A Battelle special report

Attacking our energy-shortage problems

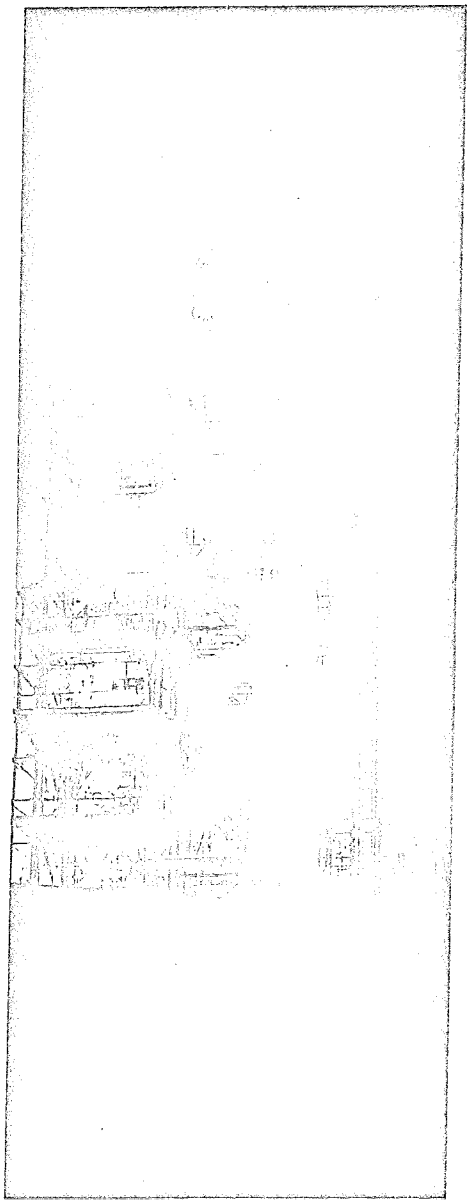
We live today in an energy-conscious world. Fuel shortages and high prices have made us acutely aware of the central role energy plays in our lives. Our concern is intensified by the possible worsening of the energy situation, which keeps gathering upon us all the time—a worsening that could lead to further economic upheaval and personal discomfort. At times, the situation may not seem urgent. Gasoline prices do sometimes dip—temporarily. The market for big cars dims, then brightens. But these are deceptive appearances. What is unmistakably certain is that the energy situation is definitely critical.

Well before the oil embargo of 1973–74, Battelle Memorial Institute recognized that energy consumption was rising worldwide, and that the disparity between energy consumption and supply would eventually grow more pronounced. To cope with the situation, Battelle was one of the early few to urge that the growing energy "gap" between supply and demand be closed by the development of alternative sources of energy.

An increasing concern

Reflecting its increasing awareness and concern about the developing energy problem in the world, the Institute's management established the Battelle Energy Program early in 1973. Substantial Institute funds were committed to the program, which has already stimulated new advances in fossil fuels and solar energy.

The program's basic policies are to perform energy research and development at the four Battelle laboratories that will augment and complement the efforts of industrial and government organizations. Research projects supported by the Battelle program, which is primarily devoted to the advancement of new energy concepts, are selected on the basis of their meeting four major criteria. They must have a high degree of innovativeness; demonstrate a fair expectation of near-term favorable impact on the cost and availability of energy; have a high potential for broad application; and finally, avoid needless duplication of other R&D programs.



This coal-gasification process development unit was designed to produce on an experimental basis about a million cubic feet of gas each 24 hours.

A major goal of the Battelle program is the near-term transfer of what's been done in the laboratories to industry for subsequent use. In this way it can make a significant impact in solving the world's energy problems within the next twenty years.

As a matter of historical interest, Battelle's commitment to energy research and development reaches back to the 1930's when the Institute's early activities included research on coal and related materials. Since then, all aspects of energy technology—including efficient utilization, energy conversion, energy sources, and reduction in objectionable by-products—have been the subjects of Battelle research. The utilization and transportation of natural gas—ranging from residential clothes dryers and incinerators to complex gas pipeline technology—have also been studied for over two decades. Similar research has involved improvement of petroleum use. Extensive fuel cell research has been done for both the Government and industrial groups. In the nuclear power field, Battelle has been among the major research participants since the initiation of the Manhattan Project, and

has become well known for its work on nuclear safety problems, environmental impact problems, and the development of site selection criteria for nuclear power plants.

Today, convinced of the great urgency for better satisfying the world's energy needs, Battelle believes that improved fossil-fueled sources are essential for the nearer term future. That nuclear energy is essential for the longer term future. That supplemental sources such as solar and geothermal energy must be developed. And that better energy conserving efforts are needed immediately.

