WATER FOR ENERGY DEVELOPMENT

WATER

for

ENERGY DEVELOPMENT

Edited
By

Gabor M. Karadi
Professor of Civil
Engineering
University of Wisconsin
Milwaukee, Wisconsin

Raymond J. Krizek
Professor of Civil
Engineering
Northwestern University
Evanston, Illinois

1978

This book contains a collection of papers and discussions that were presented at a Conference on Water for Energy Development which was held at the Asilomar Conference Grounds in Pacific Grove, California, in December of 1976 under the sponsorship of the Engineering Foundation and the U.S. Water Resources Council.

Foreword

It has become painfully clear that the "energy crisis," which only a few years ago was labeled nonsense by various self-appointed experts, is indeed very real and undoubtedly here to stay. In March of 1973, R.G. Folsom emphasized in his address to the Second Energy Forum that a "Pearl Harbor in Energy" was needed to induce people to recognize the seriousness of the situation, which might very well create an economic disturbance sufficient to precipitate a world-wide depression.

Although a variety of factors have contributed to the energy crisis, the most significant single factor responsible for the continuing deterioration of our energy situation was the availability of a relatively inexpensive and almost "unlimited" supply of foreign crude oil. In 1960 the United States imported 18% of its petroleum requirements; in 1970 this figure rose to 23% and in 1973 it was 35%. This trend was paralleled by a steady increase in the price of oil after the OPEC cartel was created in 1960. By 1973 the United States and Japan were each importing six million barrels of oil daily, and the oil import of Western Europe had exceeded fifteen million barrels per day. Thus, the economies of the entire Western World had become dependent on OPEC oil, and the stage was set for collective action to raise the price of oil dramatically. By the end of 1974 it reached $10 per barrel and continued to increase to more than $12 per barrel.

As a consequence of this increase in the price of oil, serious economic disruption occurred in the Western World and led to a "Pearl Harbor in Energy." The gravity of the situation forced the industrialized nations to begin developing comprehensive energy policies in order to avoid further economic disruption and even more serious recession. Since the United States plays a key role in maintaining world-wide economic stability, the highest priority was given to evolving a plan to escape from the energy trap brought about by increasing reliance on foreign oil. The most important component of a comprehensive energy policy is to find alternate sources of energy and to establish effective energy conservation measures. It is also significant to identify the most efficient and economical techniques to develop alternate energy resources, and efforts to achieve these objectives are currently being undertaken at all levels. By adapting an appropriate national energy policy the United States could become self-sufficient in energy production in less than two decades; this would represent a significant step toward securing the health of the economies of the entire western industrialized world.

The evolving new energy policy must address a vast collection of complex problems, with implications going far beyond the determination of available alternate resources and the formulation of new technologies for development and conservation. At this point the impact of a national energy policy on the physical and social environment is difficult to predict, but it is not inconceivable that a complete reassessment of our lifestyle will be needed to effectively cope with these problems.

Energy development must be accomplished without any overall harmful effects on environmental quality. The new national energy policy must provide sufficient safeguards to protect our physical environment, including the nation's water. Consequently, it cannot be accomplished without pursuing a new and effective water management program, because water is needed—and frequently in very large quantities—for all feasible energy alternatives. Hence, energy development is inseparable from the effective and scientific management of the nation's available water resources.

With this perspective in mind a conference on "Water for Energy Development" was organized to address the close interrelationship between energy and water resources development. This conference assessed in detail the impact of future developments of energy resources on the nation's water resources and the associated technological, social, and economic implications. Analyzed and discussed at length were the roles and responsibilities of various government agencies, private enterprises, and public utilities involved in the development and implementation of programs to allocate the presently available water resources in the most efficient and economic manner. Although the conference addressed both conventional and unconventional sources of energy and water resource development, emphasis was placed on coal, oil shale, synthetic fuel, and geothermal resources.

This publication includes papers that were presented at this meeting and the summary of a panel disucssion that was organized under the auspices of the United States Water Resources Council. This conference was sponsored jointly by the Engineering Foundation and the U.S. Water Resources Council; both of these agencies, together with a grant received from the Office of Water Research and Technology, provided the financial assistance to organize the meeting and to support the participation of experts with a wide variety of interest and concerns. In addition, partial financial support by the U.S. Water Resources Council to publish the proceedings of the Conference is gratefully acknowledged.

