The role of industry in international energy programs

A semi-submersible drilling rig in the North Sea exemplifies international cooperation in action on the energy scene. This rig, the *Waage II,* an international project, incorporates a dc motor and control unit by General Electric to provide the power for its deepsea drill.

International cooperative efforts, so necessary to develop the world's energy resources, will give industrial scientists a chance to assume an active role.

Roland W. Schmitt and Peter J. Stewart

The time has come for technical people in industry to take the lead in establishing international programs in energy research and development. To show why we believe this, we will have to explain why we think international ventures in the energy field will turn out to be best handled by industry-to-industry contacts, rather than through some kind of government-to-government dialog, and also why we think it is time that industrial scientists, rather than purely business-minded executives, played leading roles. Close links with cooperating government agencies will of course still be appropriate and necessary, but initiatives should now come from industrial scientists.

But, you may ask, has not industry already established a vital role in international technology transfer, and are not industrial scientists already internationally minded? It is true that during the past twenty-five years the transistor, the integrated circuit and the computer have all moved from US developments into world-wide products by way of industry-to-industry channels, and during the same period developments such as float-glass manufacture and oxygen steelmaking have moved, *via* industrial channels, from Europe to the US. Also true is that industrial scientists have as strong an international outlook as their academic counterparts. However, their internationalism has been motivated principally by the sense of community among technical people everywhere *as technical people*. By and large, they have not had a sense of urgency about the need for an active international role to serve economic ends—except when others have pointed the way.

Industrial scientists must change their attitude toward international development programs from a reactive role to one of genuine leadership. Only then will we be able to translate into the energy area much of the momentum of international technology transfer that has characterized the last twenty-five years.

Let us look first at the role industrial scientists have played in the past, then at some of the factors making for change, and finally let us examine the role industrial scientists should now be beginning to assume in the energy-technology area.

The past

First the past. As we have already hinted, the role of the industrial scientists on the international scene has been twofold: They have participated in the international exchange of scientific knowledge, and they have helped to support the international commercial initiatives of their business colleagues.

James Fisk, the former president of Bell Labs, can speak better than anyone on the subject of science in industry. In 1972 he said of US–USSR scientific contacts[1]:

> "Despite the formal exchange agreement between the countries, contacts in science and technology have been largely what I would call scientific and technical tourism, the exchange of individuals and of delegations to see what the other side is doing. With a few exceptions, there was little follow-up on these visits leading to continued cooperation."

If we are to believe that the aim of internationalism in science is simply to keep open the necessary channels of communication and the free flow of ideas among scientists everywhere, the result that Fisk notes is quite natural, and nothing more is needed. Moreover, industrial scientists are as human as other scientists; they like to participate in international conferences, especially those held at Lake Como or Caracas or some other pleasant spot. But, as Fisk points out, this "scientific tourism," valuable as it might be for international scientific communications, has not generally led to significant joint research programs.

Technical support of trade reveals quite a different story; it has had an even more profound influence upon the industrial scientist than has tourism, especially in the US industries concerned with energy or electric power. Most of the companies in these fields are large, technically sophisticated and truly international, accustomed to selling all over the world and undertaking development projects all over the world.

The list of US energy companies contains many genuine multinationals. Shell, for example, already carries out R&D at Amsterdam, at Cheshire in England, in Canada and in two US locations. Many of the suppliers to the primary energy industries—the geophysical exploration companies, the drilling companies and the pipeline and refinery builders—operate as much or more outside the US as they do inside. This is true for small companies as well as large ones. General Electric recently spun off a small company called Terradex, in the business of uranium exploration with track-etch technology for detecting radon; most of its first year's business turned out to be in Australia.

GE itself is, of course, a very large company operating in many foreign countries, with subsidiaries or affiliated companies in 30 countries and one-sixth of its revenue coming from overseas. All electrical-equipment manufacturers trade and compete in world markets. Just as GE is able to sell US-designed nuclear reactors in Japan, Spain, Italy and many other countries, so we are confronted with French power circuit breakers, Swedish transformers, Japanese and Russian turbines in the US; we must compete on a genuinely world-wide basis in almost all of our energy equipment.

