OPEC Prices Make Heavy Oil Look Profitable

In Canada, companies line up to develop the huge and hugely expensive tar sand deposits

Edmonton, Alberta. The devotees of heavy oil and tar sands met in Edmonton this month at a United Nations conference to discuss their favorite subject and consider whether the production of heavy oil—largely untapped until now—will soon stabilize the panicky energy market. No single view dominated the meeting. But then no one strongly disputed the thesis put forward by the conference's organizers, that an irreversible shift in resource economics is taking place, making heavy oil competitive with light oil.

The significance of this is that an identified resource in the Western Hemisphere amounting to about 4 trillion barrels of heavy oil is now turning ripe for commercial development. (This figure does not include oil shale, which is more costly to produce.) The known conventional (light) oil reserves of the Persian Gulf nations are estimated to be 350 billion barrels. The total amount of oil consumed by the world in history is estimated to be about 300 billion barrels—roughly one-third of the oil in place in the tar sands of a single province of Alberta, Canada.

The conference, running from 4 to 12 June, was organized by the United Nations Institute for Training and Research (UNITAR), with the impetus coming from UNITAR senior fellow and energy specialist, Joseph Barnea. An Alberta official said the conference was originally planned for California, but when the chief of the Alberta Oil Sands Technology and Research Administration (AOSTRA)—Clem Bowman—was invited to present a paper, he counterproposed that the meeting be held in his hometown, Edmonton. That plan was agreed upon last fall, and AOSTRA became a cosponsor, along with UNITAR and the U.S. Department of Energy (DOE).

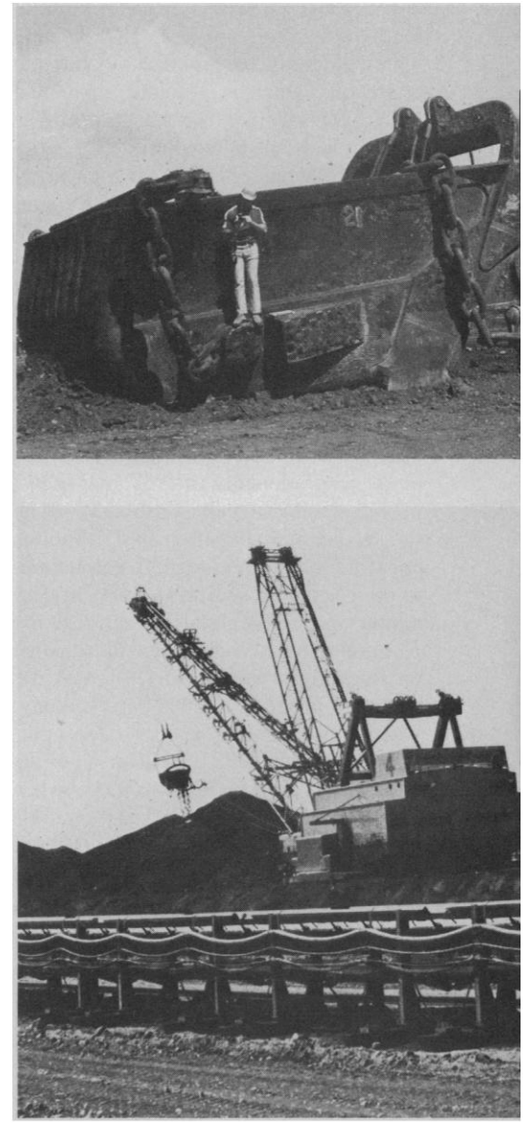
The ostensible purpose of the meeting was to exchange information between the owners of technology—AOSTRA and the oil companies—and the developing nations that lack technology but possess heavy oil deposits. The four largest known deposits in rank order are in Venezuela (1 trillion to 3 trillion barrels), Canada (more than 1 trillion barrels), the Soviet Union (1 trillion barrels), and the United States (175 billion barrels). Other large deposits are thought to exist in Argentina, Peru, Ecuador, Colombia, Madagascar, Upper Volta, India, Holland, France, Italy, Romania, and all the OPEC nations. There has been no organized exploration for this resource, so these estimates generally represent accidental discoveries and imprecise observations.

The purpose of the meeting was blurred somewhat by the conflicting interests of those who came. Some journalists came expecting to learn another way to break OPEC. The province of Alberta seemed to view the occasion partly as a trade fair, for it would like to sell its tar sands technology to Third World customers. The province became a partner with industry in 1975, financing research, development, and even the commercialization of the oil sands. As an inducement to sample its wares, AOSTRA offered to do a thorough laboratory analysis free of charge for any nation that wished to send in samples of tar sands.