TABLE OF CONTENTS

Page

Foreword iii

Energy's Environmental Issues
by James L. Liverman 1

Keynote Address—Asilomar Conference
by Gilbert G. Stamm 12

Energy Crisis?
by Ellis L. Armstrong 18

Role of Coal Vis-A-Vis Our Energy Problem and Water Requirements for SYN Fuel Processes
by Harold E. Podall 28

Water Resources Issues for a Growing Coal Industry
by G.E. Stout and E.D. Brill 43

Surface-Water Quality in the Yampa River Basin, Colorado and Wyoming—An Area of Accelerated Coal Development
by Dennis A. Wentz and Timothy Doak Steele 56

Coal, Water and the Environment in a Hierarchical-Multiobjective Framework
by Yacov Y. Haimes 75

Social, Political, and Institutional Aspects of Coal Utilization
by Sue Johnson and Alan Randall 97

Legal Aspects of Water for Coal Conversion
by William R. Walker and William E. Cox 106

Hydrological Aspects of Deep Strip Mining in the Lower Bank Region of the Rhine River
by Werner Lindner and Klaus Lindner 115

Shale Oil Technology: Status of the Industry
by David Eaton 132

Los Alamos Hot Dry Rock Geothermal Energy Experiment
by Roland A. Pettitt 151

Water Budget Perspectives for Energy Development
by Frederic March 163

Water for Energy Development: Economics of Environmental Impact
by Lester P. Silverman 187

Hydrometeorological Aspects of Electric Power Production
by Steven R. Hanna 200

Aquatic Ecosystem Considerations in Water-Energy Development
by Edwin E. Herricks and Michael J. Sale 215

A Series of Related Papers Based Upon the Nevada State Water Planning Program . . . 229

A Series of Choices Between Water for Electric Energy or for People in the Las Vegas Valley, Nevada
by Victor R. Hill . . . 230

Electric Energy—Water Future in Nevada
by Victor R. Hill . . . 246

Economic Study of Population-Water-Energy Effects in Nevada
by Everard M. Lofting . . . 262

Overview of a Siting-Rating System Under Development for Electric Energy Generating Facilities in Nevada
by Robert E. Walstrom . . . 272

Mathematical Modeling of a Siting-Rating System in Nevada
by Fred H. Dugger . . . 303

A New Projection Methodology for Use in Population-Water-Energy Planning and the Implications for Nevada, California, the West and the Nation
by Victor R. Hill . . . 310

A Conceptual Brief on Market, Technical and Thermodynamic Limitations for Energy Conservation
by Victor R. Hill . . . 321

Emerging Potential for Use of Geothermal Resources
by Robert E. Walstrom . . . 326

Panel Discussions

The Federal Geothermal Leasing Program
by Reid T. Stone . . . 344

Water and Energy in the Missouri River Basin
by John W. Neuberger . . . 348

Water and Energy in California—The Role of the Public
by Arliss L. Unger . . . 353

Water—The Key to Shale Oil Processing
by Richard G. Griskey . . . 357

State Water and Energy
by Ray W. Rigby . . . 359

Water for Energy Development Conference
by Kenneth O. Kauffman . . . 365

Plenary Panel . . . 374

Energy's Environmental Issues

By

James L. Liverman*

At the State of Arizona's 29th Town Hall meeting last October, the one-hundred twenty-one (121) participants concluded that Arizona's economic future looked bright—*if* adequate supplies of water and energy remained available. They further concluded that: "Arizona needs to strike a balance between economic demands, environmental concerns, governmental activities, and resource limitations."

I couldn't resist opening with this because it sounds so much like what I've been preaching around the country since ERDA's creation two years ago. And it's comforting to know that there are others who independently have reached the same conclusions which gives us government bureaucrats that needed credibility boost.

I was pleased to be asked to address this conference on the broad implications of energy and the environment because I believe that if we are going to find solutions to any of our problems in these areas, it is going to be by addressing them together in the big picture so that the necessary trade-offs can be made. There can be no such thing as an environmental solution completely out of context from the social, economic, resource and energy demand realities. That we are all here this week is testimony to that realization.

