OIL SHALE HEALTH AND ENVIRONMENTAL EFFECTS RESEARCH PROJECTS AND RISK ANALYSIS REQUIREMENTS

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ABSTRACT

The U.S. Department of Energy has sponsored an effort to analyze the potential human health and environmental risks of a hypothetical one million barrels-per-day industry as an aid in the formulation and management of a research program. The proper use of risk analysis by decision-makers could provide an analytical framework to guide the acquisition and application of scientific information necessary to reduce uncertainty concerning the potential health and environmental impacts of emerging energy technologies and policies and to guide the cost-effective development, installation, and operation of energy options. The ongoing health and environmental research activities sponsored by the Department of Energy are discussed. The objective and status of an oil shale risk analysis project and the interplay between research and analysis are reviewed.

INTRODUCTION

The Biological and Environmental Research (BER) Program is a 40 year old activity under the sponsorship of the U.S. Department of Energy (DOE), and its preceding agencies that were consecutively responsible for the national energy mission. One of the major objectives of the BER program is "through research, provide scientific information to reduce health and environmental uncertainties associated with energy activities." (1)

There are many inputs to identifying BER research issues and to setting priorities among them. At the highest levels, these inputs include general national policies, energy policy, departmental mission, and a variety of legislative mandates. The BER's Health and Environmental Risk Analysis Program (HERAP) is designed to provide objective, analytical insight into the difficult issue of identifying research needs and determining priorities. It also aims at strengthening the Department's ability to meet DOE's statutory responsibilities by providing decision-makers with a comprehensive description of the potential health and ecological impacts of emerging energy technologies and policies based on analyses of the current scientific data base.

Risk analysis is an iterative process that integrates scientific information concerning exposure and hazard parameters to quantify potential impacts. At the same time, the analysis process identifies the range of uncertainty regarding the nature and magnitude of the impacts analyzed. By identifying areas of uncertainty, it is possible to formulate, set priorities for, and manage a program of health and environmental research focused on providing information required to reduce the uncertainty in these critical areas.

The products of the HERAP are annual Health and Environmental Effects Documents (HEEDs) covering energy technologies and generic and methodology issues, technical papers in refereed journals, proceedings of workshops and symposia, and reports of technical reviews and discussion meetings. These activities are designed to provide objective, analytical insight into whether or not the BER research activities are correctly focused on particular aspects of potential health and ecological impacts and the associated uncertainty of emerging energy technologies and policies. In short, HERAP is designed to be a means of presenting the results of BER's research findings in a form useful to decision-makers.

A research strategy which explains the interplay between risk analysis and research planning and the management process is shown in Figure 1. The process of iteration using the research results to improve the existing scientific information data base is an essential part of the research strategy. The risk analysis portion is a dynamic process as opposed to a definitive step which can be completed. The risk analysis is used to structure the available

