Exxon Builds on Basic Research

New corporate research laboratories reflect R&D policy of going back to the fundamentals

Clinton, New Jersey. It is a far cry from Exxon's old corporate research laboratories in the heart of New Jersey's refinery belt near Newark Bay to their new quarters some 40 miles west of there. Not only do the labs occupy imposing new buildings on open land in rural New Jersey, but they are designed for a new style of industrial research.

Exxon spent $200 million on the land and laboratories and probably a third as much again to pay the costs of the move. A good portion of Exxon's 850 acres in Clinton Township is still being farmed, much of it by the former tenants. But Exxon obviously did not move to Clinton for the corn crop.

The Clinton labs figure firmly in a new business strategy adopted by the giant oil company in the wake of the abrupt shifts in energy markets during the past decade. Like just about everybody else in the energy business, Exxon misread the signs, made some bad investments, and has been forced to rethink its policies.

Describing Exxon's initial response to the 1974 Arab oil embargo, Edward E. David, Jr., the company's research chief, said in a recent talk that, "Although Exxon had long been an integrated petroleum company, the focus became to increase the company's role as a supplier of a broad range of energy resources—not just oil and gas, but also coal, uranium, solar thermal, solar voltaic, and synthetic fuels. Likewise, Exxon's R&D strategy was strongly development oriented. Though we didn't ignore fundamental science, short time horizons dictated a functional engineering approach to the products and processes we were seeking to deploy."

The expectations of steadily increasing energy prices and recurring shortages, however, failed to materialize. Conservation and a world recession cut demand. Energy prices in real terms have been declining as supplies of oil and natural gas have come close to a glut. As a result, says David, "Exxon has reverted to being mainly a supplier of conventional hydrocarbon fuels—petroleum products, natural gas, and steam coal."

In the process, Exxon has disengaged from its heavy commitment to synthetic fuels development. The company has withdrawn from several expensive synfuels commercialization projects and reoriented its R&D on synthetic fuels. The commercialization projects depended essentially on existing technology, and it became apparent that under present supply and price conditions the synthetics were uneconomic.

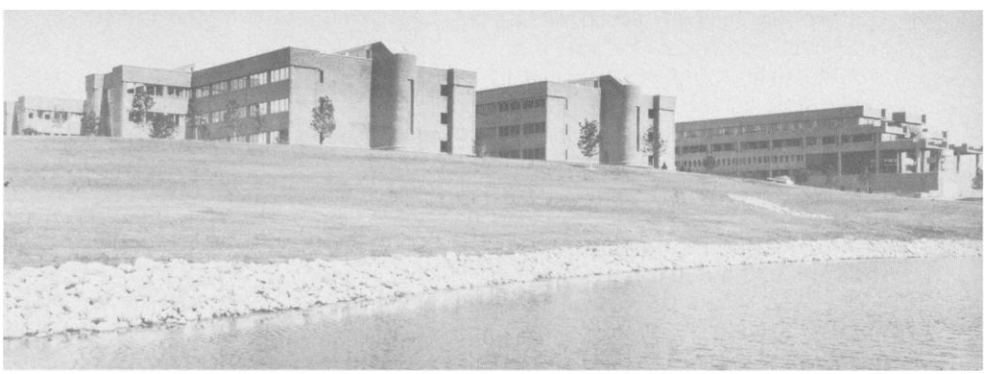
Exxon has not changed its mind about the eventual need for fuels from unconventional sources, says David. "But such fuels, including synthetic fuels, must compete with an oil price not much higher than today's in real terms. In turn this means a search for fundamental understanding on which to base clearly improved technologies. It means going back to the fundamentals in materials, processes, control systems, reaction paths, and so on."

What is implied, of course is a major change in R&D policy. Exxon is paying more attention to basic research—which will be a major function of the Clinton labs—forging new links with the universities, and attempting to do a better job in transferring technology within the company.