Essentially all of the US industries engaged in the primary energy and electrical equipment fields engage in various types of international trade that facilitate technology transfer. At the same time this international trading ensures that the products derived are produced and used as widely as possible. Most of these companies have foreign wholly or partly owned subsidiaries; GE, for example, has about 85—from Canada to Singapore.

As well as direct subsidiaries, various types of joint ventures exist in the energy industries. For example, at GE we have nine joint ventures with Japanese companies, in fields as diverse as information services and silicone polymers. Two are concerned with energy products (one with nuclear fuel, and the other, recently formed, with high-power vacuum interrupters).

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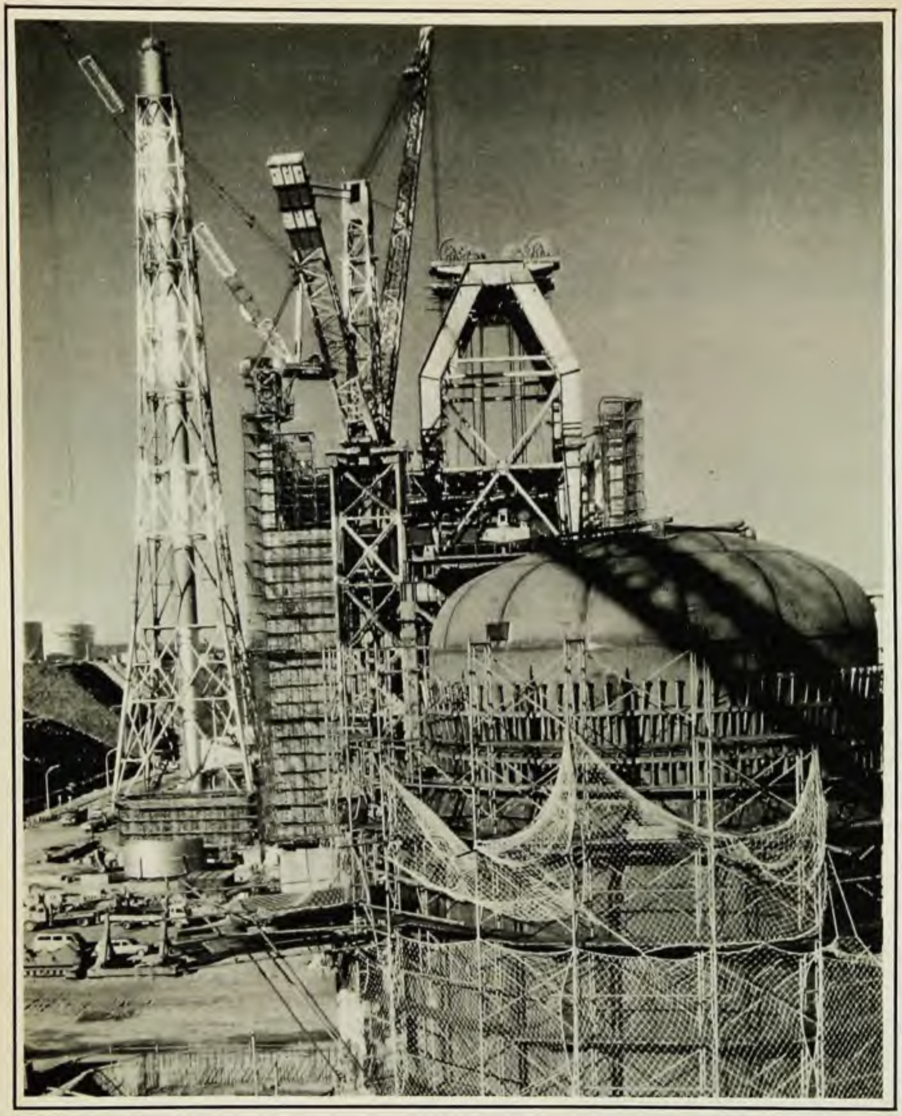


Nuclear reactor at Fukushima, Japan, under construction. One of six reactors on the site, this boiling-water reactor is a GE design in the 1000-MW range. US-designed reactors are sold in Japan, Spain, Italy and many other countries; at the same time the US is confronted with competition on world markets from French, Swedish, Japanese and Russian manufacturers.