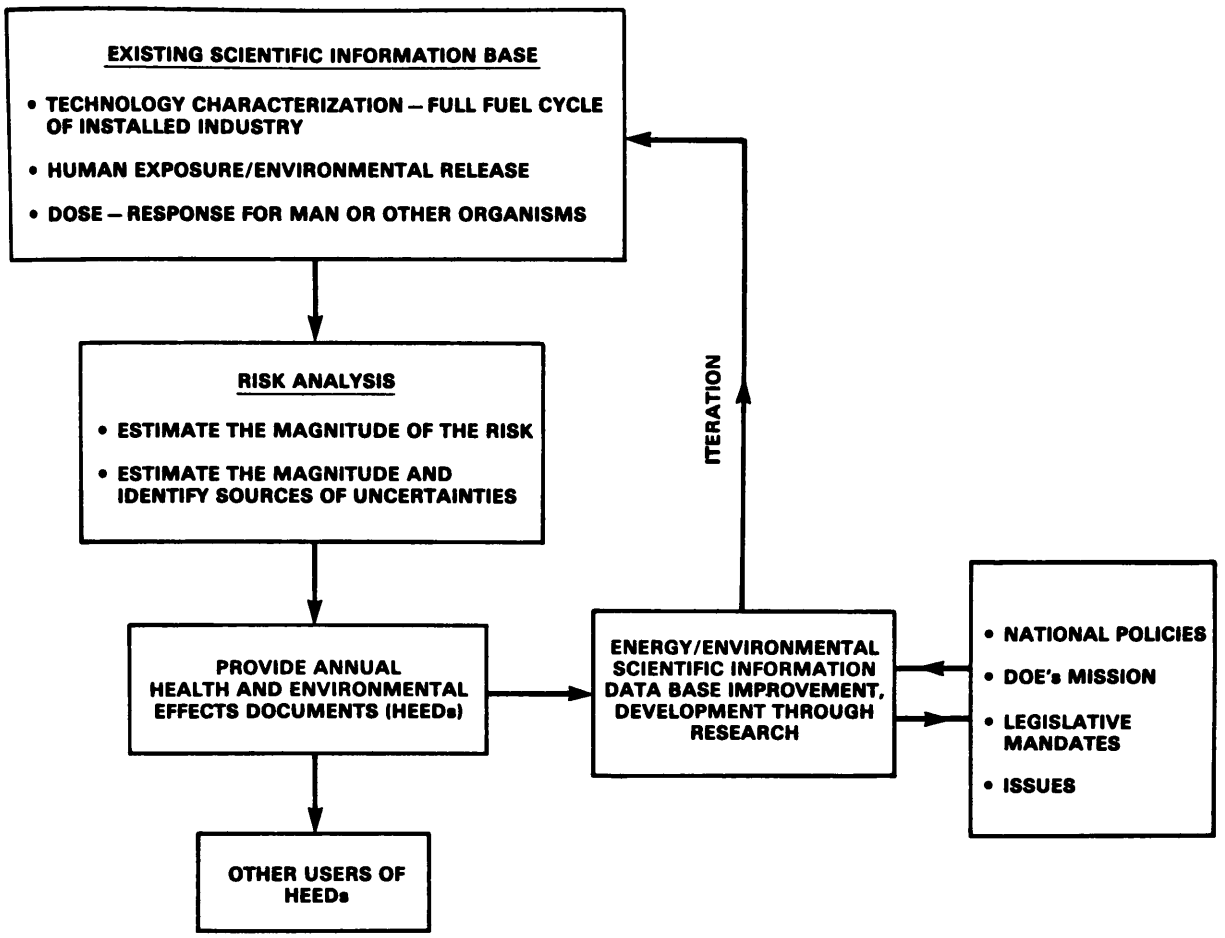

Figure 1. RESEARCH STRATEGY

information and to elaborate the strength and weakness for decisions under uncertain conditions. Since decisions need to be made, it is hoped that the risk analysis process will increase the likelihood for correct decisions.

OIL SHALE RISK ANALYSIS

In 1980, HERAP initiated a continuing project to analyze the potential health and ecological impacts of a hypothetical one million barrels-per-day (BPD) oil shale industry. The first HEED for Oil Shale was completed in November 1981 (2). Results were also discussed in some detail in an article (3) published by the Colorado School of Mines in 1982. This HEED project team was led by Dr. Lawrence B. Gratt of the IWG Corp., San Diego, California. The second HEED for Oil Shale (4) was completed in December 1982; this document was subsequently reviewed by a National Academy of Sciences' (NAS) Committee on Health and Ecological Effects of Synfuels Industries. Full comments are available in a National Academy Press report entitled, "A Review of the 1982 DOE Health and Environmental Effects Assessments on Coal Liquefaction and Oil Shale Technologies," (5) published in 1983.

Impacts of a hypothetical one million barrels-per-day oil shale industry established in the oil shale resource region covering an area of approximately 46,620 sq. km in Colorado and Utah were analyzed in the 1982 HEED in four major categories:

- Public Health
- Occupational Safety
- Occupational Health
- Ecosystem

Fourteen shale oil production sites distributed along five of the major tributary systems in the oil shale

region feeding the Colorado River were envisioned. Production was based on underground room-and-pillar mining, with above-ground retorting for all but one site, which assumed a modified in-situ operation.

Results of the 1982 HEED for Oil Shale included estimates of premature deaths with uncertainty ranges associated with workers and the general public. The results of this analysis were summarized in last year's symposium (6) and will be covered in detail in this year's symposium by Perry, Gratt, Marine, and Savitz (7, 8, 9, 10). The ecosystem risk analysis quantified mule deer, indian ricegrass, and plant community disturbances using two generic solid waste models, the "valley" and "mesa" fill approaches. The research recommendations were based on both the relative magnitude of the risk estimate and the associated uncertainty factors.

For example, the largest uncertainty is in the estimate of premature deaths due to public exposure to air pollutants as predicted by the sulfate surrogate dose-response model. Research is needed on the actual health effect mechanisms involved and the correlation to emission data, environmental measurements, and uptakes.

Upgrading of this HEED during FY 1984 will focus on response to comments on the 1982 HEED by the NAS Committee. For example, consideration should be given to the release of radon from mine walls, the availability of water supply for the installed industry in the Western United States, nonlinear dose-response relationships and health effects of air pollution, atmospheric dispersion analysis, ground water transport of pollutants, and the impact of mining and in-situ retorting on ground water quality. The 1984 Oil Shale HEED will be completed by October 1984.