Oil companies have not stood high in rankings of R&D–intensive industries, in part because oil companies must make heavy expenditures on exploration and transportation, which are not required in the operations of other industries. In a new report on resources devoted to R&D by the Organization for Economic Cooperation and Development (OECD), Exxon ranked 11th among large U.S. companies in total expenditures on R&D, but was the only company in the top 20 to spend less than 1 percent of total annual sales on R&D. Because Exxon is the world's leading company in point of annual sales, however, its R&D spending in absolute terms is formidable—some $700 million last year. (The latest Fortune 500 listing puts Exxon annual sales at $85 billion; Shell ranked second and General Motors third.)

Despite a general effort at retrenchment at Exxon in recent years, the budget for corporate research, where the company's basic research operation is lodged, rose from $46 million in 1979 to $115 million last year. Total spending on basic research last year, which includes some research billed to organizations other than corporate research, is estimated at $123 million.

David notes that oil companies' research is not like that in many manufacturing industries which aim at new products. "The oil industry is a process industry," says David. "A great deal of Exxon's effort, therefore, is pointed at process not product" and has been concerned with efficiency, quality, yield, and reliability.



Exxon Research and Engineering's new research center

Laboratories on the left and building housing pilot units at right.

Corporate research is part of Exxon Research and Engineering Company, the biggest of the R&D units that serve the huge, international energy company. ER&E, as it is called within Exxon, deals primarily with the "downstream" side of the oil business, that is, the refining, transportation, and marketing of petroleum products. Corporate research, as the name implies, however, is expected to make its expertise in basic research available to all of Exxon's far-flung companies. The main exceptions are operations like Exxon Office Systems and Zylog, a manufacturer of microprocessors, which both developed under Exxon Enterprises, the branch established when Exxon was bent on diversification. The recently acquired

Reliance Electric, an electrical equipment manufacturer, also has its own basic research unit.

Basic research was launched at Exxon in 1959 with the creation of a small central laboratory headed by John Longwell, who is now at Massachusetts Institute of Technology (MIT). It gained more prominence when corporate research was established as a separate entity in 1968 to explore the scientific base for new and prospective technologies. At the time, basic research was in vogue in U.S. industry and served mainly in many cases to burnish the corporate image. But it achieved a more functional role at Exxon as a result of the upsets of the 1970's.

In 1977, more or less in the midst of the roller coaster ride for company policy, David joined ER&E as president. He had served as President's science adviser from 1970 to 1972 and was a knowledgeable and highly visible player in national science affairs. Trained as an electrical engineer, David had spent two decades as a researcher and administrator at Bell Labs.

At the time he joined Exxon, says David, "the company perceived that the world is influenced by scientific research." This led to a change in management style in the late 1970's. "There used to be a distinction between basic and applied research," said David. "Now the emphasis is on the connection between the two." And there is increasing stress on the translation of basic research into useful technology.

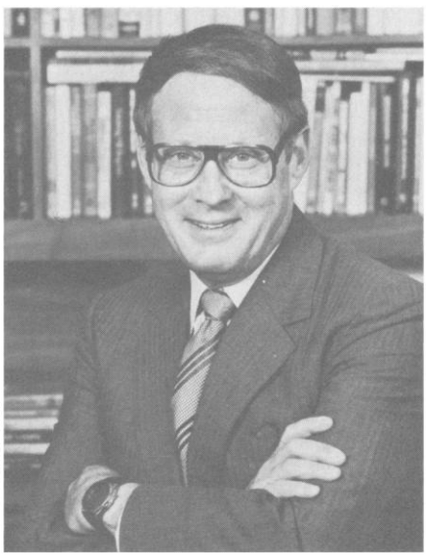
David says that basic research is chosen for apparent relevance to Exxon's business. Subdivision of the scientific laboratories into six labs—catalysis sciences, chemical sciences, theoretical and mathematical sciences, polymer sciences, material sciences, and physical sciences—reflects Exxon's main lines of interest in basic research.

