomic energy utilisation

NUCLEAR POWER PROGRAMME IN JAPAN

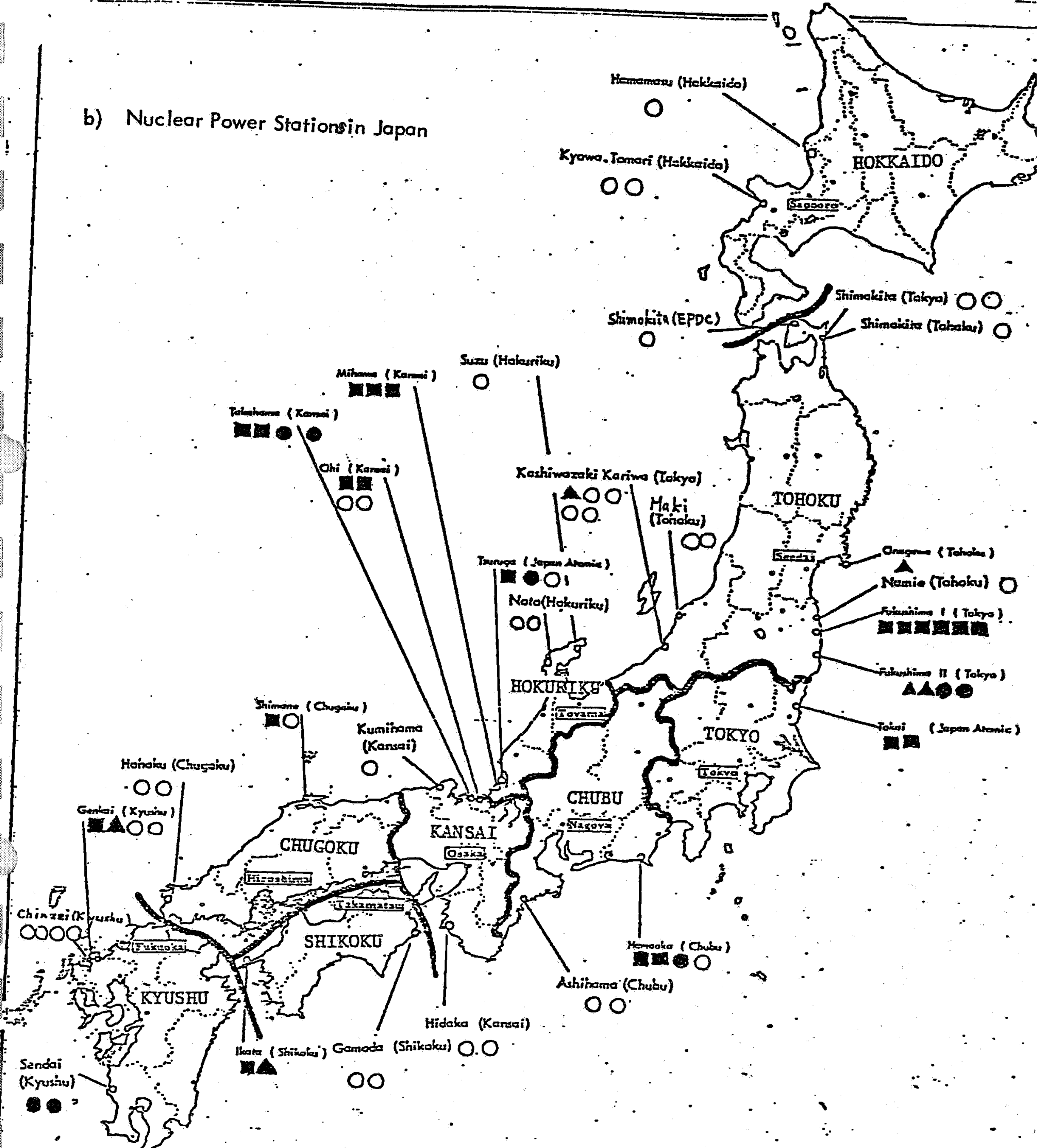
(Start of Operation)