HEALTH AND ENVIRONMENTAL RESEARCH RELATED TO OIL SHALE

Just five years ago, the plan to develop synthetic fuels was to be another Manhattan Project - a dramatic, accelerated national effort to meet energy needs from domestic energy resources and help make the U.S. less dependent on foreign crude. In connection with that upbeat scenario, DOE organized a group, The Oil Shale Task Force (OSTF), as the mechanism for coordinating the research activities being done in four major areas:

- Resource characterization and planning
- Development and extraction
- Processing and instrumentation
- Environment

The last element has three components:

- Data base development and risk analysis
- Control technology
- Compliance

The primary functions of the OSTF are: (1) planning and implementation of research and (2) communication of research results. For example, a symposium, "Oil Shale, the Environmental Challenges", sponsored by the OSTF through DOE was held at Vail, Colorado, during August 11-14, 1980. Proceedings (11) published in 1981 by the Colorado School of Mines contain papers addressing research on the health, environmental, and socioeconomic impacts related to oil shale development. The second and the third symposia of a similar theme were held in August of 1981 and 1982, respectively. Two proceedings (3, 12) were subsequently published again by the Colorado School of Mines in 1982 and 1983.

During the 1978 to 1982 period, the OSTF successfully accomplished many health and environmental related oil shale research projects. Salient conclusions (13) were summarized by Dr. Willard R. Chappell as follows:

- The high concentrations of organics and salts in the oil shale wastewaters present a considerable challenge in treating these waters.
- While the important constituents (e.g., TDS, F, B, Mo) in leachates of raw and spent shales are well characterized, the ultimate fate of these constituents is not understood.
- Since the materials under the spent shale piles will not be impermeable, it is likely that leachates will eventually reach ground and surface waters and result in significant increases in TDS and, perhaps, other constituents as well.
- While the crude shale oils and other materials are carcinogenic and present a potential risk of increased cancers, it appears that non-neoplastic pulmonary health effects (pneumoconiosis, bronchitis, and chronic airway obstruction) may be the most important occupational health concern.
- Oil and wastewater spills may have adverse impacts on aquatic organisms. High levels of molybdenum in plants on the spent shale piles and in irrigation water may cause areas where

foliage contains concentrations toxic to livestock.

- Ecological risks are very difficult to quantify, but adverse impacts on agriculture and wildlife will occur because of land disturbance and increased TDS and other constituents in the ground and surface waters.

The OSTF provided valuable connections to the oil shale risk analysis through the research coordinating mechanism. The participation of both the technical researchers and advisory committees provided valuable guidance for the analysis process. Numerous consultants and government laboratory researchers also aided the process. The interaction of the Synfuels Committee of the American Petroleum Institute was particularly rewarding. Oil Shale Risk Analysis workshops (14) provided a forum to allow public interest groups, industry, researchers, and government to both understand and strengthen the analysis.

Dramatic changes in the prospects for oil shale development have occurred in recent years. The shale oil development that made sense economically with the "expert" prediction of $50 or more per barrel of oil by the mid '80s was not a good business proposition in a world of $30 or $33 per barrel petroleum. In May of 1982, Exxon, discouraged by falling crude prices, a sharp rise in interest rates, and soaring construction costs, abruptly cancelled the Colony Shale Oil Project near Parachute, Colorado. Union Oil Company is near completion of a 10,000 BPD plant near the Colony site that may employ a simpler, less expensive technology to extract kerogen from shale.

Amidst the changes which have taken place in the United States regarding the scope of, and incentives for, synfuel technology deployment, DOE has also re-directed its health and environmental research activities towards more generic analysis that is to focus more on research common to a number of operations and technologies instead of process- or technology-specific research. In FY 1984, DOE is conducting fewer technology-specific synfuel health and environmental research projects than the year before.

According to a DOE publication (15), there are already 731 individual projects sponsored by the BER program in FY 1984. Five major categories of research and assessment activities include: (1) source and dose determination, (2) environmental behavior and effects, (3) health effects, (4) risk analysis, and (5) nuclear medicine. Table 1 provides a gross compilation of health and environmental research projects dealing with synfuel-specific technologies. Seventy-six projects (including two synfuel risk analysis projects), representing about ten percent of the total research projects in progress sponsored by BER program in FY 1984, may be considered to be synfuel-specific research. The other ninety percent of BER research projects may also have some relevance to synfuel technologies.

One can argue that the bulk of the ongoing BER research projects and their findings may not provide direct explicit information useful to the Oil Shale HEED. However, the results of the HEED may be useful to the management of most of the research projects. In fact, several technology HEEDs, including the 1982 Oil Shale HEED sponsored by HERAP, have been used as important inputs which aid DOE's BER program and Fossil Energy Technology program in the formulation and management of research activities. To solicit suggestions for improvement, HERAP has commissioned a survey among oil shale research scientists and program managers regarding "HEED for Oil Shale - 1982 and its use in Research Planning". (16) The feedback is generally positive.

