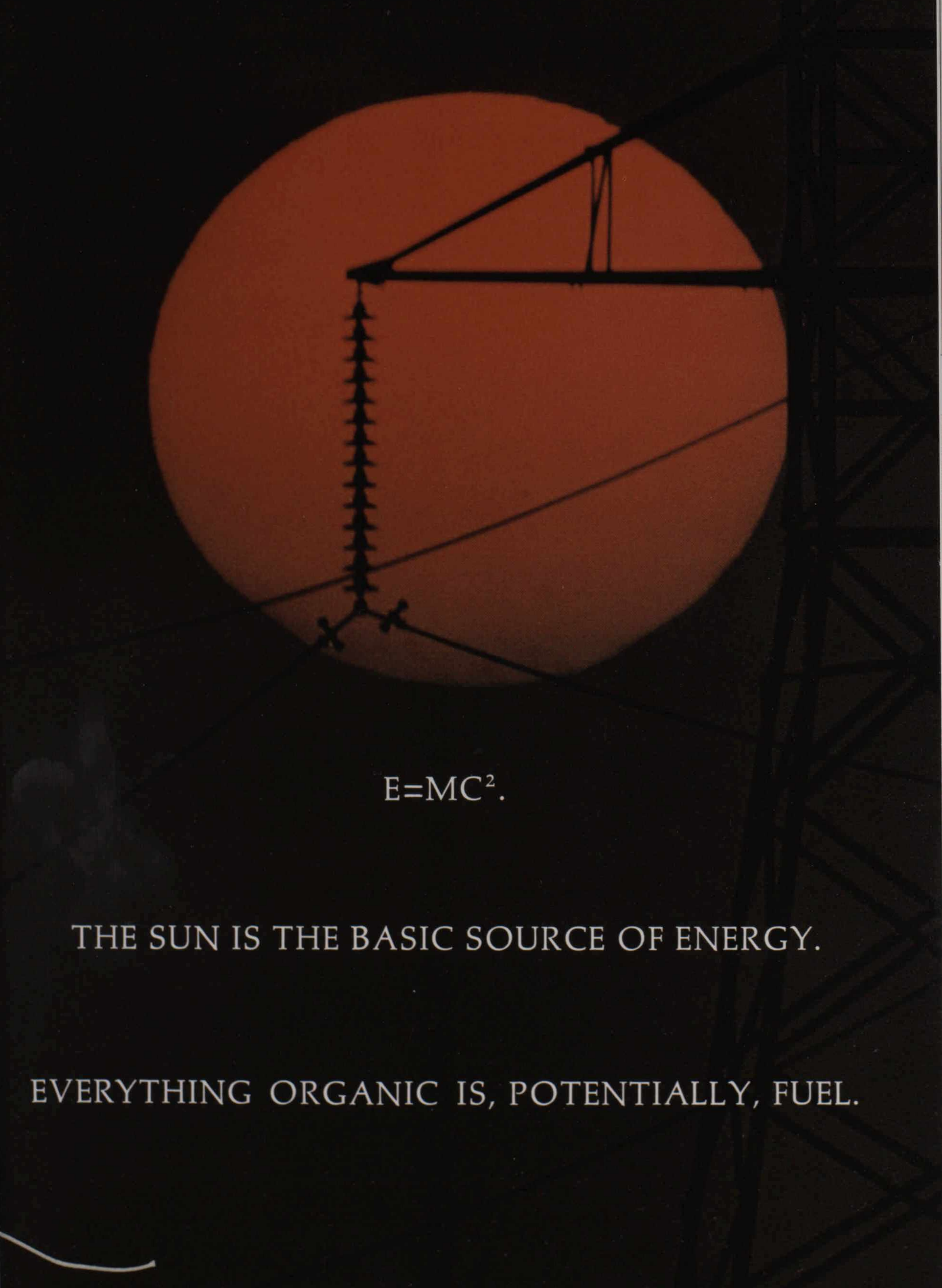
CANADA
TODAY / D'AUJOURD'HUI



$E=MC^2$.

THE SUN IS THE BASIC SOURCE OF ENERGY.

EVERYTHING ORGANIC IS, POTENTIALLY, FUEL.

VOLUME TEN NUMBER TWO NINETEEN SEVENTY-NINE

PHOTOS: [COVER] ROBERT VAN DER HILST / MILLER SERVICES, TORONTO; [PAGE TWO] GULF CANADA LTD

Oil and gas, natural and unnatural, will continue to spin Canada's wheels for some time to come, but as the prices of the limited fossil fuels go up, conservation and alternative sources of fuel will be used more and more.

Canada, a country colder than most, is bulging with unrealized kilowatts and BTUs: it has trees, wind, water and sunlight; and though these may seem more like ingredients for a poem than for a factory, there are industries that run by the first, an island sometimes heated by the second and scores of happy homes that are made comfortable by the last.

In this issue of CANADA TODAY/D'AUJOURD'HUI we report on nontraditional energy in Canada, kinetic and potential.

The Government's Policy on Alternate Energy

In 1973, when oil and natural gas were cheap, Canada seemed to have an abundance. Both are now expensive, and Canada's energy needs have been growing faster than its resources. The federal government will spend $380 million in the next five years to develop other promising sources of renewable energy and energy conservation. Included are water-pump windmills on Cape Breton Island, solar water heaters in a Montreal photo processing plant, a garbage-burning incinerator on Prince Edward Island and a new cement-making process in Mississauga, Ontario.

It is hoped that Canada will have an unsubsidized solar industry requiring 15,400 man-years by 1984 and that solar sales will total between $400 and $800 million annually by 1990. The plan includes federal purchases, incentives to manufacturers, building design awards and funding for research.

The government also plans to have seven per cent of the nation's energy needs supplied by converting biomass, mostly wood wastes—an effort that would create jobs requiring 24,000 man-years in and out of the forests. The forest industry would supply all of its own energy needs and produce surplus electricity to sell.

How to Heat Your Building Without a Furnace

[BUT WITH SOME HELP FROM THE LIGHT BULBS]

Gulf Canada Square, a two-block development in downtown Calgary, which opens this fall, will be the largest, single-development office and commercial complex in western Canada with almost two million square feet of space, 1,500 parking spaces and a 20-story tower. It will probably also be the most energy efficient complex in the world.

It will incorporate a refined version of the energy conservation system pioneered by Canada Square Corporation in Hydro Place, Toronto, the headquarters of Ontario Hydro.

Conservation

Conservation may be the most effective short-term means of extending energy resources. A technique being tested by the St. Lawrence Cement Company of Mississauga, Ontario, will reduce the amount of oil needed to produce a ton of cement from a half to a third of a barrel. (The federal government will pay half of the costs of converting the St. Lawrance kiln, and the company will make the technology available to other Canadian firms.)

Hydro Place, which has no furnace, recently came through the coldest Toronto winter in forty-three years with heat to spare. The energy system is not solar; the outer "skin" of the building is designed to exclude as much solar heat as possible.