We in the government and you in science and industry who are trying to solve energy-related environmental problems must listen very hard to what the states and the public are saying. And, if I'm listening right, the message that is coming through again and again is that there must be a balance—a balance between energy resource development and its set of implications and a clean environment and its implications. To have one without the other is an empty achievement. And there is a second half to this message—economic viability is equally important. I do not believe, and I think the nuclear initiatives bear this out, that the American people are willing to sacrifice all they have worked for to have a perfect but economically impractical energy source. This is not to say that the risks aren't real. Instead, it implies a reasoned approach which says, "Let's not rule out the alternatives until the *facts* are in."

This is the philosophy supporting all of ERDA's research and development efforts. Our programs are designed to develop multiple energy technology options which are environmentally acceptable and economically sound. Thus, the Nation, the individual states, and each locale can have a role in choosing the best mix of technology to satisfy its own unique energy and environmental requirements. We all have been made painfully aware, while waiting in the gas lines, by the heavy hit in the pocketbook, by impacts on human health, and by environmental costs, of the potential repercussions of not taking this approach and doing so at the earliest possible moment.

What this means in terms of ERDA's programs is that there is an Assistant Administrator for Environment and Safety whose responsibilities and authori-

---

*Assistant Administrator for environment and safety. United States Energy Research and Development Administration.

ty equal that of the technology AA's. My biggest responsibility is to ensure from the beginning of the energy development process to the end—from extraction to waste management—that environmental concerns are identified, studied, and resolved at each step in the technology research and development process. This responsibility extends to the full mix of ERDA research and development technologies. Failure because of inability to resolve environmental concerns constitutes a death knell for that technology just as surely as would failure of the technology process itself. As importantly, past experience has shown that stoppage of a technology by environmental issues late in development can be extremely costly.

Although my responsibility and that of ERDA is to insure that energy/environmental concerns are dealt with in a timely manner, this does not mean that ERDA does or dictates all the work. There are at least 17 other Federal agencies whose responsibilities also mandate that they insure health, environmental integrity, and public acceptability of their particular technology or activity. The fact that all of the various impacts, whatever their origin, finally come to rest in the human body, in the same human environment and in the same societal structure demands more of us who work in this area. Turf fights about whose responsibility it is really have no place. I maintain that those of us who are charged with protecting the health of our Nation's people, with insuring the integrity of our environment, and with keeping to a minimum the impact of our technologies and activities on society have a very special responsibility to society. This responsibility demands that we rise above our agency duties and the parochial "turf" issue to spend our time fully coordinating our efforts, our programs and our information. We must insure that our individual and collective activities *do not destroy* those things for which we are responsible but in fact, preserve, protect and enhance the quality of those things which we share in common—our health, our environment, and the integrity of our quality of life.

If one looks at the energy resources available and matches abundance with technological readiness, then one comes out on energy research and development priorities much as the ERDA National Plan does. Near term emphasis must be on coal, conservation, and the light water reactor with mid-term help from synthetic fuels, geothermal, solar heating and cooling, and the nuclear breeder. That leaves the more exotic technologies for the far future such as solar photovoltaic electricity and fusion. But our selection alone based on the excitement of technical challenge is not adequate. As we have gone around the country during the past several months discussing the ERDA plan, the public has told us, "Get on with giving us more options for energy in the short term by developing means to conserve energy and by development of new sources." Last Wednesday in Boston we discussed the ERDA plan. There, where 90% of the oil is imported, we were told in no uncertain terms—go, go, go and help us. At the same time we were also told that these options must be usable without degrading either our environment or our way of life. Still another group insisted that we must stick to the long-term solutions. Someone else will solve the short-term needs. There seemed little room for an effective cost/benefit discussion. But there *must* be some room for compromise. Whatever you may have been told, whatever you may believe, none of our energy comes totally free of impact. Even that from the sun has its costs, reflected in parched land and in skin cancer. So the issue with energy then becomes one of choices between the various possible costs and the perceived or demonstrable benefits. I say "perceived" because many of our public acceptability problems have to do, not with actual facts, but with emotional responses to problems which, over time, are perceived by some to be truly established fact. Thus, we must be prepared to inform and educate to the point where fact and perception are identical and to march ahead in the face of criticism and adversity to provide the safe, clean energy supply the Nation demands.

Let me walk you hurriedly through some of the key environmental issues surrounding ERDA's technology development programs.