Output: MWe

Utility	-'77	'78	'79	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93	'94	'95
Hokkaido											(1) 579		(1) 579					(1) 900	
Tohoku							(1) 524			(1) 825	(1) 825		(1) 1,100		(1) 825		(1) 825		(1) 1,100
Tokyo	(3) 2,028	(2) 1,568	(1) 1,100			(1) 1,100	(1) 1,100	(2) 2,200	(1) 1,100			(2) 2,200	(2) 2,200	(1) 1,100	(1) 1,100	(2) 2,200	(1) 1,100	(2) 2,200	(1) 1,100
Chubu	(1) 540	(1) 840						(1) 1,100				(1) 1,100	(1) 1,100	(2) 2,200	(1) 1,100	(1) 1,100	(1) 1,100	(1) 1,100	
Hokuriku											(1) 500			(1) 1,000		(1) 800			(1) 1,000
Kansai	(5) 3,318	(1) 1,175	(1) 1,175				(2) 1,740		(1) 1,200	(1) 1,200		(1) 1,200	(2) 2,400	(1) 1,200	(1) 1,200	(1) ~~200~~ 1,200	(1) 1,200	(1) 1,200	(1) 1,200
Chugoku	(1) 460								(1) 800				(1) 1,100		(1) 1,100				
Shikoku	(1) 566				(1) 566							(1) 566			(1) 890				(1) 890
Kyushu	(1) 559			(1) 559				(1) 890	(1) 890					(1) 1,170	(1) 1,170			(1) 1,170	(1) 1,170
JAPC	(2) 523	(1) 1,100							(1) 1,160										
Total	(14) 7,994	(5) 4,183	(2) 2,275	(1) 559	(1) 566	(1) 1,100	(4) 3,364	(4) 4,190	(5) 5,150	(2) 2,025	(3) 1,904	(5) 5,066	(8) 8,479	(6) 6,670	(7) 7,385	(6) 6,500	(4) 4,225	(6) 6,570	(6) 6,460
Accum. Output	(14) 7,994	(19) 12,677	14,952	(22) 15,511	16,077	17,177	20,541	24,731	(37) 29,881	31,906	33,810	38,876	47,355	(61) 54,025	61,410	67,910	72,135	78,705	(90) 85,165

Figures in ( ) describe number of reactors.

b) Nuclear Power Stations in Japan



A Legend (as of March, 1980)

■	Operating Reactor:	20
▲	Reactor under construction:	7
●	Reactor approved or will be approved by EPRDCC:	8
○	Proposed Site:	37
	Total:	72 units (65,223 MW)

Nuclear Energy Department
C. ITOH & CO., LTD.
Tokyo, JAPAN

The Minister for Science and Technology is Chairman and there are three full time and three part time Commissioners. The Commission has established a number of committees comprising representatives of relevant organisations, including nuclear fuel safety, nuclear fuel cycle and international enrichment plans.

The Power and Nuclear Fuel Development Corporation (PNC)

PNC was founded in 1967 to conduct R & D of advanced types of power reactors and nuclear fuel cycles; the only way left for that country is to develop "the peaceful utilisation of nuclear power, while doing our best to meet the severe requirements of nuclear non-proliferation regulations and physical protection".

The company employs 2,500 and is engaged in prospecting, mining and concentration of uranium ore; uranium enrichment by the centrifuge process; the production, reprocessing and storage of nuclear fuels and management of radioactive wastes, fabrication of fuel elements; development of the fast breeder and the heavy water reactor.

PNC collaborates with U.S., U.K., Germany and France in exchange of technical information relating to development of fast breeder reactors. An experimental fast breeder reactor (Joyo) is now operating at a capacity of 50 MW and a prototype heavy water reactor (FUGEN) was commissioned in 1978.

The nuclear power reactors now generally used are of the light water type which use enriched uranium as fuel. Therefore, there will be a steadily increasing demand for enriched uranium as an essential fuel for nuclear power generation and security of sufficient supplies of enriched uranium will be a matter of increasing importance.

Japan is to be supplied with enriched uranium to meet her immediate needs by the U.S. in accordance with the U.S.-Japan nuclear energy agreement. However, a world shortage of enriched uranium supply is anticipated in the beginning of the 1990's and "Japan might be unable to secure a stabilised supply of enriched uranium if she continues depending on foreign supplies. The centrifugal enrichment process being developed by PNC was designated as a national project in 1973 by the Government, and research and development works have been promoted with the co-operation of academic circles and private organisations concerned, with remarkable success."

"The aim of the project is starting operation of a uranium enrichment plant competitive on the world market in the late 1980's and to carry out a wide range of activities, through the development of centrifuges, experimental cascades and the construction of a pilot plant."

PNC started construction of a pilot plant for uranium enrichment at Ningyo Toge in 1977. The plant started partial operation in 1979 and will be completed in 1981. Unit OP-1 will have a capacity of 50 tons SWU/year. Pilot plant (OP-2) on which construction started in 1979 is expected to be operational late 1981. It is then planned to design and construct a demonstration plant of 250 tons SWU/year capacity to be in operation early 1985; a commercial plant is proposed to be in operation early 1989 with a 2,000-3,000 tons SWU/year capacity which represents about one third of Japanese nuclear industry requirement.

The nine Japanese utilities have signed contracts for supply of 180,000 tonnes of enriched uranium to 1990 based on natural uranium supplied from Canada and South Africa and are, therefore, in no hurry to sign new ones. They would seek to diversify their sources of supply by importing requirements beyond 1990 from Australia. (Australia has previously sold uranium to Japan under old contracts but no deliveries have been made recently, awaiting resolution and negotiation of a new safeguards agreement).