The basic premise is that any building with a million or more square feet of space generates enough waste heat from bodies, light bulbs and electric equipment to supply its own energy needs year-round without either furnace or conventional air conditioning. In winter, most large buildings cool interior space while heating the perimeter. Even during three-day weekends in winter, when all lights are turned off and only a skeleton staff is in the building, the Hydro Place storage system maintains temperatures at a comfortable 70 degrees.

The system is controlled by an operator at a central computer. Conditions throughout the building are monitored every 20 minutes by sensors, and necessary adjustments are made automatically.

Gulf Canada Square has six main features:

1. Patented environmental controls.
2. Thermal storage in heated and chilled water in four 250,000-gallon storage tanks in the basement, with patented flow controls. (The tanks in Hydro Place are larger than those designed for Calgary;

Gulf Canada Square in Calgary, Alberta, may be the most efficient complex in the world. It will use the heat given off by workers and machines. Sunlight is not part of the system; the outer skin, opposite, is designed to exclude as much solar heat as possible. Left, workmen insulate the interior of one of four 250,000-gallon water tanks that will store heat under the basement floor. Hydro Place, right, in Toronto pioneered the system.

the first tanks provided more storage than was necessary.)

3. Patented silver-treated, double-glass curtain walls capable of reflecting 85 per cent of solar radiated heat (about twice as much as conventional glass) with little colour distortion of natural light.

4. Perimeter air distribution incorporated into the curtain walls.

5. Highly effective insulation.

6. A low-energy, high-quality coffered lighting system with increased reflectivity. The fully-integrated ceiling recycles heat from the building to heat pumps (for heating and cooling) and to the energy storage system.

A survey of modern Ontario office buildings over the past five years indicated an average annual use of 182,000 BTUs of energy per square foot. Conventional buildings in Calgary consume between 200,000 and 250,000 BTUs. Gulf Canada Square will require less than 50,000 BTUs of energy per square foot annually. Forty per cent of all energy consumed in Canada, and 30 per cent of that in the United States, is used to heat buildings.

Tar Sands

The jet black sands of Alberta may contain some 900 billion barrels of oil—more than the world's proven conventional reserves. The amount that can be recovered is uncertain—perhaps no more than twenty-five per cent. Most of the sands are deep, 200 feet or more below the surface.

They have been accumulating a long time. Dead marine plants and animals began piling up at the bottom of a shallow sea over 200 million years ago. Glaciers came, and time, chance and chemistry went to work. Now they are ready for burning, but they are mixed with the sands and covered by layers of clay and water and vast swampy fields of black spruce and tamarack.

J. Howard Pew, of the Sun Oil Company, was the first to mine the sands on a massive scale. He

Draglines, bottom left, remove the overburden and mine the tar sand, piling it up in windrows. Bucket-wheel excavators scoop up the oil sand and dump it into trucks, top, or a conveyor system, bottom centre. It is carried to extraction plants where the bitumen separation process begins in tumblers the size of railroad cars, bottom right. The top picture is from GCOS; the bottom ones are from Syncrude.

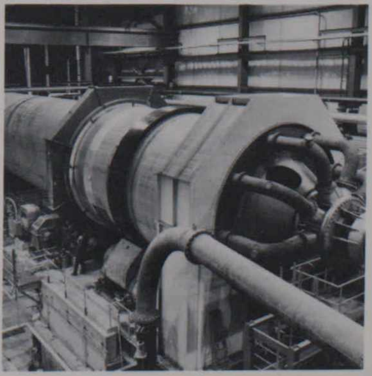


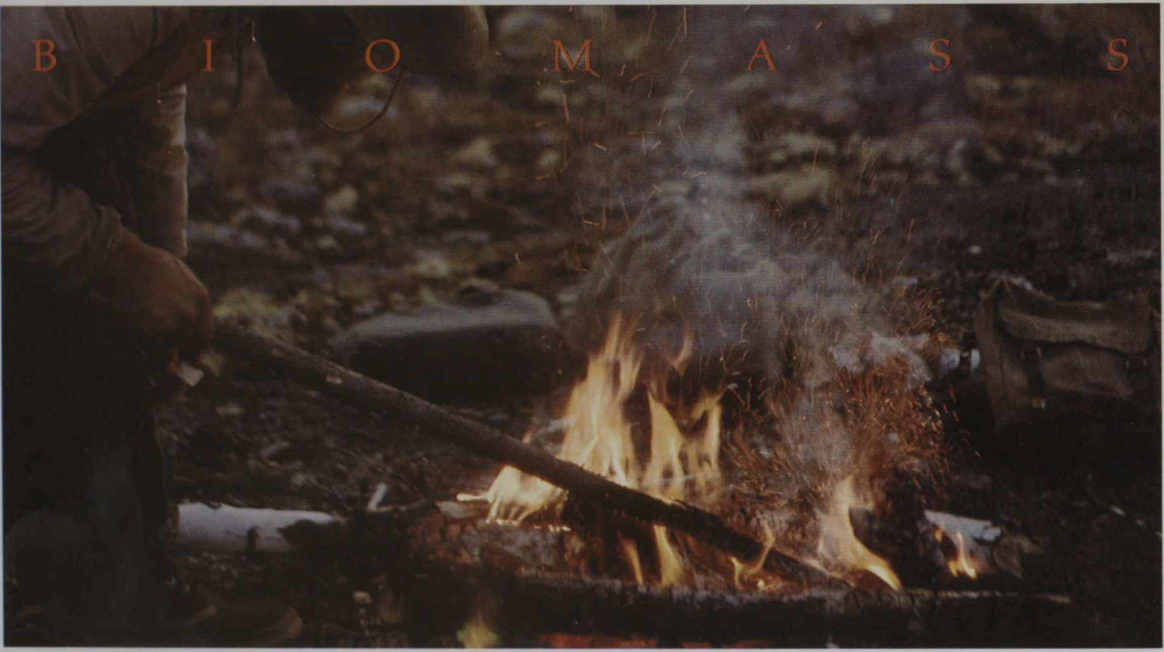
PHOTO: PAUL VON BAICH

formed Great Canadian Oil Sands, Ltd. in 1967 and built a 50,000-barrel-a-day plant.

GCOS drains the muskeg swamp every two years, but in the summer the ground is softer than melted ice cream and almost impossible to work. In the winter 1,800-ton bucket-wheel excavators (each costing $6 million) scoop it up and dump it. Each bucket cuts out a chunk of spongy clay or tarry sand 21 by 37 metres (70 by 120 feet) and dumps it in special 150-ton trucks (each costing more than $300,000). The tar is then separated from the sand by dousing it with hot water, producing what has been called "contaminated asphalt." It is run through a coking and hydrodesulphurization process and becomes a synthetic crude oil, which is sent south to Edmonton where it joins the thick black river flowing through pipelines. GCOS is now producing 45,000 barrels of oil plus 300 tons of sulphur and 2,300 tons of coke a day, but the coke and sulphur are too far from markets to be salable, and they just pile up.