The new Clinton labs, which house ER&E headquarters as well as corporate research, will have a staff of about 900 when the late arrivals move in. The research contingent has about 325 Ph.D.'s and some 220 support staff—technicians and professionals with lesser degrees. Over the last 5 years, manpower assigned to basic research increased by about 25 percent.

Corporate research is divided into two main sections, the scientific laboratories and the smaller technological feasibility center. About 80 percent of the research personnel are assigned to the scientific laboratories and the rest distributed among management, planning, applications and technology transfer activities.

Research administrator Roger W. Cohen describes Clinton as primarily a materials laboratory. Exxon scientists, for example, do not usually deal with a single crystal, as might be the case in the electronics industry, says Cohen, but rather with "dirty material" which is heterogeneous and amorphous. The major theme is the study of very complex materials and the long-term goal is to control interactions.

The new effort by corporate research to translate scientific results into useful applications more rapidly is focused in the technology feasibility center. The



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Edward E. David, Jr.

Presides over new R&D strategy.

head of the center, Harold Weinberg, objects mildly to the term technology transfer, which is often used to describe the center's function. Weinberg suggests the term is misleading since it evokes "a baton passing" image. Weinberg argues that major ingredients in successful technology transfer are interdisciplinary research and "committed participation." The latter means bringing development and business people into a project early and dissuading scientific types from dropping out before the project is carried through.

Often, a technology transfer victory does not cause a conspicuous splash scientifically but makes a substantial impact commercially. A recent example is a new family of chemical scrubbing agents called "hindered amines" which are bringing Exxon important savings in removing hydrogen sulfide and other acid forming gases, which are common impurities in natural gas and in oil refining operations.

As part of its altered R&D strategy corporate research has also broadened its relationship with the universities. Exxon has long maintained contacts with university scientists, but these were mainly conventional consulting arrangements until the late 1970's when the connection was expanded and diversified. The change came about at a time when industry and universities generally were newly disposed to cooperate. Exxon's most visible initiative is probably an agreement concluded 4½ years ago with MIT. With the collaboration scheduled to run for 10 years, Exxon is supporting the program at a level of $900,000 this year and is expected to provide funding at a similar level in constant dollars for the term of the agreement.

Chemical engineering professor John Longwell, who has played a lead role in the program from the start, says that the agreement was the product of "great pain and effort," since it was, in effect, a prototype for both parties. Under the arrangement, MIT owns all patents produced by the program and Exxon has access to them royalty free. License income is shared. The research focus of the program is high temperature chemistry, which is obviously relevant to Exxon's refinery and petrochemical industry interests.

A sharper departure for Exxon was marked by the 5-year agreement concluded in 1980 with Cold Spring Harbor Laboratory on Long Island. Exxon scientists are working at the well-known molecular biology and genetics lab as a step to establishing a small but ambitious biosciences program in corporate research. Exxon is not considering branching into fields such as pharmaceuticals, which have beckoned to other companies bullish on biotechnology, but rather sees such research as offering a long-term opportunity for radically changing Exxon technology. One future possibility is selectively catalyzing hydrocarbons with enzymes. Enzymes do catalysis very well, but they do not do it very quickly, says Cohen. And the challenge is to find out how to accelerate the process.

The company has moved closer to the universities in several other ways. In the late 1970's, for example, corporate research instituted a postdoctoral program that now operates with about 25 postdocs at ER&E at any one time. The term is 1 year, renewable for a second and Exxon executives say a strong effort is made to assist the postdocs to return to universities when they finish at Exxon. The general aim of Exxon's university program is to encourage university interest in the research areas important to the company. Exxon, accordingly, has de-

veloped a variety of programs for faculty and students and now has collaborations of various kinds with some 60 institutions.

The shifts in Exxon R&D strategy occurred at a time when the company at large was adjusting to the fall in demand for oil and operating in what one staff member calls a "shrinkage mode." Along with closing some refineries and other facilities and cutting back the work force worldwide, the company also reduced R&D budgets and employment including ER&E's.