Figure 1. CONSERVATION

- ELECTRICAL ENERGY SYSTEMS (make more efficient)
- ENERGY STORAGE SYSTEMS (reduce peak load generation)
- INDUSTRY (reduce energy needs)
- BUILDINGS (reduce energy needs)
- WASTE SYSTEMS AND UTILIZATION
- TRANSPORTATION
- ENERGY CONVERSION

Figure 1 outlines the multiple conservation technology areas. In general, the first four areas will have the net effect of reducing the energy requirements and thus, should improve the status of the environment and reduce impacts. The area of waste utilization can come out positively, provided we guard closely to insure that adequate control technology is built in to remove pollutants. Thus, not only can we get rid of our waste by also converting it to heat, but we can recycle several valuable materials for reuse.

In the transportation area, we are pushing aggressively to develop engines that will get more miles per gallon but with pollutant streams which are greatly reduced. At the same time, we will continue to pursue an aggressive program to insure no surprises from our control efforts as we had with the catalytic converter on exhausts in recent memory.

I doubt that I need tell you much about the mostly perceived but partially real worst environmental and societal issues regarding nuclear energy—whose public acceptability questions make this the most emotionally charged energy development program we are pursuing in ERDA. The problem areas outlined in Figure 2 are those of greatest concern.

Figure 2. NUCLEAR KEY ISSUES

- WASTE MANAGEMENT
  - TERMINAL DISPOSAL
  - SOCIOECONOMIC IMPLICATIONS
- SAFEGUARDS
  - NON-PROLIFERATION
  - TRANSPORTATION AND CONTROL (strategic materials)
  - LMFBR (plutonium inventory)
- HEALTH AND SAFETY
- EXPOSURE FROM NUCLEAR FUEL CYCLE
    - REACTOR ACCIDENTS
    - TRANSPORTATION ACCIDENTS
    - GENETIC AND SOMATIC EFFECTS
  - THERMAL EFFECTS

In waste management the questions concern demonstration of long-term isolation from the biosphere with the question of need for long-term surveillance and for who will pay for it.

The area of safeguards, both domestic and international, relates to the non-proliferation of countries capable of producing nuclear weapons materials. There is also a major concern about the ability to prevent theft or diversion of sufficient quantities of special nuclear materials to build clandestine weapons.

An additional concern, but one not often voiced, is the possibility of diversion of enough common radioactive waste materials by terrorists who could disrupt activities by threatening the use of radioactive weapons built with common explosives.

Finally, but of much lesser concern, is the question of biological toxicity of plutonium and related heavy metals.

When considering these issues, I ask you to remember one thing—that however unpopular or undesirable a given energy source is presumed to be by some, we in ERDA are mandated to look at all those options likely to yield significant amounts of energy in a safe, clean manner. Facts must be the basis of our decisions and we intend to seek them. Only when the facts tell us there are unquestionable and unsurmountable hazards will we abandon a source because of environmental concerns alone.

Another and a major one of our big three or four energy options is the fossil option, particularly coal. Coal is predicted to become an increasingly important part of the domestic energy mix. In 1976 we expect to use 675 million tons of coal. By 1985 that tonnage will increase to 1 billion tons and by 2000 to 1.8 billion tons. Estimates for the use of oil from oil shale are for 300,000/ BPDE (barrels per day oil equivalent) by 1985, and as much as 5 million BPDE by 2000. Figure 3 shows in outline the coal fuel cycle, and Figure 4 summarizes some of the key environmental issues.

Figure 3. COAL FUEL CYCLE

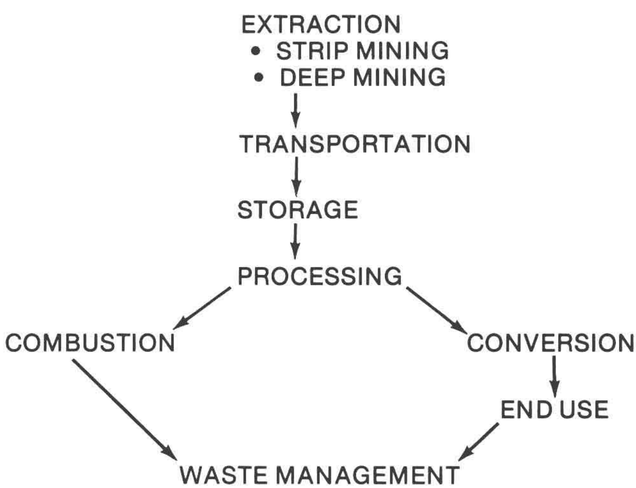

Figure 4. COAL RELATED IMPACTS

FACILITY SITING—ASSESSMENTS

- LAND/WATER AVAILABILITY
- COMPETING LAND/WATER USAGE
- COAL AVAILABILITY—PROXIMITY AND TRANSPORT
- COAL PLANT EFFLUENT EFFECTS ON PEOPLE/ECOLOGY/AGRICULTURE
- WASTE WATER, LIQUID AND SOLID WASTE DISPOSAL
- POSSIBLE DISRUPTION OF HISTORICAL/ARCHEOLOGICAL TREASURES AND OF FLORA/FAUNA ENDANGERED SPECIES

SOCIOECONOMIC (Ramifications?)