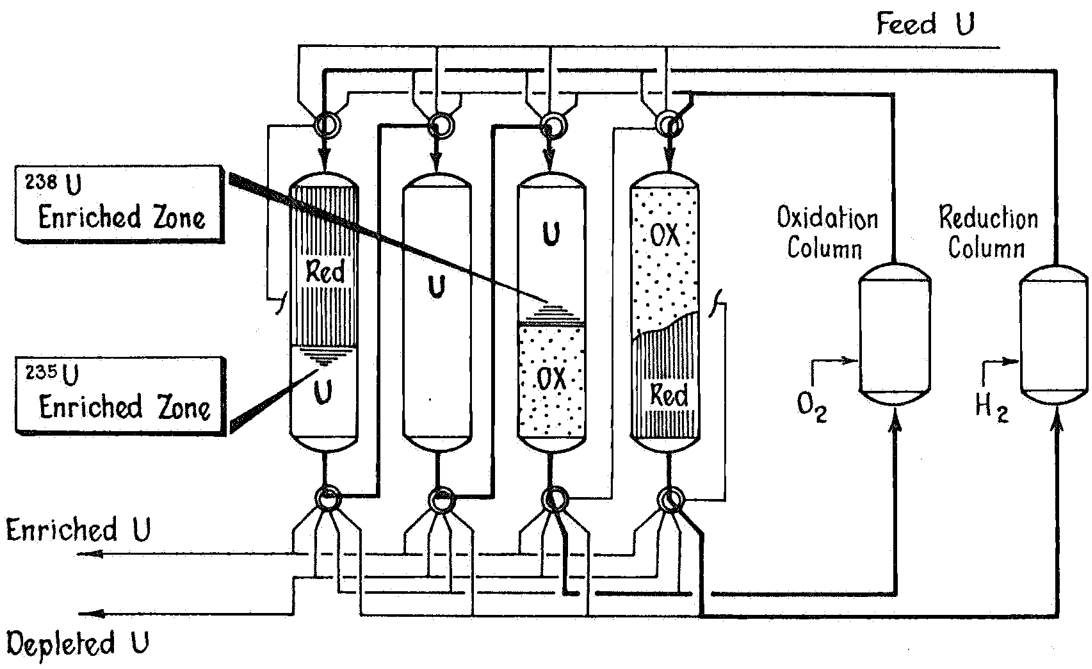
However, the Japanese appear to face a dilemma on enrichment, as to whether they should develop indigenous centrifuge technology or to procure requirements through involvement in an Australian facility by an assumed joint venture with an Australian group or Government partners. While recognising the Australian desire to maximise added value of resource through further processing, of 35% of exports in the case of uranium, the Japanese would obviously prefer to import natural uranium and seek to develop domestic uranium enrichment facilities.

Possible future involvement with Australia follows agreements made with Japan in 1974 and in 1978 and renewed through the UEGA study, whose report is now awaited. Interest was displayed in the Roxby Downs project development, the relation existing between UEGA and the Commonwealth and State Governments, the attitude of the South Australian Government towards enrichment and the interest of other States in such a facility, the activities of the South Australian Uranium Enrichment Committee, status of URENCO proposals, and the expectation of the South Australian Government from Japan.

Engineering studies have been completed for a UF6 plant in addition to the enrichment operation discussed above. For requirements beyond 1990, the Japanese seek to co-operate in setting up a facility in Australia.

Chemical exchange process for uranium enrichment (Asahi Chemical Industry Co. Ltd.)

Since 1973, Asahi has expended $17 million in uranium enrichment research and propose to expend a further $60 million (2/3 to be provided by the Government, including MITI) on R and D and development of a pilot plant in Kyushu of 1 to 2 tonnes SWU/year capacity in three to five years.



CHEMICAL URANIUM ENRICHMENT PROCESS
FLOWDIAGRAM OF CONTINUOUS RUN

The company has developed a process of uranium enrichment based on redox chromatographic separation utilising ion exchange resins; an inspection was made of the Kawasaki laboratory where bench scale development is in progress.

The uranium isotopes are separated through differential chromatography of tetravalent and hexavalent uranium ions in four columns (10 cm x 3 m high towers) packed with spheres of an ion exchange organic resin which absorbs hexavalent uranium from solution in hydrochloric acid.

An oxidant, uranium solution and a reductant are successively circulated through the columns to form a 'uranium adsorption band' between the oxidation and the reducing agent zones. The 'uranium adsorption band' migrates without changing shape or diffusing to the base of the column; U235 and U238 are concentrated at the top and bottom, respectively, of this band through differentials in migration velocity of these isotopes. The respective enriched and depleted U235 fractions are separated through valves at the bottom of the tower and are continuously recirculated to derive 4% enrichment in approximately 100 days.