The *Esso Marcia,* a supertanker or "very large crude carrier." Oil research, no less than oil production and transportation, has become an important world-wide multinational operation.

A still further type of business arrangement facilitating international technology transfer involves licensing arrangements, generally concluded between companies not organizationally tied in any way. GE has over 370 such agreements with more than 200 companies in 33 countries.

So there already exists in the industries of the world a variety of trade agreements, which have involved significant international exchange of technology. But few of these have come about through the initiative of industrial scientists. Our role as scientists has instead been mainly to support opportunities perceived and created by internationally minded *business* executives. It is they who have led the way, not us.

The present situation

So much for the past. Let us now look at several important features of the present situation that suggest the need for change. As we see it, there are three: first, the size and significance of energy-research programs; second, the similarity of objectives among many nations, and third, the worldwide distribution of technical expertise.

Even a casual reading of the Dixie Lee Ray report of last December[2] or of the more recent Project Independence blueprint[3] will provide a perspective on the first feature, program size and significance. Look at just one item: The breeder reactor program, which is budgeted at \$473 million in this fiscal year and close to \$2 billion for the period 1975–79. This is an example of the magnitude of a development program in the energy field when the development nears commercialization. That is what it takes; many billions of dollars of expense and ten to twenty years of time.

Look at *all* the technologies that the Dixie Lee Ray report and the Project Independence blueprint mention: twenty or thirty major technical areas, some envisaging four or five different types of equipment. Not all the equipment will cost as much to develop as a breeder reactor, although to engineer a reproducible, thousand-megawatt power plant to the cost and reliability standard of the electric utility industry will cost about the same whatever technology you use—fusion reactor, solar power plant, magnetohydrodynamic generator or whatever. The fact is that there just is not enough money in the federal energy R&D budget, or in the entire R&D budget of the nation (including that of industry) to take more than a few of the energy systems that are being considered and develop them through to the point of initial commercialization. Yet it *would* be desirable to carry a number of them quite far along that path in order to make the best choices.

The second important feature of the

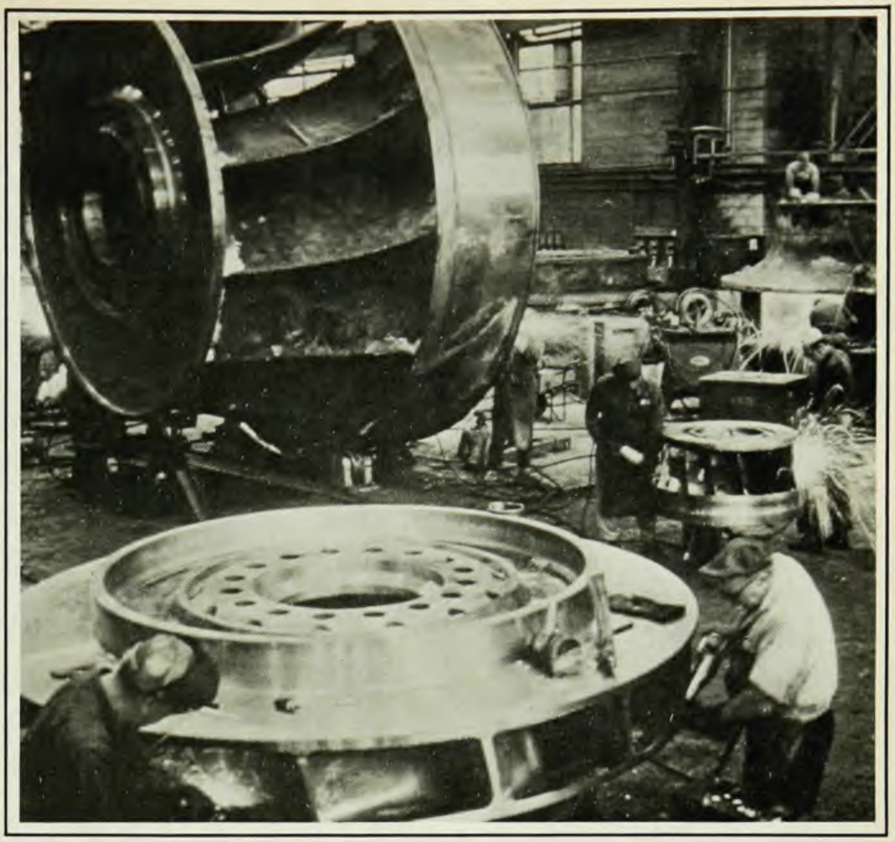
present situation is that many nations, especially the developed ones, have development objectives quite similar to our own. Japan, for example, is just initiating a national energy R&D program, "Project Sunshine," budgeted at over $1 billion through 25 years, of which 75% is related to solar and geothermal power development. Now the US plans to spend at the rate of about $100 million annually on these two areas of technology, and about 90% of the patents issued in the last ten years in these areas have originated in the US. Here we see what appears to be a clear case of common objectives.