- BOOMTOWNS AND BURDENS ON EXISTING INSTITUTIONS
- SOCIAL DISRUPTIONS (Crime)
- QUALITY OF LIFE CHANGES

Although relatively easy to extract through strip mining, coal strip mining has resulted in unacceptable, however small, environmental costs in land disruption, reclamation and water quality degradation. We are also faced now with large occupational health costs from the inhalation of coal dusts and fine particulates. Moving through the fuel cycle, coal is bulky, difficult to transport and store. Furthermore, coal combustion produced a number of emissions which are known to be toxic and subject to governmental regulation. As a result, expensive control technology must be a part of a coal combustion operation which not only drives up costs but also poses another set of waste control problems related to disposal of the resultant sludge.

Despite these problems, coal is an attractive and significant energy source if we can develop the new technologies so as to eliminate or alleviate the various environmental and socioeconomic problems.

ERDA is vigorously exploring a wide number of options. In the coal combustion area, for example, a fluidized bed combustion process is being developed which permits the removal of more than 90% of the potential SO_2 emissions. It seems likely to create fewer NO_x emisions, leaves the ash in a dry state, and seems to produce a more manageable waste. All of these advantages seem to place this combustion technology well below the EPA standards for new coal installations.

At the same time, environmental research is in progress to characterize and evaluate more completely the hazards associated with acid sulfate mists, other types of sulfate aerosols, and mixed combustion products. We also have research programs which address water quality, problems from the leaching of acid mine wastes, and the role of coal dust and exhaust fume from transportation in occupational and population exposures.

What of the use of oil shale? Figure 5 shows the shale fuel cycle. It is difficult for the man in the street to conclude one way or the other about oil shale as a viable energy source because of our on-again, off-again policy on leasing, on development and on loan guarantees. Nevertheless, this is an enormous resource which I believe will one day be used and we are investigating and evaluating the environmental and related socioeconomic and health questions now. A list of some key issues are indicated in Figure 6.

Figure 5. OIL SHALE

OIL SHALE— IN SITU RETORTING / SURFACE RETORTING

EXPLORATION
↓
EXTRACTION
↓
PROCESSING → WASTE MANAGEMENT
↓
REFINING → WASTE MANAGEMENT
↓
(PRODUCT)

TRANSPORTATION
↓
END USE

Figure 6. OIL SHALE KEY PROBLEMS

- SURFACE DISRUPTION / RECLAMATION DIFFICULTY
  - EXTRACTION (surface / deep mining)
  - WASTE MANAGEMENT (toxic effluents control) (spent shale disposal quantity)
  - REVEGATATION
- AIR QUALITY DEGREDATION
  - EXTRACTION → PARTICULATES / EMISSIONS
  - PROCESSING → PARTICULATES / EMISSIONS
  - REFINING → PARTICULATES / EMISSIONS
  - SOCIOECONOMIC (growth)
- DECREASED WATER QUALITY / QUANTITY
  - EXTRACTION (leaching, aquifer disturbance)
  - PROCESSING (waste disposal)
  - WASTE MANAGEMENT (water conflicts, reclamation runoff)
- SOCIOECONOMIC IMPACTS
  - BOOMTOWNS
  - WATER USE CONFLICTS
  - INSTITUTIONAL LIMITATIONS
- HEALTH AND SAFETY EFFECTS
  - ALL STAGES (mine safety, occupational exposure to toxic compounds, particulates, gaseous emissions

What are the environmental implications of this increased usage of fossil fuels? First of all, it is clear that most of the oil shale and much of the easily mined coal is located in the western part of the United States. Even if the fossil resources or their synthetic by-products are shipped elsewhere, the west with its very fragile ecosystems is facing a whole new set of environmental realities and decisions across the board, from ecology to social and institutional effects. Extraction processes and transportation will affect air quality, water quality and use, land use, economic, social, and institutional growth. If one adds processing, conversion, or end use to the fuel production cycles, then environmental effects will be intensified in the *degree* to which these sources are implemented.