The United States joined in, said Richard Hertzberg, the chief American delegate and director of fossil fuel extraction at DOE, because it has "a special interest in and responsibility for maintaining stable world petroleum prices. Thus, the United States believes now is the time to lay the necessary groundwork for increased production from heavy crudes and tar sands." On 4 June Hertzberg signed a joint research agreement with the provinces of Alberta and Saskatchewan, AOSTRA, and the Canadian energy ministry, pledging to cooperate on experimental work on tar sands, steam and combustion recovery of oil, and the treatment of wastewater from such projects.

The organizer of the conference, Barnea, is a passionate believer in the value of heavy oils, with a conviction that does not suffer dissent easily. As one Alberta official put it, Barnea "listens only when he's talking." Apparently he found the major American oil companies inimical to his vision, for he said he consciously chose not to invite them. He did not explain further. The companies' Canadian affiliates and subsidiaries did attend, however.

In Alberta it is possible to measure the promises made for heavy oil against harsh realities. Two full-scale commercial plants are in operation now, pro-



Tar sands in the Syncrude mine are lifted in huge dragline buckets (top), dumped in windrows (bottom), and transferred from there to conveyor belts which carry them to the plant.

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ducing a synthetic crude oil from a low-grade material (10 to 20 percent bitumen by weight) that looks like sticky dirt. There are other large petroleum deposits in the area, including more than 100 billion barrels of heavy oil, a lighter and less viscous material officially defined as any oil heavier than 20° API* that still flows into production lines at a profitable rate. Oil from the sands does not flow unless heated or diluted. The tar sands are more interesting, however, because they are the poorest quality petroleum resource being developed anywhere in the world. They stand at the economic frontier, and yet they are attracting many investors.

The two running plants are essentially strip-mine operations linked by conveyor belts to rudimentary refining systems (or "upgrading" equipment, in the industry term). The bitumen is washed out of the sand with hot water and sodium hydroxide, purified, and blended with lighteners to produce a synthetic crude oil, which is put into a pipeline built expressly for the tar sands. The product is usable in most refineries. Both mines are located in the Fort McMurray area, about 300 miles north of Edmonton, atop the most accessible and highest-quality sands in the immense Athabaska field. Construction of the first plant, known as Great Canadian Oil Sands (GCOS), 96 percent owned by Sun Oil of Philadelphia, began in 1964. Capital investment amounted to $300 million or more in today's dollars. It began producing 50,000 barrels of synthetic crude oil or syncrude daily in 1968, and is just now beginning to make a profit. Work on the second plant began in 1967, although construction did not begin in earnest until the early 1970's. After a series of economic and political misadventures, the plant, christened Syncrude Ltd., opened on schedule in the fall of 1978. It is designed to produce 129,000 barrels a day, when fully expanded, and its owners predict that, with luck, it will produce its current full capacity of 100,000 barrels a day for a month or two this summer. Its cost was $2.2 billion to $2.5 billion, meaning that to double the output of GCOS, Syncrude needed seven times the capital. The next plant of this kind, called Alsands Ltd., will be an approximate replication of Syncrude and will cost even more, at least $4 billion.

Before looking at the economics of

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*The American Petroleum Institute (API) maintains an index of the quality of crude oils based on a simple viscosity test. The tar sand oil has an API rating of 8° to 10°; one Venezuelan heavy oil (Bachequero) is registered at 16.8°; and Saudi Arabian light (Berri) at 38.8°.

Briefing

What to Do With Leaking Weteyes

The Army is coming under increasing pressure to neutralize 894 nerve gas ("Weteye") bombs that have been in storage at Rocky Mountain Arsenal since 1969.

The bombs are all that remain of the nation's air-to-ground nerve gas capacity. They were scheduled for demolition in 1973, but the Navy, which owns the bombs, decided to keep them when it was learned that new binary nerve gas bombs would not be coming on line to replace them.

Plans were made instead to move the bombs to Tooele Army Depot in Utah because of the risk from overflights at Denver's Stapleton Airport (the arsenal is located at the end of a runway). However, last year it was discovered that four of the bombs were leaking. Following the issuance of a supplemental environmental impact statement, the bombs were scheduled to be moved this month, but a pretransfer inspection revealed leakage in six more bombs. So the Army has again delayed action pending assessment of the new development.

The bombs have become exceedingly unpopular and practically everybody except the Department of Defense (DOD) wants them neutralized. The Environmental Protection Agency has written the Army asking for a public reassessment of the transfer plans, and Utah Governor Scott Matheson was about to go to court to ask for a restraining order to prevent shipment to his state when the Army announced its postponement.