This fall Syncrude Canada (a consortium of Petro-Canada, Cities Service, Pan Canadian Petroleum and Gulf) began operating a $2.4-billion strip-mining complex, which has a capacity of 129,000 barrels a day. The strip-mining technique strikes most participants as cruder than the oil, and it cannot reach tar sands in places like Cold Lake where they are covered by 275 to 490 metres (900 to 1600 feet) of overburden. Imperial Oil has proposed a plant using processes (heating the bitumen in the ground by steam injections) that could produce 125,000 to 140,000 barrels a day at Cold Lake.

The profit prospects for tar-sand recovery are good. The GCOS plant initially lost a total of $90 million but has been in the black since 1976 and reduced its accumulated deficit to $40 million.



BIOMASS

In its broadest sense, biomass includes all plant life and the wastes, residues and by-products of all living things. It can be converted to solid, liquid and gaseous fuel.

Dry biomass is biomass that is, more or less, ready to burn. It includes logs, twigs, dry straw and the stumps of chopped down trees. Wet biomass is biomass that is at least 50 per cent moisture—manure and municipal garbage for example—and it can be burned or made to produce methane gas.

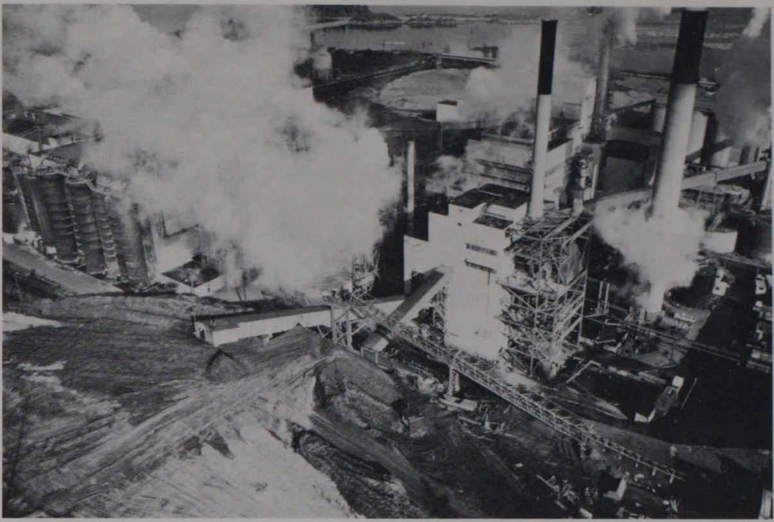
Trees

The best present source of biomass fuel in Canada is its forests. A hundred years ago wood was North America's principal source of energy, and Canada's forest industry will supply most of its own energy needs by 1985.

Cariboo Pulp & Paper Ltd. in Quesnel, British Columbia, produces 80 per cent of its own mill power with waste wood.

British Columbia Forest Products Ltd. is investing $20 million in waste-burning boilers. One at Crofton on Vancouver Island uses the equivalent of 420,000 barrels of oil a year. A turbine

PHOTOS: MACMILLAN BLOEDEL; BC FOREST PROD.; WESTERN FOREST PROD. LAB; AGRICULTURE CANADA



Several lumber companies in British Columbia burn hog fuel to power their mills. Bark, sawdust and waste wood are hogged (chopped up), and moisture is pressed out. Left, the prepared hog fuel comes out of the press at the MacMillan Bloedel mills at Port Alberni. Right, hog fuel is piled outside the British Columbia Forest Products mill at Crofton on Vancouver Island.

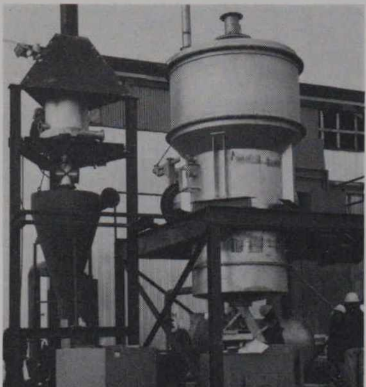
generator at the company's pulp and lumber complex in Mackenzie, British Columbia, will produce 20 megawatts of electricity.

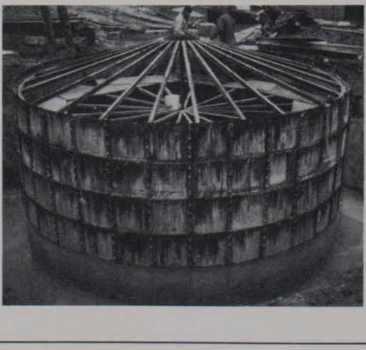
Lamb-Cargate Ltd. of Vancouver, with help from the Department of Energy, Mines & Resources, is building a pilot system to produce gas from waste wood to fuel a lumber-drying kiln.

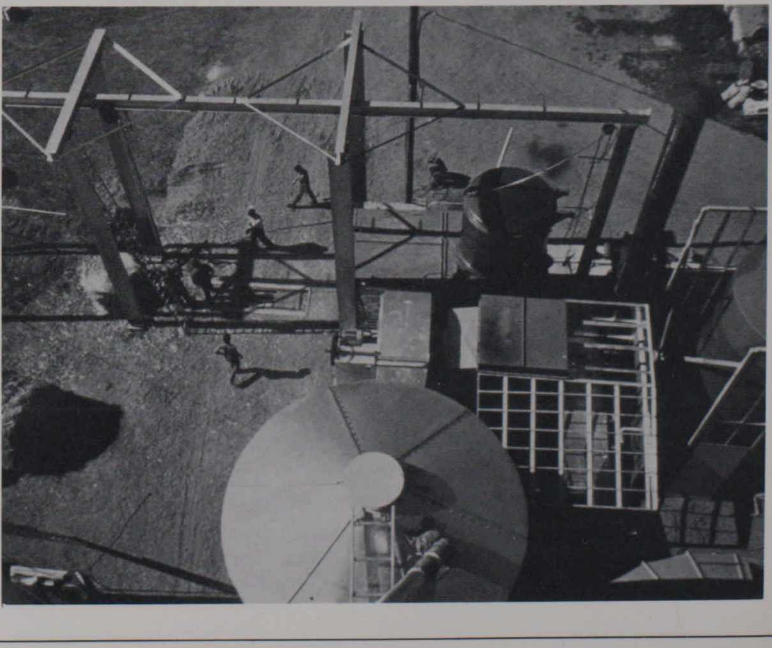
The five MacMillan Bloedel mills in Port Alberni, British Columbia, produce 325,000 tons of waste wood a year and use it to supply 65 per cent of their energy needs. Until 1975, the waste was incinerated or used as landfill. Now it is pressed dry and burned to produce steam that in turn produces electricity. It replaces about 250,000 barrels of oil a year.

With improved forest management—planned thinnings, culling and the cultivation of special tree species—the amount of available fuel could be enormously increased. The best-developed concept is for tree farms of short rotation hardwoods. The trees would grow to a few inches in diameter and be cut down every three to eight years. They would resprout from the stumps, producing trees for three to five successive harvests.