The third and final important feature of the world-wide energy situation is the *relative* equalization of expertise in energy technologies throughout the world. In general, an increasing share of US patents are now being granted to residents of foreign countries,[4] up from 18% in 1963 to 32% in 1973. In some energy areas, the percentage is considerably higher—half of all the MHD patents granted by the US during the past decade are foreign, for example. Half of the US patents on boiling-liquid reactors are granted to foreign residents, even though most important of these—the boiling-water reactor—is basically a US design. For gas-cooled reactors the foreign percentage is up to 60%.

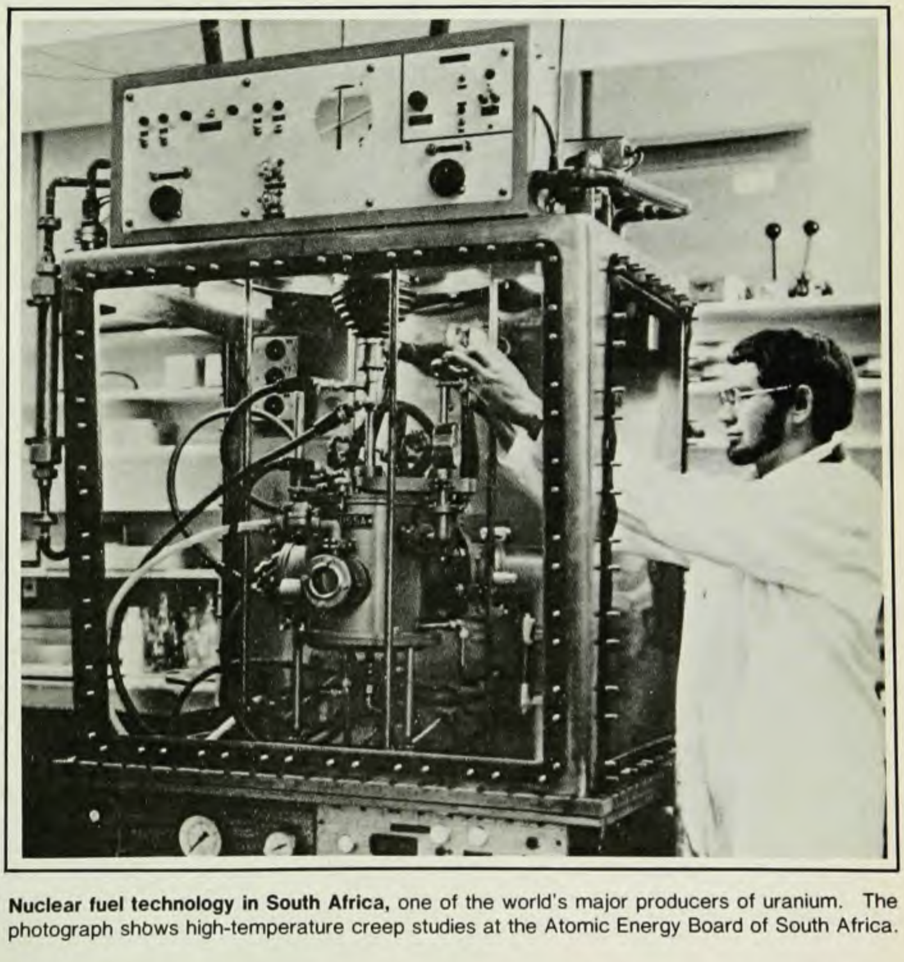
The US does not have the same uniquely leading position in energy technologies as it perhaps had in, for example, solid-state electronics. France, USSR, and the UK are all ahead of the US in developing the liquid-metal fast breeder reactor. The USSR has strong programs in such diverse areas as MHD, fusion, batteries, superconducting machinery, and others. France has leading programs in areas such as fuel cells, batteries, power circuit breakers. Britain has carried development of sodium-sulfur batteries to the point of using them in a prototype service truck, and also has had strong programs in superconducting machinery. Sweden has a strong position in ac and dc electrical-transmission technologies generally. Flywheel storage is being studied in the UK, Germany and Switzerland. Synthetic-fuel programs are strong in Germany and South Africa. In Germany the research establishment of the West German government at Jülich has pioneered pebble-bed gas-cooled reactor development and the associated concepts for transporting heat by reversible chemical reactions.