Battelle also feels that the time span from R&D to public benefit must be shortened. Accordingly, to be even better prepared to play a key role in these vital areas, the Institute has been strengthening and intensifying its participation in the development and operation of complex facilities, pilot plants, and demonstration projects. Also, Battelle has been working on improving the transfer of knowledge on issues of public policy, communication, and acceptance.

No more quick solutions

Looking first at options for very near-term solutions to the energy problem, the effort to find new sources of oil and gas has been increasing in recent years. But it's not as easy as it used to be. The search has led to hostile environments such as the Arctic and the North Sea. Yet despite the oil industry's best efforts, new oil and gas finds have been hard put to keep pace with consumption.

That's why, in terms of time, Battelle sees coal as one of the most immediate fossil fuel sources for additional energy. And, in both internally funded and sponsored research, there is considerable emphasis on increased utilization of coal.

One example of this research thrust is the novel approach to fluidized-bed combustion. In this approach, crushed coal is burned in a bubbling bed of air and limestone that makes combustion cleaner and more efficient. Intended for industrial boiler and utility application, the advanced combustion process can use high-sulfur fuels. Also, it allows higher heat-transfer rates and reductions in equipment size, costs, and air pollution.

Obviously, before coal can be put to use as a fuel, it has to be unearthed. In the case of deep mining especially, this takes considerable effort. To help make the vast underground reserves of coal more available as an energy source, Battelle researchers have studied ways to improve some of the interrelated elements involved in deep mining. Specifically, they were concerned with increasing mine productivity; improving working conditions of miners; and achieving high health, safety, and environmental standards—all in an economically feasible manner.

Gasification of coal to produce pipeline gas is another Battelle energy-research goal. In making gas out of coal, a cumbersome, inconvenient, dirty, solid fuel is transformed into a convenient clean, gaseous fuel—or into synthesis gas. An advanced, experimental process that will handle 25 tons a day of U.S. bituminous coal is now in partial operation at one of Battelle's laboratories. Intended for the production of synthesis gas suitable for further conversion to pipeline quality, synthetic natural gas, the process will experimentally produce a million cubic feet of gas each 24 hours.

Many other coal-related studies are under way at Battelle in attempts to make this resource meet expanding energy needs in environmentally acceptable ways. In some areas, coal's potential usefulness is just beginning to be recognized. New ways to convert coal-derived liquid hydrocarbons to Btu's should be looked into. And much of the electricity that will be generated in pollution-free coal-fired systems are just now being investigated. Old "King Coal", then, is expected to reign again since it will be relied upon heavily to help meet short-term demand.

The need to conserve

Turning to another practical option for meeting short-term energy needs, Battelle is looking at ways to cut down on the consumption of energy, especially in industry. Conserving energy in the industrial sector holds enormous potential as a way of narrowing the developing supply/demand energy gap, of stretching out our energy resources, and of minimizing the adverse environmental impacts of excessive energy usage. In the U.S. alone, the industrial sector accounted for 41.2 percent of the total energy consumption in 1968.

Battelle has developed a computer model that has been used successfully to analyze energy-saving opportunities in the steel, copper, aluminum, glass, paper, synthetic rubber, and plastics industries. Its target can be an entire industry, a single industrial process, or any of the unit operations that are employed within the process. The model is a powerful tool for identifying those operations where significant fuel savings can be made through straightforward process modifications. On the other hand, the model will also show where the potential for energy conservation is limited by the irreversibilities inherent in the basic process employed. This information is valuable in directing the attention of process engineers to those operations which offer the greatest potential for overall fuel savings.

Energy Conservation at Battelle

Like many industrial organizations, Battelle has placed a strong emphasis on energy conservation at its facilities in both the U.S. and in Europe. Although the buildings that house Battelle's laboratory and office space cannot be equated with large, energy-consuming industrial plants, conservation efforts by Battelle have been highly effective.

For example, at Battelle's Columbus Laboratories, during the first half of last year, gas consumption was 41 percent less and electrical consumption 27 percent less than for the same period in 1972.

In the interval, unit costs for gas and electricity almost doubled since 1972 and are likely to continue to increase in the future. However, Battelle-Columbus was able to cut its expenditures for electricity in the first half of 1975 by $110,000 over those for the first half of 1972 and to reduce its gas bill by $40,000 from that in the comparative period.

Significant energy savings were also achieved at Battelle-Northwest by keeping a tight rein on use of gas and electricity during the years 1972–1975, a period marked by substantial increase in space.

These energy savings were accomplished through a comprehensive program at each laboratory which included such elements as cutting back heating and cooling during non-working hours, reducing room temperatures during working hours, modifying lighting levels, weatherproofing windows, and careful monitoring of gas and electricity usage.

