Kahn and Simon agree with the desirability of moving to nuclear power, but they neglect to underline the principle which makes it necessary. One of their contributors, Bernard L. Cohen of the University of Pittsburgh, does understand, however. Appended to *The Resourceful Earth* is a Statement of Dissent by physics professor Cohen, which makes the following cogent point:

"As a scientist I see no barriers to a bright future for America and for mankind. Irrespective of present trends, many minerals will eventually become more scarce and expensive. But we can develop substitutes for them. Food supply and environmental difficulties may well develop, but they can be solved. The only thing we need to handle these problems is an abundant and everlasting supply of cheap energy, and it is readily available in nuclear reactors, including the breeder. Given a rational and supportive public policy, science and technology can provide not only for the twenty-first century, but forever. . . ."

Cohen cites the success of uninformed "public opinion" in sabotaging nuclear power, and states:

"Unless solutions can be found to this problem I believe that the United States will enter the twenty-first century declining in wealth, power, and influence, and within the next century will become an impoverished nation. I therefore find it difficult to share in the optimism that characterizes this report. That does not mean that I sympathize with *Global 2000*; indeed, some of those who were most influential in its preparation have been among the leading perpetrators of the policies that are ruining us. The coming debacle I foresee is not due to the problems they describe, but to the policies they advocate."

Dr. Cohen is, if anything, understating the case. Economic catastrophe in the form of famine, epidemics, and a rise in infant morality rate is already striking whole continents. Food shortages are looming not only in the Third World, but also in the United States, due to deliberate policies to take land out of production, and to loot the U.S. farmer. The transportation infrastruture, key to the functioning of any industrialized nation, is in a state of total collapse, including in the United States.

The world needs more than optimism to handle these problems. It requires a program for putting people to work producing again, a program which is supported by a new monetary system worked out between sovereign governments and geared to funding massive new infrastructure projects, especially in the Third World. The Third World cannot be left a raw materials producer. It must not only industrialize, but leapfrog the developments in the so-called industrialized world today.

We recommend that the Reagan administration, one of the major targets of this study, and all other honest conservatives, think twice before taking the advice of *The Resourceful Earth*. The fantasy that "everything is okay" is the quickest route to disaster.

Science & Technology

Breakthrough set

by William Engdahl

A small energy company in Oklahoma has teamed up with a national research laboratory to launch what could become one of the most significant technological developments in recent decades for recovery of heavy crude oil and tar deposits.

Deploying the physics of electromagnetic radiation at the radio frequency end of the spectrum, the Uentech Corporation of Tulsa appears to have made the breakthrough. Preliminary computer simulation of one producing well of Venezuelan heavy oil using the new method took production from previous rates of 35 barrels per day (bpd) up to 90 bpd after 30 days, and 165 bpd after six months—an increase of almost 500%.

While the principles of physics employed are the subject of a wide-ranging series of advanced experiments, such as that going on at the Princeton Plasma Physics Laboratory to investigate the radio frequency heating of plasmas, the Uentech breakthrough, the result of years of laboratory and field research, is actually in the process of commercial application in two projects in Oklahoma.

Crude oil deposits range in grade from very light, such as found in the Middle East, to heavy. The lighter grades, those with an American Petroleum Institute (API) gravity index of 25° API up to about 38° API, flow easily at well-reservoir temperatures. But there are vast reserves throughout the world of heavy crudes (below 21° API) which are highly viscous, do not flow easily, and, therefore, are often uneconomical to tap. With refineries forced to use increasing amounts of these heavy crude grades in recent years, the industry faced the problem of making it economical to recover this oil. Uentech, a subsidiary of Universal Energy Corporation working jointly with the Illinois Institute of Technology Research Institute of Chicago (IITRI), a non-profit institute affiliated with the Illinois Institute of Technology, is confident it has solved this problem.