Canadian companies are also experimenting with processes to convert wood to methanol,

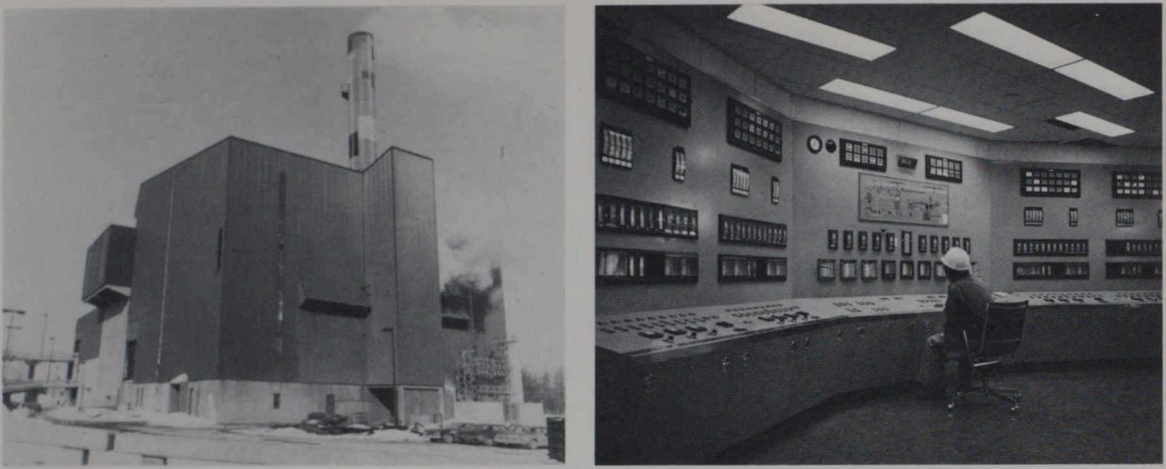






Left, waste wood is converted to flammable gas in Saskatchewan Forest Products' fluid bed gasifier at Hudson Bay. Bottom left, natural fermentation will create methane in this 23,000-gallon anaerobic digester. Below, large straw bales are burned to dry grain and heat buildings.

PHOTOS: THE SNC GROUP



The Quebec City incinerator, left, burns trash to make industrial steam. Everything is controlled from a single room, right.

which could power cars and tractors in areas where petroleum would be unavailable or where it would be much more expensive than it is now.

Crops

Surplus field crops and residues are also being used as fuel, though on a limited scale. Jacques Piell of Nova Scotia, for example, burns 400 tons of straw left over from his wheat and barley crops in a $35,000 big-bale burner manufactured in Germany. The heat dries his grain in a conventional dryer and supplies hot water to heat his house and barns.

Manure

Canadians are also experimenting with anaerobic hog manure digesters. Natural fermentation in oxygen-free environments produces a burnable gaseous mixture that is 60 per cent methane and 40 per cent carbon dioxide. The effluents contain nitrogen and can be used as fertilizer. The systems are not generally economically viable, though they may be in areas where decomposition must be controlled for environmental reasons.

Trash

Trash collected from homes is used to fire steam boilers in Quebec City and half a dozen other Canadian municipalities. This method is often economical since the high costs of disposing of the trash by landfill or conventional incinerating offsets the cost of producing the steam.

The federal government and Prince Edward Island are building a 100-ton incinerator, a size suitable for small communities, to provide all of the heat, air conditioning and hot water plus 75 per cent of the electricity for a new 350-bed hospital in Charlottetown. (There are many 750-ton incinerators in use in North America, but only a few 100-ton ones.) The incinerator will consume 80 tons of garbage each day. Waste wood will be used as the auxiliary fuel, so low-garbage days will not be low-heat ones. The power unit will cost about $6,150,000 to build, but it will eliminate the need for a new landfill site and 17,000 barrels of fuel oil ($300,000 worth at today's prices) each year.

WIND

An experimental vertical axis wind turbine, manufactured by DAF (Dominion Aluminum Fabricating), went up on the Magdalen Islands in the Gulf of St. Lawrence in May 1977. The blades, two curved strips of metal, are attached at both ends of a vertical axis, which is 37 metres (120 feet) high. It was designed to operate at a constant rotational speed and deliver a maximum of 230 kilowatts of electric power (about five per cent of average local demand). The National Research Council (NRC) and Hydro Quebec picked the Magdalens for the turbine site because they are windy and isolated. On July 6, 1978, the turbine fell over. It had been disconnected from its main disc brake the day before. The aerodynamic blade spoilers' unbalance weights had not been installed, and when the turbine began turning, it continued to accelerate until the blades began striking support cables. When a cable turnbuckle broke, the rotor broke off. Hydro Quebec and DAF are replacing it with a model with an improved brake system and stronger supports.

The NRC also operates several small vertical axis turbines, one at the Rideau Falls in Ottawa. Its axis is 5.5 metres (18 feet) high. It provides power for some electric equipment in a small, well-insulated building, equivalent to a three-bedroom house. (The building also has solar collectors, a strip of solar cells on the roof and a large window facing south.) Newfoundland and Saskatchewan each have experimental 50-kilowatt models operated by utility companies.

A new federal demonstration project in Nova Scotia will attempt to overcome two basic windmill problems: intermittent winds and high energy storage costs. Two vertical axis windmills at the Wreck Cove hydroelectric plant, just off the Cabot Trail on Cape Breton Island, will pump water from a lake into the plant reservoir. One will be used as a direct-drive water pump; the second will generate electricity to power an electric water pump. The first will be cheaper to build but the second may be more cost-effective.

The possibilities of Canadian wind power do not end with these eggbeaters. Canada is a breezy place. High wind energy potential exists in the Maritimes, on the west coast of Hudson Bay and, to a lesser extent, in the southern prairies. British Columbia may also have a potential for wind energy, but its mountainous terrain necessitates many more measurements than have been made to date. Hydro Quebec hopes to erect a three- to four-megawatt vertical axis windmill in about five years and to eventually build windmill parks.

The United States has concentrated on horizontal axis wind turbines, which resemble airplane propellers. NASA is committed to six experimental models, and a huge two-megawatt model is under construction in North Carolina. Donald E. Carr, author of *Energy and the Earth Machine*, suggests that a wind-powered grid system could supply half the continent's electric energy by the year 2000. However, the US Department of Energy estimates it would take over 300,000 megawatt-sized windmills to supply 10 per cent of the United States' projected electric energy needs for the year 2000.

There are also windy possibilities of a more extraordinary nature. William E. Heronemus, professor of civil engineering at the University of Massachusetts, has designed a huge offshore power system that would use windmills floating on platforms in the Atlantic to supply fuel for Canada and New England. (The power would be used to electrolyse sea water producing hydrogen that would be pumped ashore and converted to fuel cells.) Russian meteorologists W. S. Lidorenko and G. F. Muchnik have proposed hanging windmills from giant balloons in order to use the steady, swift winds of the tropopause, five to seven miles up. The balloons would be anchored to the ground with electric cables.

This experimental vertical axis wind turbine was installed in the Magdalen Islands in May 1977. It was toppled in an accident last summer and is now being replaced.