The resin is regenerated and the spent redox agents are reactivated by gaseous oxygen and hydrogen in a separate column.

Developments are under way to improve the separation feed, automated computerised controls and reactivation catalysts; scale-up of equipment must be considered for commercial application; although no schedule for commercial development has been determined.

The Asahi chemical process offers the following advantages over conventional uranium enrichment methods:-

- Small unit size, allowing incremental instalment of separation modules as required.
- Low construction costs.
- Low electrical power consumption
- No requirement for cascade system.
- Ease of maintenance, due to the small number of moving parts.
- Conversion to UF6 obviated.
- Due to time constraints, cannot be modified to produce weapon-grade enrichment without detection and, thus, commensurate with the objectives of the nuclear non-proliferation Treaty.

Petrochemicals (Asahi Chemical Industry Co. Ltd.)

In 1975 Asahi developed an ion exchange chemical membrane chlor-alkali process for production of caustic soda and chlorine for petrochemicals and synthetic fibres manufacture from industrial salt and naphtha which obviates pollution and hazard problems resulting from the usage of mercury and asbestos diaphragm in the conventional processes and over which it is claimed to be superior from the view points of product quality, flexibility of operation, energy consumption and investment cost. Asahi Chemicals technology combines application of perfluoro-carboxylic acid ion exchange membrane, metal anode, electrolyser and evaporator, all of which were developed by Asahi.

The company are also involved with foodstuffs, pharmaceuticals, and construction materials and magnesia clinker with 200 other associated companies, including Dow Chemical. Company sales approximated $US3 billion during the past year ($US4 billion if subsidiaries are included).

Caustic soda imports for the Japanese aluminium industry (1/3 of requirements) are valued at $3.7 million annually. Because of escalating costs of energy, naphtha and salaries and superior Asahi technology, the company considers that the world's 30 million tonnes caustic soda requirements will be ultimately based on the ion exchange membrane process (at present 10 million t.p.a., is based on mercury cells and almost ½ million tons from plants employing Asahi Chemical technology). Thus, Asahi interest in production of chlor-alkali, ethylene and EDC at Redcliff on a scale similar to that proposed by Dow, with caustic soda being utilised locally in aluminium smelters and ½ million tonnes/year output of EDC being exported to Japan.

Electric Vehicles in Japan

During the period 1971-1976, $23 million were expended on electric vehicles R and D by MITI in addition to that undertaken by motor vehicle manufacturers and academics. In 1976 the Japan Electric Vehicle Association was formed to promote R and D and utilisation of electric vehicles including the development of electric, hybrid and dual mode vehicles; provision of testing facilities; quick battery charging systems; and promotion of electric vehicle use.

There are 36 million cars in Japan with a domestic production totalling four million per year. There are 450 electric vehicles in general operation (plus about 12,000 used for specific work e.g. golf cars) - by 1986, MITI anticipate 200,000 vehicles of all types in use, at which time the cost of an electric vehicle in Japan is expected to be similar to that of a petrol driven vehicle. The price of petrol is currently 56 cents/litre (with high octane rating gasoline, 63 cents/litre and diesel at 32 cents/litre).

Advantages of electric cars in such densely populated centres as Tokyo where toll express-ways and major roads seem to be normally choked with late model cars include elimination of exhaust emissions, noise and energy waste in stop/start situations; and stabilisation of energy consumption through battery recharge in off-peak periods.

Disadvantages of electric cars, currently, include cost (two to three times greater than petrol cars); range (performance limits them to urban areas and weight (30% heavier than conventional vehicles).

Buses (70 passenger capacity) using lead-acid batteries (requiring 80 seconds for change of battery sets) have been introduced into public transport service in the hilly city of Kyoto. These have a top speed of 40 km/hour and a range of 30 km; their initial cost is three times greater than that of conventional vehicles and their running cost is seven to eight times greater; battery life is short and only survives 800 cycles (i.e. 800 x 30 km); weight of battery pack is 3½ tonnes; nickel-iron, batteries are being developed and sodium-sulphur, researched.

A demonstration, including a short drive, was given of a Daihatsu light-delivery van which had a 400 kg payload. Its running cost was said to be 50% that of a conventional vehicle but if the cost of batteries (400 to 500 cycles, with a range of 40 km i.e. 20,000 km life) is included then it is comparable. Principal R and D effort is being directed to batteries, to increase life and to increase energy density for improvement of that provided by lead/acid which are the only ones used commercially and for which battery changer alone cost $150,000.

Hybrid and dual mode diesel delivery trucks are being developed for extended range beyond urban area; their initial cost was cited as being twice that of conventional vehicles but running costs were not ascertained.

HONG KONG

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Chuck McCoy Jnr., Vice President, Director of Manufacturing and Engineering
Tom Smith, Vice President, Director of Marketing.