If the field tests now underway in southern Oklahoma prove as promising as laboratory simulations indicate, the

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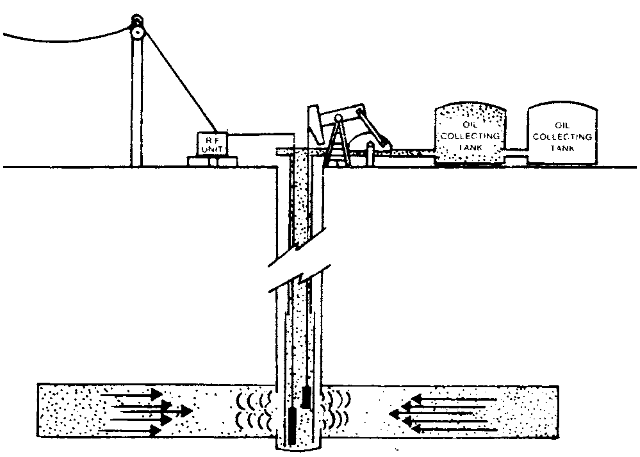
new process could make economical recovery possible for the huge reserves of heavy oil in the cold reaches of Prudhoe Bay, Alaska, and for the tar-sand deposits in Utah, Canada, and Oklahoma.

Most important, the new process would enhance the recovery of oil from partially depleted reservoirs in heavy oil zones such as Venezuela. In addition, the process would make it economically possible to tap the estimated 1 trillion barrels of oil in the Orinoco Tar belt which cuts across Venezuela, Colombia, and Surinam.

Work on the process has been underway since the 1970s, when IITRI obtained a research contract from the U.S. Department of Energy Office of Advanced Energy Projects for investigation of use of electromagnetic energy on hydrocarbon-bearing formations, especially shale and tar sands.

Single well radio frequency heating process.



This approach was a dramatic contrast to the more publicized methods, especially the thermal methods such as Occidental Petroleum's difficult-to-control underground "fire-flood" retort to obtain oil from shale, or Union Oil's malfunctioning "rock pump" above-ground retort. Those methods require price supports well above current world oil prices and large federally backed loan guarantees. They also have serious air and water quality impacts not associated with the electromagnetic method.

Ironically, just as IITRI successfully completed several small-scale field tests in Utah, the project was shelved during the bureaucratic chaos of the near-dissolution of the Energy Department, the project's principal sponsor. It was up to an imaginative company in Oklahoma to see the untapped potential of the IITRI research. The "marriage" of resources between IITRI and Uentech of Tulsa, which began in 1983, has already extended the application of IITRI's work to enhancing the possible recovery flow from existing older wells.

Enhanced oil recovery

The U.S. Department of Energy estimates there are some 300 billion barrels of oil in known reservoirs around the world, lying in wells that have lost pressure as initial oil has been drawn out, at the same time that we will need at least 2 million bpd from enhanced recovery sources in the next few years. The conventional thermal process used to recover this oil—shooting steam down the well to increase pressure and decrease viscosity—is very energy-intensive, inefficient, and can be used only in relatively shallow wells. Steam injection requires source water (often in water-scarce regions) and an oil-driven boiler to produce large amounts of steam, and usually yield only 1-2 barrels of recovered oil for each barrel consumed in the recovery process.

The underlying principle of the Uentech/IITRI method is—like most such advances—both ingenious and simple. Using electromagnetic energy in the radio frequency (rf) range, simulation tests indicate possible increases in well production flow rates of 200-500%.

One computer simulated test based on a program developed jointly by IITRI and Texas A&M University simulated a known producing region of Venezuela. A typical well in the region, producing 35 bpd, flowed at 90 bpd after 30 days of electromagnetic stimulation, a rate which climbed to 135 bpd, and reached 165 bpd after six months of rf power input. Uentech calculates these increases in output are possible at an additional cost per well of only $20,000 to $50,000.

More important, as Uentech president Homer Spencer stressed in a recent interview, "Significant power is not lost by our process in transmission down the bore-hole." This advantage is potentially invaluable in places such as Venezuela where billions of barrels of oil lie at depths of 8-9,000 feet, too deep for steam to be effective.

For single-well simulation, Uentech lowers a specially designed antenna or electrode down the bore-hole. Energy at radio frequency is then applied through this antenna, heating the surrounding oil deposits with rf energy. As viscosity decreases as temperature increases (recall the change in viscosity of cold maple syrup upon heating), the oil surrounding the bore-hole becomes more mobile, stimulating fluid flow and hence, production of oil from the well.

Similar approaches had been tried before, but the problem was, according to industry sources, that experimenters worked in the microwave end of the electromagnetic spectrum, whose characteristic heating properties are undesirable for this application. The rf spectrum was largely ignored. When Uentech approached IITRI with their proposal, IITRI well understood the problem. They research high-level electromagnetic effects including EMP (electromagnetic pulse), rf interference, and electromagnetic heating.