Representative Pat Schroeder (D-Colo.) and Senator Gary Hart (D-Colo.) have for some time been trying to get the Army to decommission the bombs. The DOD claims they are still needed as a "deterrent" to Soviet chemical weapons—as an Army spokesman in Denver told *Science*, "Since we've had a deterrent no one has used chemical agents against us."

This is quite true, as no one has used chemical antipersonnel agents since World War I. Schroeder points out that the bombs are Korean War vintage and would not fit into any modern battle scenario. "We'd only use them in Europe," says Schroeder, but the Europeans will not let us store the bombs on their soil. Besides, if they wanted nerve bombs they could make them themselves. "There's nothing mystical about poison gas," she observes, "they're not like nuclear weapons."

The bombs in question are 20 inches in diameter and 103 inches long and weigh 851 pounds each in their shipping containers. They are filled with nerve agent GB (for German type B sarin), developed but never used by the Germans during World War II. The agent kills a human being in seconds.

Public opinion in Utah and Colorado is running strong against the proposed bomb transfer. "The only thing worse," says Schroeder, "would be an announcement they're going to do it in a DC-10."

Modified Surgery for Early Breast Cancer

There is no scientific evidence that a radical mastectomy gives any better results than a modified one for early breast cancers, according to the consensus meeting held on 5 June at the National Institutes of Health.

The daylong meeting, featuring the opinions of an international panel of eight breast cancer experts, also concluded that segmental (removal of the lump) mastectomy and primary radiotherapy may be sufficient treatment for very small cancers, but that more research was needed.

In this country 107,000 cases of breast cancer among women are diagnosed each year. Of these, 85 percent are early (stage one and two) cancers. Yet about 30 percent of mastectomies performed are radical ones, involving removal of underlying chest muscles.

Bernard Fisher of the University of Pittsburgh reported the results of a 5-year study of 1680 patients who were randomly assigned simple or radical mastectomies. No significant differences between survival rates of the two groups were noted, even when those whose cancers had spread to lymph nodes had only a simple mastectomy plus radiation.

Umberto Veronesi, head of Italy's National Cancer Institute, offered evidence that in early cancers segmental

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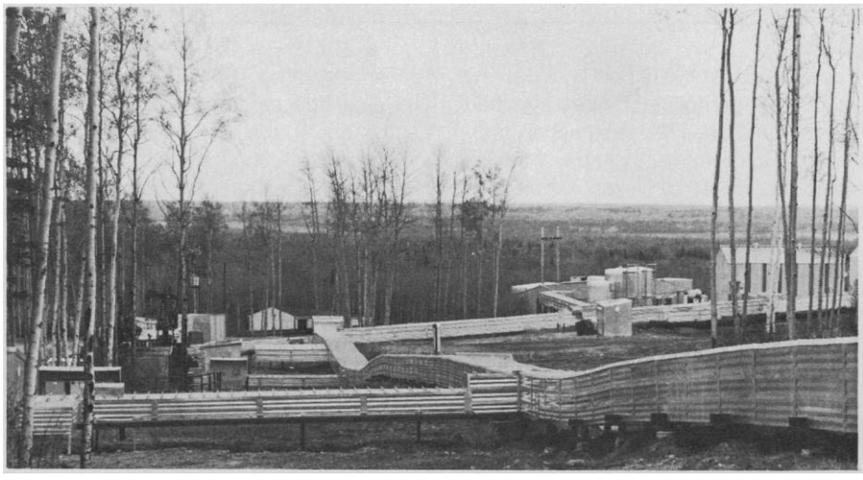

An AMOCO project at Gregoire Lake, kinder to the environment than Syncrude's mine, extracts oil from deep sands with hot air and steam.

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Syncrude, a word must be said about the physical problems of mining the sands. Thomas Maugh has described these in considerable detail (*Science*, 17 February 1978), and as far as Syncrude is concerned, the worst of them is simply the Canadian winter. The designers of the mine, according to one engineer, did not anticipate Fort McMurray's brutal weather. The plan called for stacking the stripped sand in large windrows and then reclaiming the windrows by bucket wheel onto a long conveyor belt to the plant. Last winter, a particularly cold one, the windrows absorbed a lot of water and turned rock-hard. Large clumps falling from the bucket wheel broke a conveyor belt several times (it snaps like an elastic), requiring repairs made all the more difficult by temperatures of −20° to −40° F. The dragline scoop and bucket wheels also lost some of their capacity to bite. One of the two cokers was out of order. The result was that the plant's capacity was cut in half. The owners were understandably glum.