Battelle's recommendations for saving energy in the industrial sector are as follows:

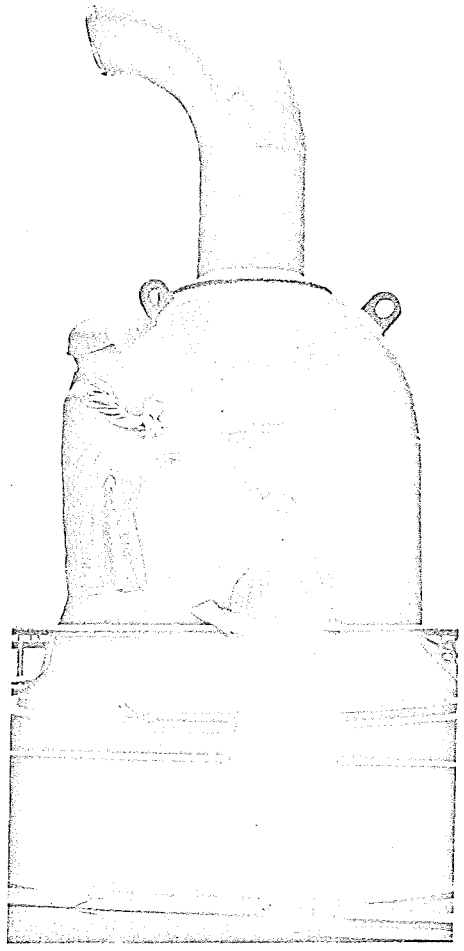
- Adopt improved techniques of waste-heat management, improve efficiency of industrial boilers, and invest in energy-saving equipment
- Encourage the use of energy-saving material in manufacture and construction
- Encourage recycling of selected materials
- Encourage use of durable rather than disposable goods.

Because of the extent of the industrial sector, the energy savings achievable by the adoption of conservation measures are quite impressive. One study estimates possible savings of 26 quadrillion Btu's, or 32 percent of the projected year 2000 industrial energy consumption.

There are other major targets for energy conservation, notably in the transportation and space-conditioning (heating and cooling) sectors of the economy. What needs to be done to conserve energy in these sectors is fairly well understood. The problem is primarily one of implementation. On the other hand, Battelle continues to be interested in any novel concepts or schemes that promise to make energy conversion processes more efficient and thus indirectly contribute to saving energy.

Let there be nuclear

While Battelle pursues a variety of near-term solutions to the energy problem, the Institute also continues a substantial effort in the field of nuclear energy where hopeful prospects are in the longer term. Members of its staff in Europe and the U.S. are engaged in a wide range of nuclear studies involving fuels and reactor emergency systems. One such study deals with reactions of Zircaloy fuel cladding during simulated loss-of-coolant accidents. Should this cladding, used in nuclear-reactor fuel rods, be found more resistant to high temperature and pressure changes than now estimated, many power reactors may be able to raise their operating temperatures, leading to increases in power output.



Large-scale experiments are carried out in support of safety analysis of nuclear power-plant emergency cooling systems.

As part of its efforts in the area of nuclear-power-plant safety, Battelle uses a large experimental facility to simulate coolant losses in boiling-water and pressurized-water reactors. In an emergency, coolant water and steam must be contained within the reactor to prevent radioactive fission products from being released into the atmosphere. The facility is used to verify theoretical computer models developed for the safe operation of nuclear reactors.

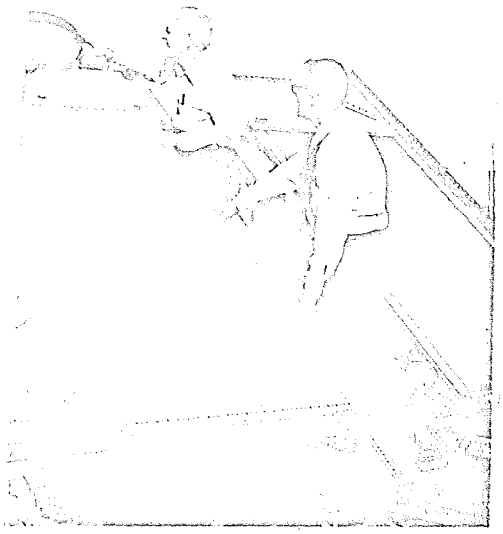
Another important facet of nuclear research concerned with safety is the acoustic emission inspection method that Battelle is developing for nuclear-reactor systems. This method can be used for pre-service inspection during the first hydraulic test, for recurring inspection, and for continuous surveillance. Based on the phenomenon that materials emit measurable sound when a flaw suddenly occurs, acoustic emission is a sensitive method of detecting leaks, loose particles, and various types of defects such as fatigue cracks, weld cracks, or slag inclusions. By fixing acoustic pulse measuring devices to large nuclear pressure vessels, it is possible to locate defects with the aid of measured time delays by methods known from seismology.