Goals

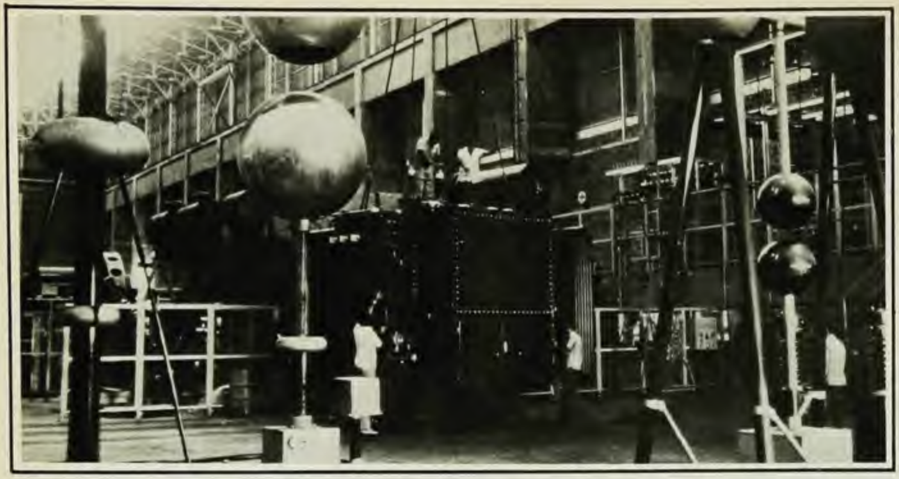
These are just a few examples of the broad, international distribution of energy programs. In such a situation international cooperation in development would appear to be almost a requirement. But the international cooperation should stress programs with a defi-



Hydraulic turbine manufacture in Canada. This relatively small turbine is seen at the plant of Dominion Engineering, a GE subsidiary in Lachine, Quebec. Hydraulic turbines are made in Russia, Japan, Canada and Switzerland, with GE's research being conducted entirely in Canada.



Nuclear fuel technology in South Africa, one of the world's major producers of uranium. The photograph shows high-temperature creep studies at the Atomic Energy Board of South Africa.