The majority partner in Syncrude, with 31.25 percent interest, is Esso Resources Canada, a subsidiary of Imperial Oil, which is, in turn, a partly owned subsidiary of EXXON. The others are Canada Cities Services (22 percent), Gulf Oil Canada (16.75 percent), the federal company PetroCanada (15 percent), the province of Alberta (10 percent), and Pan Canadian Petroleums (5 percent). The last three in the list inherited their shares directly or indirectly from the Atlantic Richfield Company (ARCO), which dropped its 30 percent interest suddenly in 1974, when two things happened. As prices and profits escalated following the Arab oil embargo, the federal government announced that it would no longer allow royalty payments to Alberta (fixed at half of Syncrude's deemed profit) as a deductible item on income taxes. That was one shock. The second was a new cost analysis just given to the partners by the chief contractor, showing that costs were going to be double what had been anticipated.

Bowman, the director of AOSTRA, said that ARCO pulled out without warning, over a weekend. It instructed its bank not to process any more checks, and was gone. In Bowman's words, the company lost its nerve. The two provincial governments of Alberta and Ontario, along with the federal government, bought ARCO's share to keep the project alive. The federal government also backed off a bit on tax policy, deferring to Alberta, allowing Syncrude—and only Syncrude—to deduct its provincial royalty payments from federal income tax. Now the shares held by the federal government and Ontario have been passed along to their present owners.

Robert Peterson, vice president of Esso Resources and general manager of the heavy oil division, said in June: "From everyone's perception this year we're going to take a bath on the operation. Hopefully we'll have gotten all the snakes beat down in the next year or year after, so that we'll be able to show a more sustained capacity." He thought the problems were not unusual for the start-up year of a project this large. A number of "fixups" designed to toughen the mine equipment are now being made. Peterson claimed that the mine is feeding sand into the plant at rates that would permit production of 80,000 or 100,000 barrels a day, "if things were working on the other side." The ailing coker is still out, and soon it will be time to shut down the working coker for maintenance. Before that happens, Syncrude would like to run at full steam with both cokers for a month or so before the winter to prove that it can be done. Cash operating costs are more than $400 million a year, so the plant must produce at a high volume to pay for itself.

A. W. Hyndman, Syncrude's general manager for upgrading, said that the company's goal is to produce 110,000 barrels a day by 1981 and 130,000 barrels a day by 1984. For the operation to break even, the oil must sell for $10 to $15 a barrel (in 1979 Canadian dollars), and the plant must run near capacity. To make a return on investment, it must sell at the current price of light crude landed in Montreal—$19 (Canadian) per barrel. He seemed to be saying the plant would make a profit now, if only it would run.

It is a sign of the severity of the oil shortage, and of the competitive value of oil sands, that despite Syncrude's problems, many investors are now lining up to build commercial plants in Alberta. The next one on the horizon is a project wholly sponsored by Imperial, to be built at Cold Lake, costing $5 billion and designed to produce 140,000 barrels a day by 1986. It will use a steam injection system to drive the oil from underground into production wells, and will be cleaner than the Syncrude plant. This is so because it will not be necessary to strip-mine the surface, and because there may be ways to recycle 50 percent or more of the water used in producing the oil—an environmental benefit not possible at mine plants. About 90 percent of the tar sand oil in the province lies too deep for strip mining, and will have to be produced by in situ methods such as the one proposed for Cold Lake. Imperial expects to produce at least 20 percent of the oil in place, and possibly as much as 50 percent. Mining gets around 90 percent.

Another group of nine investors led by Shell Canada is planning to build a mining plant like Syncrude—with a 125,000- to 140,000-barrel-a-day capacity—in a tar region nearby. It will cost at least $4 billion, although some people say just as casually that it will cost $5 billion. Its backers hope to have it going no later than 1987.

In addition to these, there are now 22 pilot oil sand projects in the neighborhood and seven heavy oil pilots. The original GCOS plant will expand soon. AOSTRA and oil company officials aim to have, aside from expansions, four or five giant new plants on stream by 1995.

Company officials confirmed the impression that heavy oil's day has come. Brian Hay, spokesman for Imperial, said his company has just finished an analysis showing that in terms of capital cost per

barrel a day of production, conventional oil fields in Alberta have become just as expensive as the oil sand areas because the cost of acquiring land is climbing rapidly and successful wells are being drilled with declining frequency. A paper delivered at the conference by two geologists for British Petroleum (BP), Roger Mowll and J. K. Hambling, pointed out that heavy oils recovered in situ "may be capable of yielding crude at a cost little different from the more expensive sources of conventional crude." BP's northernmost North Sea Field, Magnus, was developed at a cost of something over $2.5 billion (U.S.), they wrote. It is now producing about 100,000 barrels a day and will gradually decline until its estimated recoverable reserves of 400 million barrels have been depleted. Syncrude, which cost about the same amount, is expected to produce at least 100,000 barrels a day for its entire 25-year lifetime, for a total of nearly 1 billion barrels.