The Clinton lab project had a high enough priority to proceed despite the retrenchment. David says that corporate research had outgrown the Linden site. The concentration of people and equipment was causing concern about safety hazards. Also, working arrangements in the postwar-vintage buildings were clearly inefficient. A country-wide search for a new site was conducted, but a decision to remain in the area was prompted by a survey finding that a move requiring long distance resettlement would result in the loss of as many as half the professionals.

The new labs are an example of "design from the inside out," says David, who had a direct hand in devising a layout aimed at "producing good science and technology." This gave the architects limited latitude and what resulted is very agreeable inside but gives a slightly stern, institutional impression outside. The labs' solid appearance—company wags call it Fort Exxon—might be said to symbolize basic research finding a permanent home at Exxon.

Is Exxon again gambling on a particular energy scenario? David says that anyone who has an R&D strategy fixed on one future is in for trouble. "The lead time is long in this business, and you have to have contingency plans," says David. "Our R&D strategy for some time has been to provide the tools to move in whatever direction is necessary."—JOHN WALSH

Population Studies Age Prematurely

The university base for world population studies is suffering a "premature hardening of the arteries" according to a report prepared for the Ford Foundation. Many programs are overly academic in emphasis and divorced from the realities of developing countries, says the study, prepared by Jack and Pat Caldwell of the Australian National University's Department of Demography.

The foundation commissioned the report for an assessment of its population program. Support grants tapered off in the late 1970's, although Ford continues to put some money into population-related activities.

Ford money totaling about $45 million established the first programs on world population and was their mainstay during the heyday of the field in the 1960's. Ford gradually withdrew as the government got involved.

Although this is the way of foundations, the Caldwells' report strongly suggests that Ford should get back in the business of bolstering graduate programs—not only because of the magnitude of the problem but because population programs need a source of flexible funding to foster innovative research and more direct involvement with developing countries.

There are two wings to population studies. Demography programs, where people are usually trained for academic professions, are generally housed in departments of sociology. Population experts are also trained in schools of public health, where they are usually prepared to administer family planning programs.

During the 1960's, as new ties were being formed in Third World countries, population studies had an activist cast, and often came in conflict with more traditional academic thinking. The Caldwells say that as foundation funding dwindled, programs became more dependent on their universities and have succumbed to pressures for academic conformity.

The report indicates that the programs in schools of public health continue to sustain contact with the Third World. Nonetheless, in many of these schools, the training emphasis has shifted from family planning programs to general health management.

Population studies associated with social science programs "regard the present period as a crisis" and "have a feeling of their Third World involvement slipping away from them," say the Caldwells. These programs have gained security and respectability but at the expense of flexibility and innovation.

The Caldwells see an urgent need for seed money to support basic research on culture and fertility. The authors say the country has been "misled" by the success of family planning in East Asia into thinking the same pattern will bring results elsewhere—despite, for example, the dismal failure of family planning to become established in Africa.

The authors are critical of the heavy emphasis on statistical research. Incessant analysis of World Fertility Survey data tapes "are not bringing population programs closer to the Third World experience," says the report. Research projects supported by the Agency for International Development are narrowly defined and usually confined to operations.

Queried by *Science*, several program directors voiced general agreement with the thrust of the Caldwells' analysis. Samuel Preston of the University of Pennsylvania said "most LDC [less developed country] demographic analysis is done primarily in computer centers," and "the field lacks ideas."

They also note that the field still enjoys infusions of private money. Part of the gap left by Ford is being filled by the Hewlett and Mellon Foundations.

Population research is still a very new field. It is only in the last decade that accurate projections of world population have been available. The report offers an ironic perspective on the current Administration's thinking: until the 1950's, the prevailing view was similar to President Reagan's—that demographic transitions would naturally accompany economic development. As early as 1944, demographer Kingsley Davis called this view into question, warning that if India followed the pattern of the West's demographic transition, its population would reach 750 million by 2024. Even Davis, who was considered an alarmist at the time, was wide of the mark: India's population is already approaching 740 million.

—CONSTANCE HOLDEN