Also indicative of Battelle's involvement in nuclear safety is its contribution to the report titled "An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants", released in 1975 by the Nuclear Regulatory Commission. The mammoth report represents an intensive study for which Battelle conducted two key tasks in risk-assessment procedure.

What about solar energy?

The difficult tasks related to further development of nuclear power are being tackled. And so are the problems attending the familiar fossil fuels. Next, the question arises as to what can be expected of the so-called unconventional sources of energy. In the field of supplemental sources of energy, Battelle is investigating two options that are familiar as the sun and steam. What makes solar energy especially attractive as a potential solution to the energy shortage is its continuity and virtual inexhaustibility. Indeed, the amount of available "free" energy from the sun is so vast that it exceeds man's current production on earth via other sources by a factor of roughly 25,000. What's preventing us from taking advantage of all this clean energy? Basically, it's a matter of economics. For technological advances in solar energy must be proven to be economically competitive in terms of price and convenience with traditional fuels before they can receive widespread application.

Active in solar energy research since 1952, Battelle has been involved in such specific studies as solar heating and cooling of buildings, solar industrial process heat, solar powered engines, solar cells, thermal energy storage, hydrogen production from solar energy, and the bioconversion of crops to fuels. Currently, in a joint venture with a private organization, 50- and 250-horsepower solar-powered irrigation pumps are being developed, as well as a new concept of a solar engine. This program also calls for development efforts on a process for making an inex-



Collectors of the sun's radiation are being developed for application in a solar-powered irrigation pump.

pensive material for solar cells, a photochemical method to collect and store the sun's energy for heating and cooling homes and businesses, and a technique to make photovoltaic cells that convert sunlight into electricity.

The hot earth

In addition to solar energy, geothermal power is another valuable supplemental energy source that Battelle is exploring. Geothermal energy, or the natural heat of the earth as manifested by volcanoes and geysers, has some outstanding advantages for those selected areas fortunate enough to possess this energy. A geothermal field can last over 100 years if properly managed and developed. Too, there is no air pollution.

While hot springs and geysers have been known since the beginning of man, serious efforts to harness the energy in the hot water and steam held in the earth's crust have only occurred in this century. In 1904, the Larderello fields in west-central Italy became the first geothermal field to provide energy for electric power. Since then, geothermal energy has gradually built up a record of usefulness. Today, geothermal electric power stations are operating in Iceland, New Zealand, Japan, the U.S.S.R., and the U.S.

Last year, Battelle carried out an evaluation of a slim-hole-drilling concept that, if successful, would offer the potential for significantly reducing the cost of geothermal exploration. Two wells, each 4 inches in diameter and about 5,000 feet deep, will be drilled to evaluate the geothermal potential at Coso Hot Springs, California, and to determine the effectiveness of the process for locating underground hot rock and water deposits. Predicted cost of the slim-hole operation is about one-quarter that of past geothermal drilling.

Several U.S. government agencies are considering an expansion of the program to investigate methods for improving the geothermal program in California. The expansion would include identifying needed administrative and legal reforms, and economic and technology changes which could contribute to the success in geothermal use. The Energy Research and Development Administration has selected Battelle's Human Affairs Research Centers (HARC) in Seattle to study the legal, institutional and political problems confronting geothermal development in California. In the initial phase of the study, HARC will identify existing Federal, state, and local statutes applying to exploration and use of geothermal resources in California.

Battelle also studied a region of abnormally high geothermal heat flow near Marysville, Montana. Purpose of the research was to determine the nature and size of the resource and its potential energy value, and to evaluate methods for extracting the energy.

Color the world's energy future dim

With all the options for both near- and long-term energy research and development opportunities, the world's energy future might seem bright. But industrial nations continue to use more fuel than they can produce, and the gap continues to widen. Too many people are complacent. Too many believe in the myth of instant technology. They believe we can solve the energy shortage simply through an effort equivalent to what was expended on the Apollo Project. Giving the lie to the myth of instant technology, however, are such hard truths as these: The elapsed time between first start on the moon project and touchdown was 12 years! The total cost of the effort took $40 billion. Furthermore, the whole nation was almost uniformly behind this effort. Delay was almost unpatriotic. Few protestors ever marched at Cape Kennedy. And none on the moon.

But solving the world's energy problems poses far more difficult and complex problems than the project that took man to the moon. For potentially viable energy solutions bring with them problems related to environmental quality, materials supply, health and safety of the public, and a concensus on developmental program priorities. And, of course, there's always the problem of finances—finding and supplying the vast amount of funding required for R&D projects, for converting existing facilities to other energy sources, and for building new plants and facilities.

Perhaps the most perplexing problem of all is that of convincing a skeptical public that there is indeed a real—and serious—energy shortage.

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