John and Donna Ramsey live in a wind-powered home in Emyvale, Prince Edward Island. They store surplus energy from their 110-volt wind generator in this battery cellar.

PHOTOS: SOCIETE D'ENERGIE DE LA BAIE JAMES

Les Eaux du Québec

Tout en haut de l'Amérique du Nord, au bord de la Baie James, dans la province de Québec, deux vieux cours d'eau empruntent de nouveaux lits.

A la fin de cette année, leurs eaux serviront à actionner des turbines installées à 140 mètres (450 pieds) sous terre, dans une cavité artificielle creusée dans le granit. Vers 1985, le complexe La Grande produira 10 millions de kilowatts, doublant ainsi l'actuelle production d'énergie électrique du Québec. Les travaux d'aménagement, commencés en 1972, sont en avance sur

The Waters of Quebec

At the top of North America, on the edge of James Bay, in the Province of Quebec, two old rivers flow through new beds.

By the end of this year their waters will help turn turbines in a man-made cavern, chisled out of granite, 140 metres (450 feet) below ground. By 1985 La Grande complex will be generating 10 million kilowatts of electricity, doubling the province's present production of electric power. The project, begun in 1972, is both ahead of schedule and under predicted costs.

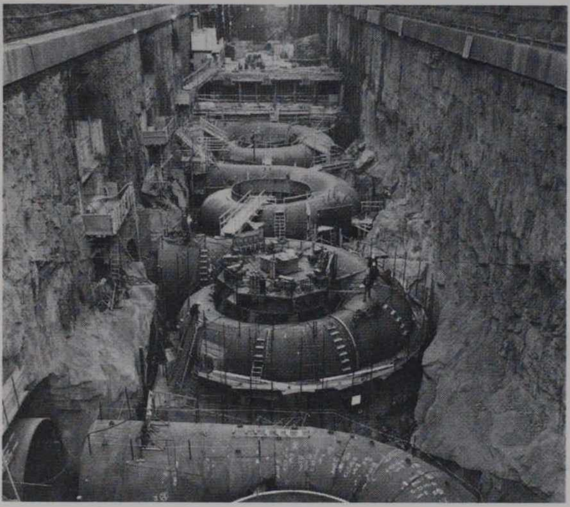
That is only the beginning. By 1990 electricity

The diversion canal in the foreground will become a spillway for the main dam on the Eastmain River.

l'échéancier prévu, et les coûts se maintiennent en dessous des prévisions.

Ce n'est là qu'un début. En effet, vers 1990, l'électricité produite permettra de satisfaire 40 pour cent des besoins énergétiques du Québec. Entièrement aménagée, la région de la Baie James pourrait produire plus de 35 millions de kilowatts. En été, période où la demande canadienne est au plus bas, une grande partie de l'énergie sera acheminée vers les Etats-Unis où, au contraire, le demande est la plus forte.

Le présent projet de 15,1 milliards de dollars, l'un des plus ambitieux de l'histoire, comprend déjà 130 kilomètres (80 milles) de digues, 1600 kilomètres (1000 milles) de routes, quatre centrales, sept barrages et un réservoir qui, une fois rempli, sera le plus grand lac du Québec.



James Bay waters will turn these turbines, 140 metres underground.

is expected to supply 40 per cent of Quebec's energy needs. The James Bay area, if fully developed, could produce over 35 million kilowatts. In the summer, the season of lowest Canadian demand, much of the power will be sent south to the United States where summer is the season of highest demand.

The present $15.1 billion project, one of the greatest construction efforts in history, already includes 130 kilometres (80 miles) of dikes, 1600 kilometres (1000 miles) of roads, four powerhouses, seven dams, and a lake, which will be Quebec's largest when it is full.

James Bay is only one of Canada's many sources of hydro power (though easily the most spectacular). Canada has more water and more hydro power than any other country in the world. It gets 70 per cent of its electricity from dammed-up waters, and it has been exporting electric power for years—in 1977 it sent 20.2 billion killowatt-hours to the United States.

In addition to the ones in Quebec, turbines spin at Churchill Falls in the Labrador part of Newfoundland (5.2 million kilowatts) and at the Nelson River project in Manitoba (4 million kilowatts by the 1980s).

Until fuel prices escalated, small or slow moving rivers were not economical producers of hydroelectric power. However, Newfoundland and the federal government are now jointly studying the practicality of small hydro installations at fifty remote sites. In 1977 Newfoundland imported 833,000 barrels of oil at a cost of $10.5 million, much of it for oil-fired generating stations in small communities that cannot be joined economically to the province's power grid.

The Tides of Fundy Bay

Never tie your ship too close to the pier in the Bay of Fundy. The tides are the highest in the world, and in the Minas Basin the range between successive high and low water can reach 53 feet.

The tides are an obvious potential source of electric power. They can turn turbines, and schemes for harnessing the Fundy tides have ebbed and flowed for centuries. The technology to control the flow on a massive scale has been long available. Dams could be built, but their construction would be enormously expensive. In 1969 the Atlantic Tidal Power Programming Board concluded that they wouldn't pay. Tidal power planners, then and now, have to compete with the economical turbines of Hydro Quebec.

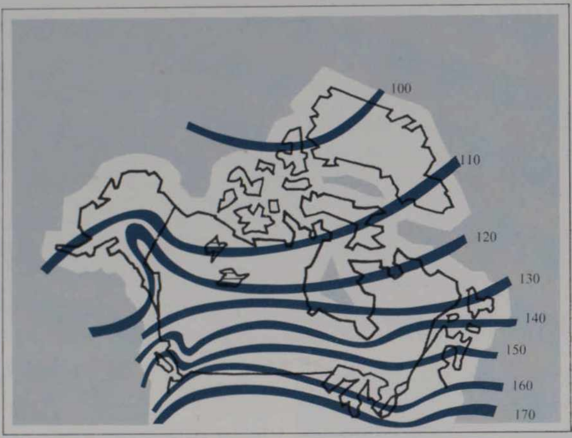
Since the rapid rise in the price of fossil fuels, however, the cost of harnessing the bay seems less prohibitive, and the possibilities are being reconsidered. Dr. G. F. D. Duff, Chairman of the University of Toronto's mathematics department, is studying a model that describes tidal behaviour in the bay and in the adjacent waters of the Atlantic. The Tidal Power Review Board has recommended consideration of construction of a 1,085-megawatt plant in the Cumberland Basin near Amherst, Nova Scotia.

Tides have been harnessed in France and Russia. The 230-kilowatt power plant at La Rance in Brittany began operation in 1967 and uses tides both as they ebb and flow. The Russians have an experimental 400-kilowatt, single-pool plant at Kislaya inlet on the White Sea. Both are considering larger projects.