Power transformers in Brazil. Made to US designs, these transformers are under test at GE Brazil, Sao Paulo; all electrical-equipment manufacturers trade and compete in world markets.

nite goal of usable outputs—equipment and processes of commercial value. Such programs must go beyond the needs of programs intended solely as instruments of foreign policy and foreign relations. For this reason, we believe that the technical leaders in industry must play a large role in the formulation of programs of this sort. Industry is perhaps best suited, by experience and motivation, to preserve and develop strong competitive advantages while engaging in such activities.

Tourism and trade are not going to be the main elements of the industrial scientist's future role in energy. His role must instead become more that of a leader and entrepreneur. Energy-development projects are long, and they remain within the jurisdiction of scientists and technologists for many years. It takes eight to ten years just to engineer a new generation of major power equipment, such as a new nuclear reactor core or a new water-cooled generator. Fusion-power equipment projects have been managed by scientists for the last 25 years and will likely continue to be managed by scientists for the next 25 years. With international energy cooperation increasingly emphasizing *development* projects rather than *product* manufacture and sale, these cooperative ventures will be increasingly initiated and sustained for many years by scientists and engineers.

A further factor is the accelerated push toward commercialization. Several options in energy are now being considered that would be deferred for a few years if only normal market forces were at work. As a purely business venture—aimed at producing a profitable product line—much research in areas such as solar power, MHD, oil-shale development and the like would have lower priority than is demanded by national interests. It *is* undertaken on behalf of national policy, with the initiation and management provided by scientists and not by businessmen. The rate-determining factor in these projects is the rate of innovation.

You may question why we emphasize the activities of industrial scientists rather than university or government scientists. Of course, one major reason is that in the US most of the scientists are in industry, which undertakes 70% of the nation's R&D. The resulting close link between American science and product development is a unique strength. Industries in the US have the research tradition, the research personnel, and well equipped research facilities.

A role for governments?

So much for US industrial competence. What about the rest of the world? The mixtures of private and government agencies that deal with energy programs in foreign countries are frequently different from the mix in the US. The energy industries of the world are now mostly controlled by their respective governments. All the energy industries in the UK are controlled from London; almost all electric utilities in the world are government-controlled (with the exception of Japan and Germany, where they are heavily government-dominated), and national oil companies exist in Italy, Mexico and most Latin American countries, not to mention the Arab world.

So you might suppose that government-to-government dialogs alone would be adequate for the setting-up of international agreements; but we do not believe this to be the case. The reason is that, in spite of being government-controlled and government-owned, foreign energy industries are still *industries* and not *agencies* in the American sense. The people running the national energy industries are industrialists, even when in the employ of governments; their laboratories are staffed, like ours, by industrial scientists and engineers; their concern, like ours, is developing acceptable products with acceptable prices.

Before most international development programs in energy can be undertaken, we believe there will have to be a clearly visible path showing the way to an eventual product. As a modest prototype of the sort of international development programs that will be initiated, let us refer again to one of the GE–Japanese joint ventures. Because high-power vacuum interrupters are still in the development stage, our Switchgear Division in Philadelphia has recently set up a completely integrated development program with the Japanese joint venture. Programs of this type, initiated and managed by industrial scientists, will increasingly become the rule.

We do not wish to downgrade the role of government-to-government agreements in energy R&D. We simply point out that, at the appropriate time, industry must play a leading role for commercial success to be assured. The role of government should now be to stimulate international arrangements of this type in the energy industries, to help overcome the constraints on them. The federal government must recognize that international development agreements involving such areas as the work of the National Laboratories in new types of electric power transmission technology, for example, will be of little value unless American industry can be involved to make the developments into a commercial success—and the earlier industry is involved the better.

Energy today constitutes a problem for almost every nation, and international cooperation in developing energy technology is a key response to the problem. We believe that industrial scientists, assisted by government action, must now take the lead to ensure the success of these new energy technologies.

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This article is adapted from a paper presented by Schmitt at the 1974 Annual Meeting of American Institute of Physics Corporate Associates, in Washington D.C., last November.

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