IITRI and Uentech have subsequently shown in extensive laboratory tests that each oil deposit has an optimal range of heating frequencies in which the applied electromagnetic energy will be absorbed with optimal heating effect. Ironically, IITRI had previously looked at but rejected a similar kind of single-well method as inappropriate to solving the problem of shale recovery. Uentech's Spencer, a chemical engineer familiar with problems of fluid flow in existing wells, triggered a re-examination of what has become their Single-Well Stimulation method.

The method is now being applied in a field location in Love County in southern Oklahoma in a $2.5 million project following extensive laboratory tests. Recent breakthroughs over the past three years in solid-state energy conversion circuitry have made solid-state rf transmitters commercially available. With efficiencies for conversion of electrical to rf energy more than three times that of older vacuum tube transmitters, these transmitters are the size of a large filing cabinet, making well-site application feasible for the first time.

As Spencer emphasizes, "The single-well stimulation method works well over a range of crudes below approximately 25° API," and will be cheaper, more energy efficient, and applicable to a much wider range of regions.

One by-product of the research experience of IITRI and Uentech in conjunction with Texas A&M has been development of some of the most detailed computer modeling ever done of the effects of electromagnetic wave propagation through the earth medium. Potential spin-offs of the data could have great benefit in other areas.

'A giant capacitor'

A second project, this one in a tar sand deposit in Murray County, Oklahoma, is also underway. Here IITRI and Uentech are using what they call their "parallel-plate" process to create commercial boiler fuel oil from tar sand deposits. In this project, the Bechtel Group has agreed to provide the engineering and management for the project.

The parallel-plate method has been under development since IITRI began work, first with its own funds, in 1976. They conducted field tests of the method in Utah under an agreement with the DOE and Halliburton Company until the 1981 fall in oil prices cut industry support.

The approach involves creation of a "triplate" type of giant in-ground "capacitor." Following extensive laboratory and field testing of optimal characteristics, IITRI has arrived as the most efficient geometric configuration of three rows or lines of 3" steel pipe inserted into the tar sand deposit, the inside row or "plate" being the "hot" side in electrical terms. This method provides uniform and maximum heating of the deposit. The advantage of this triplate method is that you can "fine tune" the frequency of rf energy input to the specific frequency optimal for a given deposit.

Extensive tests showed that the tar sand deposit had electrical characteristics dramatically different from the surrounding overburden and adjacent rock strata, in effect creating a type of natural heterogeneous dielectric, analogous to a capacitor in an old vacuum-tube radio. As electromagnetic energy is pumped in (optimal, as with the single well method, at the rf rather than microwave end of the electromagnetic spectrum), the rf energy is converted into heat which is transferred into the tar sand deposit. A heavy oil begins to precipitate out, and can be withdrawn via conventional mining methods.

Heat losses or leakages with the IITRI method are negligible, making it possible to recover from 5 to 10 barrels of oil for each barrel used.

The IITRI/Uentech method indicates that substantial cost reductions for so-called synthetic fuels are imminent. In one Utah tar sand formation, IITRI calculated that with an initial capital outlay of approximately $84 million for installation of a large rf recovery facility (which would include infrastructure to emplace the electrical excitors and production equipment), a substantial 10,000 bpd production facility could produce the Utah bitumen at an operating cost of $5.88/barrel and a capital cost of $3.62/barrel for a total cost of $9.50/barrel. Add another approximate $10/barrel to upgrade this Utah bitumen to commercial quality syncrude for a total cost of less than $20/barrel. This is a far cry from the Carter administration estimates of $80-$100/barrel for commercial synfuel costs.

In the Uentech Murray County project, where the tar has much lower sulfur content and electric power costs are far lower than at the Utah site, Homer Spencer estimates that the costs of power input to heat the tar sand will range only $2-$3/barrel of usable oil produced. Provisions of a Congressional Alternate Energy Tax Credit of about $4/barrel give further financial incentive to investors in the method even with falling world oil prices. But, as Spencer stresses, the economics of the application of rf heating for recovery of oil from tar sands are sufficient to be able to compete in its own right. It should provoke a long-overdue debate on the relevance of the physics of electromagnetic wave propagation to production of hydrocarbon energy in the process.