DIAGRAMS: NATIONAL RESEARCH COUNCIL OF CANADA

THE SUN

[ALL HOMES ARE HEATED BY THE SUN]



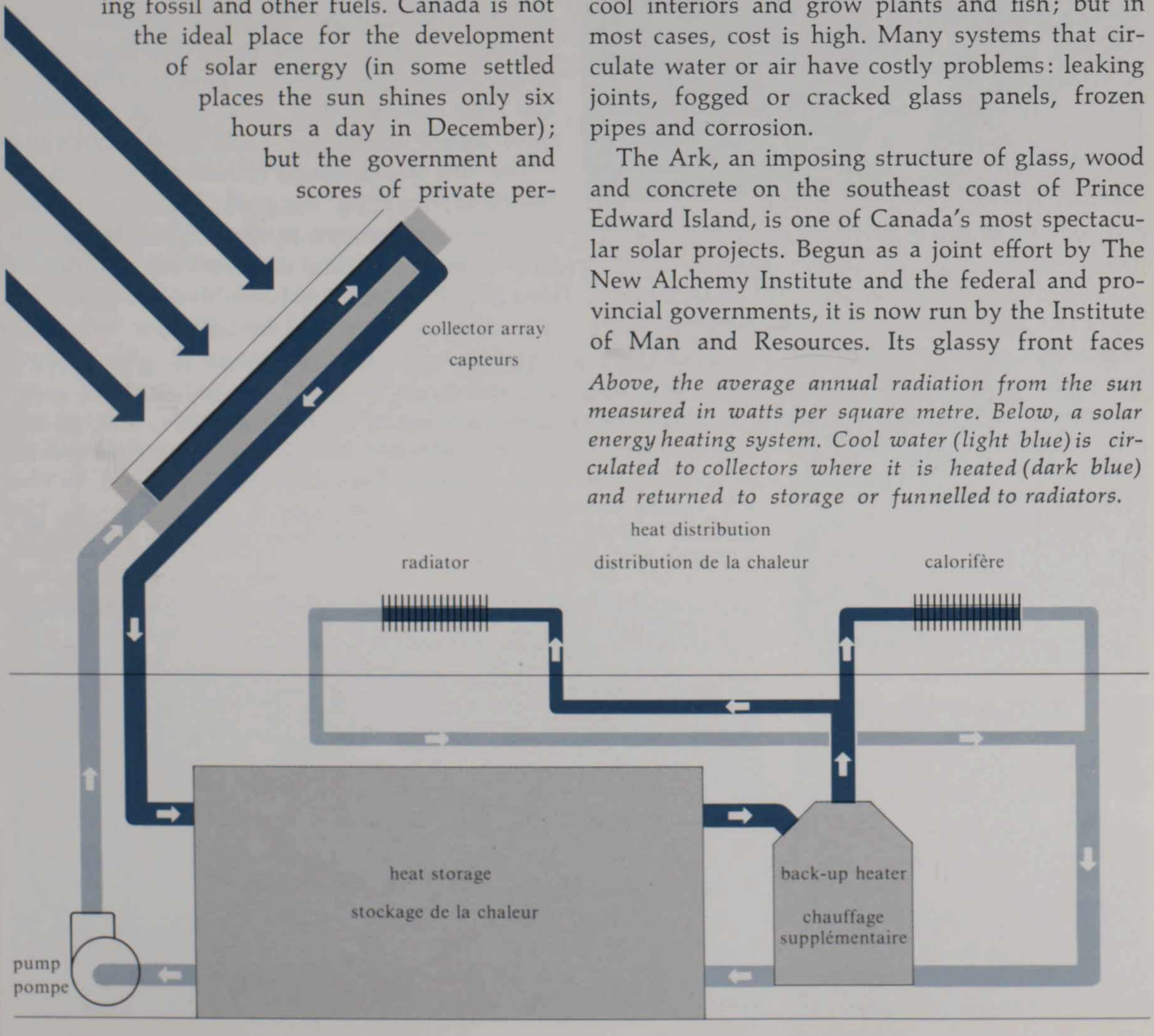
If the sun's heat were lost, the temperature, inside as well as out, would be absolute zero—minus 459.69°F—a chill that has been approached but never achieved in laboratories. The sun alone provides the heat that makes it possible for plants, animals and people to survive.

Fuel-burning stoves or furnaces add a small but vital margin that allows us to survive in twentieth century comfort. Even here, the sun can contribute by replacing fossil and other fuels. Canada is not the ideal place for the development of solar energy (in some settled places the sun shines only six hours a day in December); but the government and scores of private persons have, nevertheless, built solar converters. On the right days in the right places with the right equipment, the winter sun can keep the indoors warm.

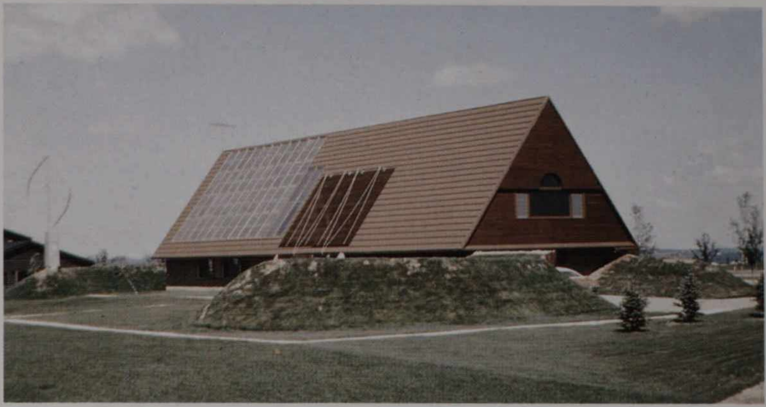
The least dramatic form of solar heat is passive—heat is captured and retained by the basic design of the building. In practical terms it is the most important form available now. Solar heat can also be used in a number of more complicated ways to heat air and water, cool interiors and grow plants and fish; but in most cases, cost is high. Many systems that circulate water or air have costly problems: leaking joints, fogged or cracked glass panels, frozen pipes and corrosion.

The Ark, an imposing structure of glass, wood and concrete on the southeast coast of Prince Edward Island, is one of Canada's most spectacular solar projects. Begun as a joint effort by The New Alchemy Institute and the federal and provincial governments, it is now run by the Institute of Man and Resources. Its glassy front faces

Above, the average annual radiation from the sun measured in watts per square metre. Below, a solar energy heating system. Cool water (light blue) is circulated to collectors where it is heated (dark blue) and returned to storage or funnelled to radiators.



PHOTOS: THE SUN BUILDERS; NATIONAL FILM BOARD OF CANADA



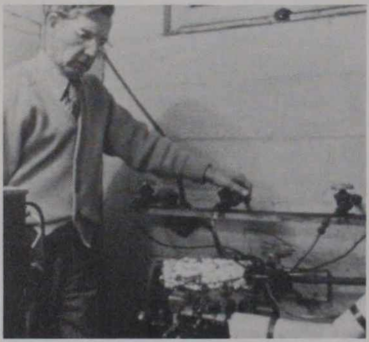
Frank Hooper built what was probably Canada's first operational solar collector, left, near Port Credit, Ontario, during the winter of 1950-51. In 1975 he designed Provident House, right, with architect John Hix. Near King City, Ontario, it is large and luxurious (with over 3,500 square feet of floor space) and heated entirely by the sun.