At the same time, we must also consider the national and global implications of increased fossil energy development. From ongoing studies of power plant emissions and air mass movements in the Northeast, we have determined that emissions from power plants as far west as St. Louis, Missouri, may be contributing as much to the acid rain problem in New England as the pollutants released within that region. This problem, first discovered in Northern Europe, is therefore not just a United States problem, but a worldwide problem as well.

Another scientific concern of global proportions is about the climatic effects of increased CO_2 levels from fossil fuel combustion. As a result, ERDA has begun a serious program to look into this question to lay to rest the fear or bring to light any impact so that it can be dealt with.

Let us turn for a moment to the presumed "Mr. Clean" of the energy sources—solar.

Figure 7 shows the principal areas of ERDA's solar program and Figure 8 indicates some of the key issues not yet adequately evaluated. The major questions relate to land productivity and use, possible alterations of climatic patterns, and the questions concerned with use of liquid organics as heat transfer fluids—fluids which could be carcinogenic, mutagenic, or major fire or explosive hazards. The only point I wish to make again is that these issues must be thoroughly evaluated as we move forward.

Figure 7. SOLAR

- THERMAL
  - HEATING AND COOLING
  - AGRICULTURAL AND INDUSTRIAL PROCESS HEAT
- ELECTRIC
  - SOLAR THERMAL
  - PHOTOVOLTAIC
  - WIND
  - OCEAN THERMAL
- BIOMASS
  - TERRESTRIAL AND MARINE
  - AGRICULTURAL AND FORESTRY RESIDUE

Figure 8. SOLAR KEY PROBLEMS

- CLIMATIC/ECOLOGICAL ALTERATIONS
  - LARGE LAND USE AREA
  - ALTERATIONS IN HEAT/WATER BALANCE
    MICROCLIMATE ⟶ GLOBAL CLIMATE
  - VEGETATION/BIOLOGICAL PRODUCTIVITY REDUCTIONS
- TOXIC MATERIALS RELEASE;RESIDUALS
  - OCCUPATIONAL/POPULATION SAFETY
  - SYSTEMS LEAKS, ACCIDENTS, FIRES
  - HUGE SUPPORT INDUSTRY (photovoltaic conversion)
- IMPACTS OF BIOMASS FROM FUELS
  - HEALTH AND ECOLOGICAL EFFECTS (bioconversion)
    - DISEASE TRANSMISSION
    - INHALATION/DUST, FUNGI, SPORES
- SOCIOECONOMIC
  - ECONOMIC DISLOCATIONS
  - POPULATION INCREASE
  - LAND USE CONFLICTS

Finally we come to geothermal energy—a particularly promising source for some parts of the country. ERDA's programs are shown in Figure 9.

Figure 9.

GEOTHERMAL
- **STEAM**
- **HOT WATER**
- **GEOPRESSURE**
- **HOT DRY ROCK**
- **MAGMA**

EXPLORATION
↓
EXTRACTION ↘
↓ WASTE MANAGEMENT
CONVERSION ↗

A Battelle study indicates that between 8-20% of the west's total electricity could be generated from geothermal resources by 1990, which adds up to a potential savings of several billion dollars in power plant capital costs, a reduction in the need for several tons of uranium, and several million b/p/d of oil. This does not include savings that could come from other applied uses of the geothermal heat, such as space heating or low quality steam for industry. But there are possible problems which must be addressed.

For instance, in the geothermal area, projected investment costs for a 100 megawatt plant exceed 100 million dollars, while the social/institutional costs resulting from this development may be as high as 500 million dollars.

Figure 10 shows some of the issues that must yet be resolved.