SCOTTISH OIL SHALE HEALTH RESEARCH

Of particular interest for future risk analysis for oil shale are the current research projects being performed by the Institute of Occupational Medicine (IOM), Edinburgh, Scotland.

The first project, a three-year research effort, began in April 1982, to study the cause of deaths of Scottish oil shale workers. The study population being used consists of Members of the 1950 Scottish Oils Ltd., Provident Fund. IOM researchers have identified approximately 6,000 Provident Fund forms, and good progress has been made on the determination of the causes of death of the shale workers and their occupational history. Data analysis of this project is just taking place to test the hypothesis that workers engaged in the mining of shale and the production of shale oil and men living in the oil shale areas in Scotland had an increased risk of developing bronchial carcinoma, skin, liver, and kidney diseases.

Table 1. SYNFUEL-SPECIFIC HEALTH AND ENVIRONMENTAL RESEARCH PROJECTS SPONSORED BY DOE - FY 1984

Major Category	Sub-category	Number of Projects	Remark
Source and Dose Determination	Analytic Research	4	
	Dosimetry Research	0	Research
	Measurement Science	9	
Environmental Behavior and Effects	Atmospheric Science	5	
	Terrestrial and Aquatic Ecosystems Research	24	Research
Health Effects	Long-term Effects of Radiation Exposure	0	
	Long-term Effects of Energy-related Chemical Aspects	27	Research
	Generic and Basic Research	0	
Health and Environmental Risk Analysis	Synfuel Technologies	2	
	Generic and Methodology		Assessment
	HEEDs	5	
Nuclear Medicine Applications		0	Research
	Total	76	

A second project, a two-year clinical study, began in October 1982, to investigate the health effects of ex-shale workers. This research is directed toward shale workers' pneumoconiosis, associated respiratory ailments, and skin tumors, plus ancillary documentation of mining and retorting processes and mineralogical characterization of Scottish and western U.S. shales. This study population is also the Provident Fund members. Survivors are being traced and men who agreed to participate and live in Britain were sent smoking and dermatology questionnaires. The chest X-ray survey is being confined to men living in West Lothian, an area which encompassed all the shale mines, retort works, and shale oil refineries in Scotland.

The third project is an epidemiologic mortality study of oil shale communities in Scotland following a feasibility study (17). The objective of this study is to investigate fatal oil shale-related health effects in workers who left the industry before 1950, those entering the industry after 1950, and in persons who lived in oil shale communities. This study supplements and complements the other two projects. This project will provide data on a substantial number of workers excluded from the previous occupational studies by the cohort definition and also will assess the health effect of the industry on the mortality of the surrounding communities. In addition, the community may identify long-term risks due to the environmental contamination from the spent shale piles. This is a three-year community health study scheduled to start in April 1984 at IOM.

EXAMPLE OF RISK ANALYSIS USE

A recent concern of the Scottish Oil Shale Worker Study managers provides an example of the utility of the oil shale risk analysis results in research management. The managers needed to know whether or not lung function measurements should be taken when the workers have their chest X-rays done. Obtaining this valuable scientific data would increase the cost of the research. Although many factors would be used in the decision process, the

oil shale risk analysis HEEDs (4, 6) provided useful quantitative occupational risk estimates. According to the HEED, pneumoconiosis, chronic bronchitis, and chronic airway obstruction are the potentially important diseases in oil shale miners. Chest X-rays can measure pneumoconiosis while the lung function Forced Expiratory Volume (FEV_1) tests measure airway obstruction. Potential annual occurrences are 51 cases of pneumoconiosis (silicosis), 92 cases of chronic bronchitis, and 4 cases of airway obstruction. The occurrence of airway obstruction is 8% of pneumoconiosis and 4% of chronic bronchitis occurrence . Workforce airway obstruction premature mortality is less than one half of one percent of premature silicosis-pneumoconiosis mortality. Therefore, on the basis of the results obtained from the oil shale risk analysis HEEDs, additional efforts on pneumoconiosis and chronic bronchitis would be warranted over lung function measurements, when research resources are limited. The research managers are incorporating this information into their decision. (Please note the health risks quoted in the example above are currently being revised (9)).

The selection and prioritization of research has always been a difficult process and, in many instances, the risk analysis will provide analytical insight to improve and strengthen the program management decision-making criteria.

CONCLUSIONS

As the research data base relevant to synfuel technologies is being continuously updated and enlarged by DOE sponsored activities, as well as by others, HERAP plans to continue the iterative process between risk analysis and scientific information to reduce health and environmental uncertainties associated with energy activities. Although quantitative risk analysis tends to be crude and rudimentary, it can be useful in providing objective and analytical insight into the difficult issues of identifying research needs and determining priorities. During an era when major expenditures of government funding of public health programs requires more justification, risk analysis has gained greater acceptance as a useful research planning tool among program managers concerned with conscientious, cost-effective resource management.

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