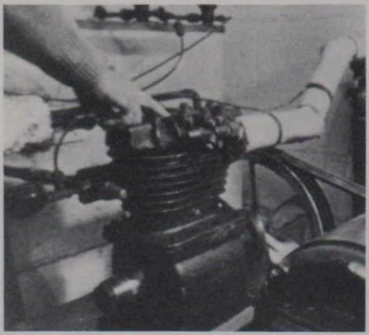
south for maximum exposure to the sun, and it has thirty-six vertical collector panels along the roof line, seven slanted panels below, a wood-burning stove and a 185-square-metre greenhouse.

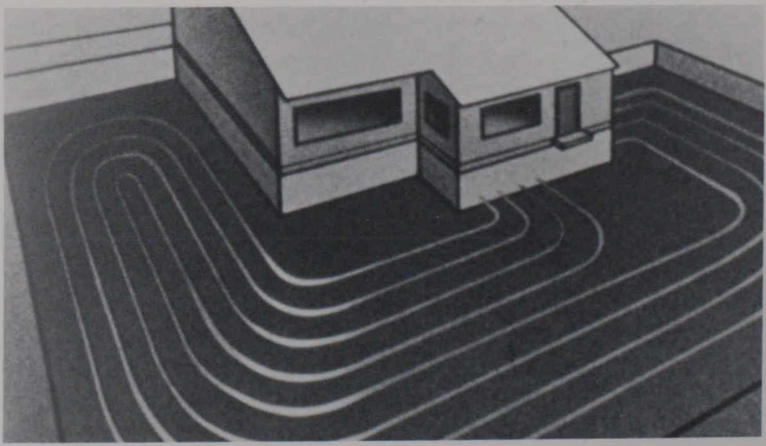
The roof panels are the most sophisticated conversion devices: water flows through pipes, absorbing heat then transferring it to insulated storage tanks in the basement. When needed, it is pumped through coils in air ducts, heating air that is blown through floor registers. The panels below the roof heat water for domestic use; the wood-burning stove keeps the room warm on cold and sunless days. Because planned windmills ran into technical problems, electricity for lights and appliances comes from the local power company.

The major successes of the Ark are its passive heat system and its combination greenhouse/fish hatchery. Passive heat collected in the greenhouse is stored in rocks and fish ponds. On sunless days it heats air that can be blown through the building. The greenhouse's coldest temperature last year was 7°C (44.6°F). It provided fresh tomatoes for Christmas and was producing lettuce and broccoli in mid-January. Energy costs are 40 to 50 per cent of those for a conventional greenhouse, and yields are the same. The heat stored in the ponds speeds up the growth of the fish. The Ark currently has 5,000 to 6,000 rainbow trout, and it is hatching 7,500 brook trout eggs.

The Ark was designed to research all kinds of questions involving survival. Waste from the Ark, both sewage and garbage, falls directly into a fibreglass composting chamber in the basement. It is decomposed by nature's own micro-organisms, slowly, safely and completely.







In 1951, when Bill Loosley, top left, built his house in Burlington, Ontario, he installed a heat pump, a "refrigerator in reverse." It circulates Freon gas through underground copper pipes, below. The ground around the pipes is 40–45°F all year. The gas is heated by the ground and returned to the house, where it is compressed into liquid, bottom left, raising its temperature. Air blown past it heats the house. The Freon is then decompressed and sent back underground as gas. In 1974 it cost Mr. Loosley $75 to heat his house.

PHOTOS: THE INSTITUTE OF MAN AND RESOURCES; UNIV. OF SASKATCHEWAN; NEW BRUNSWICK POWER

The Ark, above, designed by the New Alchemy Institute, is on the southeast coast of Prince Edward Island. A large greenhouse, right, is part of a basic family dwelling now operated by the province's Institute of Man and Resources. The heat is circulated through ordinary forced-air ducts. To cool it in the summer, the residents simply open the windows and doors. The greenhouse produces tomatoes in December, broccoli in January. The fish tanks are to the left.

There are many solar projects besides the Ark. Its architectural design for passive solar heat has been used in two low-cost houses in Charlottetown. One was sold (at the same price as other houses in the development); the other is being rented by the institute, which is measuring its effectiveness. Two farms on the island are building greenhouses patterned after the Ark.

In 1976 and 1977 the National Research Council used fourteen solar space-heating systems installed in single-family, detached houses, spread across Canada from Halifax to Vancouver, to test a variety of systems. Last spring it tested systems in multi-unit dwellings, low-rise apartment buildings and row houses. It is now letting contracts for similar projects in non-residential buildings, such as hospitals, that use large amounts of warm water. Etco Photo Limited of Ville LaSalle, a

The passive design aspects of solar heating are at least as important as the active elements. Saskatchewan's Conservation House in Regina, left, is designed with conspicuous overhangs to exclude summer sun and admit winter sun. On the lower level are shutters that come down at night. New Brunswick Power's district office in Shediac, right, combines offices and a warehouse. The solar-heated office is on the south; the electrically-heated warehouse, on the north. Banks of earth on the side add insulation.

DIAGRAM: ATOMIC ENERGY CANADA LTD.

suburb of Montreal, will install 8,820 square feet of solar collectors to heat 18,000 gallons of water each day. The water is used in colour photo processing, and heating it accounts for 55 to 60 per cent of Etco's energy use. In all, one hundred or more solar projects, public and private, are underway in Canada.

Geothermal

Below the earth's surface—at depths ranging from 750 to 2000 metres—are many pools of boiling water.

The University of Regina, in Saskatchewan, is drilling a test well on its campus. If it proves practical, steam from the ground will provide heat for a new sports complex.

Reykjavik, Iceland, derives most of its heating power from hot springs, and the use of geothermal power is increasing rapidly. A Canadian oil-well-drilling team from the Westburne International Drilling Co. has been developing the Mahiao multi-well field on Leyte Island, 300 miles southeast of Manila, in the Philippines.

Geothermal drilling techniques are similar to those used in oil fields, but the problems are different. When the well is sounded, it sends steam mixed with boiling water high into the air. The water is separated from the steam and re-injected into the ground. Each well has a cooling tower that is used to bring down the temperature of the drilling mud and prevent flash blow-outs.

A geothermal well is capable of producing 5 to 10 megawatts of electricity. They are usually found in young geological settings, and the Philippines, with more than 50 sites, is the biggest potential producer in the world. Canada expects to find productive wells in British Columbia and the Prairies.