Figure 10. GEOTHERMAL KEY ISSUES

- SUBSIDENCE, SEISMICITY
  - EXTRACTION (origin of problem)
  - WASTE MANAGEMENT (reinjection) (solution)
- WELL BLOW-OUTS
  - ALL STAGES (drilling, seismicity)
- SOCIOECONOMIC
  - BOOMTOWNS (institutional growth)
  - WATER USE CONFLICTS
- COST RISK (dry hole)
- RELEASE OF GASES AND TRACE ELEMENTS (H_2S, AMMONIA, CO_2, methane)
  - EXPLORATION (drilling)
  - EXTRACTION (drilling)
  - CONVERSION (cooling pond/tower drift)
- WATER USE, WASTE WATER DISPOSAL AND EFFECTS ON WATER QUALITY
  - CONVERSION—WASTE WATER MANAGEMENT/ WATER USE CONFLICTS/ WATER CONTAMINATION
- HEALTH EFFECTS
  - OCCUPATIONAL AND POPULATION EXPOSURE TO WATER/ AIR CONTAMINANTS
- ECOSYSTEM EFFECTS
  - NOISE/BEHAVIORAL CHANGES
  - H_2S LEVELS DAMAGE

One of the biggest barriers to geothermal's implementation are the exploration and extraction risks. Beside the potential problem of drilling a "dry hole," the impacts and costs of seismic triggering or irreparable aquifer damage are real enough to discourage industrial investment. ERDA is researching in both of these areas to determine difficulties and preventative methods.

Further, in the superheated water or steam are dissolved solids, gaseous pollutants such as H_2S, H, methane, ammonia, and highly corrosive saline brines which could be damaging to human health and the environment. Technologies are being developed to deal with these problems in the engineering and environmental sense.

The environmentally related waste management questions are much more difficult to deal with, particularly in the waste water disposal area. Control technology to dispose of brines and other liquid wastes will likely continue to elude development while there are still questions surrounding leasing, resource ownership, water rights, mineral rights, and taxes.

The question that we in ERDA are faced with is how to combine our talents to deal with these kinds of problems—just as real to technological acceptability and commercialization. We feel that we have come up with a successful approach which we call environmental development planning. What this means is that from a technology's beginning to end, and at each decision point in between, we try to identify appropriate environmental concerns will be taken into account and given equal consideration in the development of that energy technology.

At the present time, ERDA is actively and successfully implementing this approach on a hydrogeothermal site in the Imperial Valley, California. We have joined with San Diego Gas and Electric Company to develop the known geothermal potential and to solve the engineering and environmental problems connected with the use of highly saline hot underground brines for the generation of electric power. Additionally, we have incorporated into the process for advice seven federal agencies, ten state and local agencies, several environmental groups and private citizens.

As you may know, this area is an immense agricultural factory whose productivity depends on the availability and careful management of irrigation water from the Colorado River. Spent irrigation water drains north into the Salton Sea through thousands of miles of underground drainage tiles. The success of this geothermal development requires that it proceed with a minimum deleterious effect on the valley and its people. To this end, the Imperial Valley Environmental Project (IVP) has been organized and is functioning to address the problems of air and water quality, ecological, health, and socioeconomic effects; and to provide an integrated assessment of near- and long-term impacts of geothermal development, including subsidence and induced seismicity.

The Lawrence Livermore Laboratory is responsible for the actual scientific management of the IVP, with active operational participation by other Federal agencies, public entities at all levels, appropriate industrial interests, and numerous educational institutions.

We are characterizing, measuring and monitoring various pollutants; we are investigating their pathways and fate in the environment, including their potential health and ecological effects. We are reinjecting the brines into the formation both as a form of waste management and subsidence prevention. At the same time, we are investigating the effects on fresh water resources and the Salton Sea. We are also investigating the possibilities of any occupation hazard and analyzing each of these factors in the context of the social, institutional, or cultural effects.

We are extremely encouraged by the success of this interactive process with the technology and the local government and interest groups—cemented largely because of the mutual benefits being realized on all sides.

If I may indulge in crystal ball gazing, I would say that we as a Nation are leaning more and more toward an energy production system which, to the extent possible, is regionally oriented, in other words, a system which relies on its own resources to meet energy requirements. As ERDA has held public meetings across the country, the interest in this issue has surfaced again and again for obvious reasons. While the advantages of local energy production may be obvious economically, the environmental implications must also be reckoned with. Regions of the country which have enjoyed relative environmental serenity will now be dealing with a new set of costs and benefits. While ERDA's environmental programs are designed to ensure that deleterious environmental effects are minimized, development will not be without impacts and without difficult tradeoff decisions for the people faced with these changes.

One of the greatest environmental implications of changing from a single resource base to a number of energy options is making that choice and being aware and prepared to deal with the effects of that choice. That is why we in ERDA believe that an important part of the energy acceptability process must