With an incentive like that, why isn't there a stampede into the heavy oil fields? There is a slow-motion stampede of sorts in Alberta, where the landscape and the economic climate are hospitable. The action is less dramatic in the United States for several reasons. First, there are environmental limits. Oil reclamation projects consume and foul huge quantities of water. Imperial's Cold Lake will probably need five barrels of fresh water for every barrel of oil produced. They also release sulfur gas and other chemicals (60 tons of SO_2 a day is the projection for Cold Lake). Alberta can afford to be more generous with its air and water than can California, where much of the American heavy oil is. Second, company officials say that American heavy oil fields often fall into the category of "old oil," meaning that their output is controlled at prices lower than market level, making them unattractive for investors. Third, reclaiming oil with heat requires sophisticated tactics designed specifically for the reservoir in question. Imperial claims to have spent 15 years and $30 million preparing for the commercial project at Cold Lake. The cost amounts to $100 million, Peterson said, if all the experiments and engineering projects associated with that field over the years are counted. Projects in warmer, more familiar fields may not require so much research, but they will require costly, individually tailored development plans.

According to Fred Hallmark, reservoir engineer for the California Division of Oil and Gas, his state produces right now about 500,000 barrels of heavy crude oil daily, half of it by steam or other thermal recovery techniques. He estimates that in California alone there are between 1.8 billion and 3 billion barrels of "unconventional" oil in place, a reasonable fraction of which could be recovered with methods such as those being proposed in Alberta. Claude Hocott, an oil consultant from Houston, Texas, said that if the price of oil were to climb to $25 a barrel in the United States, the estimated crude oil reserves of California, Louisiana, and Texas would increase by about 7 billion barrels.

The world market price for light crude oil is now around $15 a barrel, with batches on the spot market selling for $25 and higher. The OPEC members are telling reporters that they want to raise the official OPEC price to $20 a barrel this summer. If the United States were to lift its domestic price controls now, there is no question but that many of the neglected heavy oil fields would be brought into production.—ELIOT MARSHALL

NCI Bioassays Yield a Trail of Blunders

Costly tests of suspected carcinogens have been dogged by negligence and mismanagement

Early last month, the National Cancer Institute (NCI) startled the general public with reports that four chemicals in commonly used products cause cancer in laboratory animals. The reports* were the most recent harvest of the NCI bioassay program, an expensive, federally supported system of testing suspected carcinogens. Frequently, regulatory officials seize the results of the bioassays and go charging into the *Federal Register* with proposals to remove products from the market. They do so with confidence because NCI has represented the tests as ranking with the best performed anywhere in the world.

Lately, it seems either that this representation is an exaggeration, or that an awful lot of poor testing is going on elsewhere. Provoked by a recent NCI disclosure that 51 long-term bioassays are so deficient they cannot be written up in technical reports, outside observers are beginning to question the reliability of the entire program. Federal investigators checking into the work performed for the NCI program under contract have discovered that much of it has been casual and haphazard, and that some of it has been unusual. Audits covering each of NCI's prime contractors for the bioassays indicate that the contracts were awarded under irregular circumstances and that the contractors have been receiving more compensation than merited by their performance. NCI itself has consistently failed to detect or correct the program's failing, three reports suggest. As a result, there is a move afoot to pluck the bioassay program from beneath NCI's wing and transfer it wholly to another federal science agency.

The bioassay program has been controversial since its inception in 1971. Congress envisioned it then as the best means to determine which of the 10,000 important chemicals in commercial use posed a hazard to human beings. The plan, which fell to NCI over its strong objections, was to test suspected chemicals in carefully selected rats and mice, typically over the lifetime of the animals. NCI objected because the tests are lengthy, expensive, and tedious. But they are also the only systematic large-scale measurements of the hazards of existing chemicals, particularly those about which suspicions have already been raised. (The Toxic Substances Control Act, enacted in 1976, mandates testing only for newly invented chemicals.) The hazards of Tris, Kepone, DBCP (dibromochloropropane), chlor-

*On reserpine, an antihypertension medication; methapyrilene, an antihistamine also used in nonprescription sleep aids; selenium sulfide, used in dandruff shampoos; and disulfiram, both a fungicide and an anti-alcoholism medication.

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