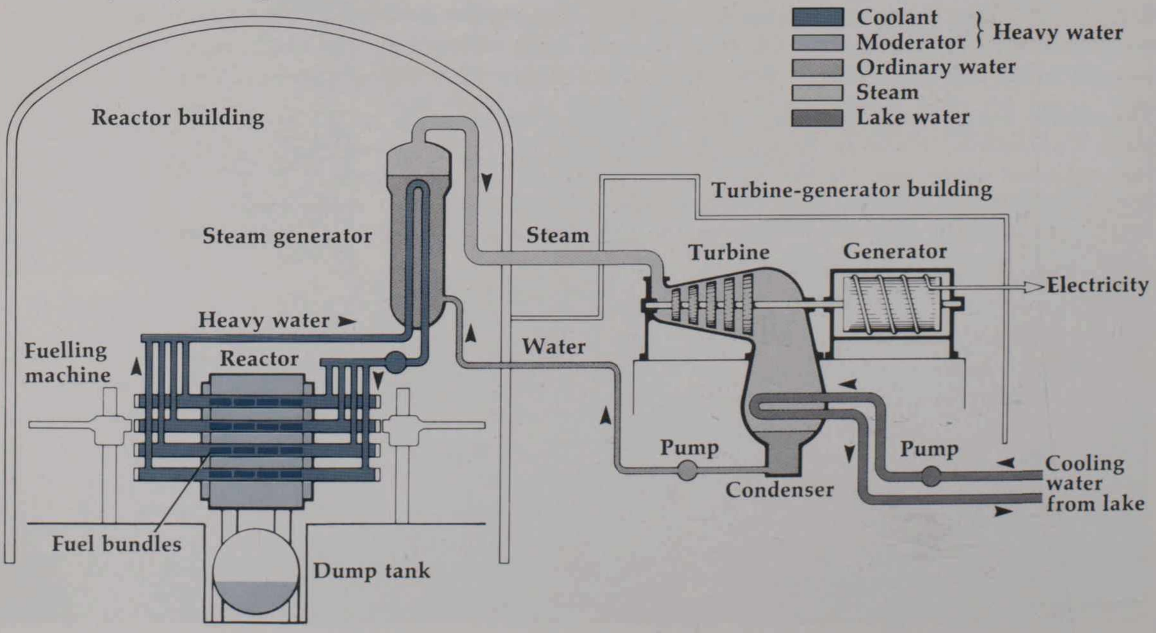
The Mighty Atom

A discussion of nuclear energy—its uses, development, wastes, dangers and problems—brings reactions all its own. It is difficult to say anything about the subject without outraging someone, but we'll try.

There are two basic ways to convert atoms to energy—fission and fusion. Fission is what we have; there are eleven nuclear power reactors now operating in Canada. Fission has well defined problems: the principal one is the disposal of radioactive wastes.

Fusion is what long-range scientists are working on now. Extraordinary technical problems must yet be solved, but some of the scientists directly involved believe fusion could be brought to commercial reality by the year 2025.

CANDU system flow diagram.



[FISSION]

Canada's CANDU nuclear reactors use heavy water and natural, unenriched uranium.

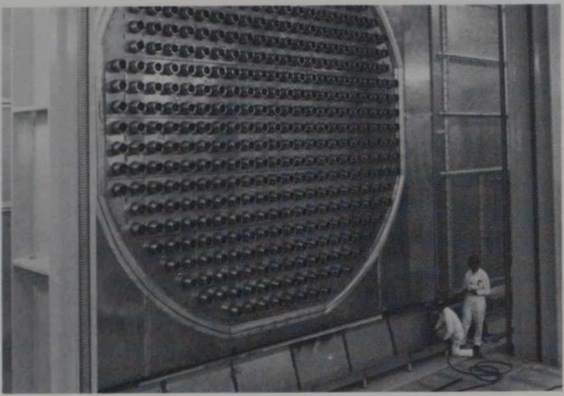
The complex at Pickering, 32 kilometres from Toronto, has four units, each delivering 514 megawatts. Pickering has produced nearly 100 billion kilowatt-hours of electricity at a cost of $0.008 per kilowatt-hour, about half the cost of conventional electric power.

Each CANDU reactor has a horizontal tank filled with heavy water (deuterium oxide). Through the tank run several hundred identical tubes containing nuclear fuel (uranium oxide pellets). The pellets radiate neutrons to the heavy water, which is used both as a moderator and a coolant. As the first, it slows down the neutrons making fission possible; otherwise the neutrons released from the uranium-235 (U-235) isotopes would not fission other U-235 atoms. As the second, it transfers the heat of the nuclear reaction to ordinary water, which turns into steam used to drive a turbine generator that produces electricity.

Each reactor holds 4,680 fuel bundles, and several of those are used up each day. The spent bundles are replaced without interrupting the process, and the spent fuel is discharged into a spent-fuel storage bay.

The spent fuel—or nuclear waste—is a serious and much discussed problem. It contains numerous radioactive elements, some of which decay in seconds and others of which stay radioactive for as long as 24,400 years. At present the spent fuel is stored within the nuclear stations themselves, and facilities exist there for many years' storage. It is estimated that the accumulated volume of spent CANDU fuel will total 565,000 cubic feet by the year 2000—enough to almost fill a room 60 feet by 100 feet by 100 feet.

PHOTO: ONTARIO HYDRO



The reactor faces at Pickering have 390 pressure tubes, each holding 12 fuel bundles.

The plan for long-term disposal of CANDU waste is to immobilize it in some insoluble solid and bury it in a mined cavity in the solid rock of the Canadian Shield. The disposal site is to be selected by 1983, and a demonstration mine is to be ready in the 1990s.

[FUSION]

There is a second nuclear energy technique—fusion. It would have apparent advantages since its principal fuel, hydrogen isotopes, is in endless supply, and presumably it would produce a lower burden of radioactive waste.

The process requires extraordinary temperatures, about 100 million degrees centigrade, and the problem is how to construct hardware that can slam the atoms together and withstand the temperatures. Two approaches are being tried: one with laser beams, one with magnetic fields.

Fusion research is enormously expensive and only the United States, the Soviet Union and a combination of European countries could afford to finance it on full scale. Dr. Morrel Bachynski of Canada's National Research Council believes, however, that Canada can develop an auxiliary program. He thinks Canada could make a particular mark in the laser area. Experiments at INRS-Energie, a division of the Université du Québec, concern delivering laser energy to a target and developing materials that could be used for building fusion reactors. Dr. Bachynski told *Canadian Business*, "We do have some very good people. . . . We also have a unique opportunity in that we have a big electric power grid that's located just south of Montreal. . . . We could use large amounts of power in off-peak periods to do experiments for longer times."

Nature's Way

Nature assembled the first nuclear reactor nearly two billion years ago in West Africa.

Scientists once assumed that natural uranium ore was always 99.3 per cent stable U-238 and 0.7 per cent volatile U-235. (The later isotope is the basic ingredient that is burned in the CANDU reactor.)

Then the French found uranium ore in Gabon that had only 0.4 per cent U-235. They concluded that the missing U-235 was burned up 1.7 billion years ago, long before the first physicist was born. The almost impossible had happened. A critical mass of ore, without such natural impurities as cadmium (which would have absorbed flying neutrons), had formed an accidental atomic pile underground, and a chain reaction had taken place.

PHOTO: GULF CANADA LTD.

The Gulf Canada Square building in Calgary, Alberta, will have no furnace. It will block out solar heat and use heat given off by workers and machines.

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