Research is conducted by universities for several reasons; it is the primary vehicle for training advanced students to the cutting-edge in their disciplines; it is one important way for a faculty to stay current and to advance knowledge; it is a way for the organizations and people involved to contribute to the solution of important societal problems. Therefore, research is mutually beneficial to both the sponsoring agencies and the universities.

Although many universities involve Masters level students in research, work at the frontiers requires training beyond the Masters degree. Therefore, while in some instances ERDA may be able to benefit from Masters-level research, the primary contribution to ERDA's high-technology programs will come from universities involved in Ph.D. level research. Hence, the quality of a university's Ph.D. program should be a significant factor in considering ERDA-university interactions.

I would like to dispel any notions that Ph.D. programs simply produce more professors for other institutions. For example, Stanford is a major producer of Ph.D.'s in engineering and the sciences but only about one third of these go to academic institutions, the remainder go to government and industry. If the nation is to maintain a strong position in advanced energy technology, this flow of fresh Ph.D.'s to industry, government, and other universities must be maintained.

There have been many surveys of the quality of graduate education and research in engineering and the sciences. Table 3 shows some results of a recent survey and lists engineering schools by their ranking for the overall quality of graduate education. Note the range of undergraduate-to-graduate enrollment ratio (UG/G), the Ph.D. production per faculty member per year (Ph.D./Fy), and the range of annual research support per faculty member (Res.K$/Fy). Note, however, that the research investment per Ph.D. produced (Res.K$/Ph.D.) at these institutions lies in a narrow range around $100 K per Ph.D.

For a variety of reasons, the engineering and science-oriented schools generally considered to be the strongest were slow, as a group, to become involved with ERDA. To illustrate this fact, let me note that only 11 of 75 universities' research programs mentioned in ERDA 77-33 as providing advanced research to the fossil energy program

TABLE 3

RESEARCH PRODUCTIVITY PARAMETERS FOR LEADING ENGINEERING SCHOOLS

Institution	Faculty	UG/G	Ph.D./Fy	Res. K$/Fy	Res. K$/Ph.D.
A	321	.85	.5	63.9	128
B	212	1.47	.69	57.5	83
C	142	.50	1.11	130.0	117
D	372	2.58	.34	46.2	136
E	--	--	--	--	--
F	270	3.19	.33	36.7	111
G	323	3.78	.33	32.8	99
H	83	2.17	.31	51.8	167
I	214	3.12	.32	31.3	97
J	74	3.62	.47	79.7	169

Source: SUNY-Buffalo Survey, corrected

were placed at universities ranked among the top 20 in this survey. This does not imply that the projects were placed at schools not qualified to do the work, but it does suggest that there is a great deal of top university talent that could be brought on-board the fossil energy program.

Table 4 shows a breakdown of funding, by agency, in the three-top institutions in Table 3, each of which could make significant contributions to the ERDA program. Note the breadth of high-technology agency support and the magnitudes of their annual research budgets; $60-70 million. These clearly are three very serious technological activities. Note the relatively small fraction of ERDA support in each case (National Laboratories managed by these institutions have not been included in this summary. In the case of institution B, an ERDA laboratory operates predominantly with faculty/Ph.D. student teams, and makes major contributions to the university research program.) Now let's look at the university funding nationwide by these same agencies; Table 5 gives this detail. Excluding DHEW, which is not primarily a high-technology agency, the NSF is the largest supporter of research in universities, followed by the DOD, ERDA, and then NASA. Now consider Table 6, which gives the ratios of ERDA-to-DOD and ERDA-to-NSF support in all universities and in the three we have considered. Note that these ratios for the three top institutions are significantly lower than the national averages. This is a clear indication that these three outstanding institutions, and

TABLE 4

RESEARCH EXPENDITURES* AT THREE LEADING UNIVERSITIES, UFY76

Agency**	Institution A	Institution B	Institution C
DOD	13.2	6.6	7.6
ERDA	2.9	0.9	1.7
NASA	7.0	3.7	5.1
NSF	20.8	14.8	15.4
DHEW	17.3	26.4	34.0
Other Govt.	5.0	7.4	3.2
EPRI	≈.7	≈.4	1.2
	66.9	60.2	68.2

*Industrial funding not included

**Not including federal laboratories managed by the institutions.

Source: Institutional Private Communication

TABLE 5

R&D SUPPORT IN UNIVERSITIES
(Millions of Dollars)

	Outlay FY76	Est FY77	Est FY78
DOD	282	312	353
ERDA	129	152	200
DHEW	1459	1287	1415
NASA	111	116	119
NSF	446	463	512

Source: Special Analysis, Budget of the United States Government, FY1978, OMB.

TABLE 6

COMPARISON OF AGENCY FUNDING IN THE THREE UNIVERSITIES
WITH THE HIGHEST-RANKED ENGINEERING SCHOOLS*

	All Universities	A	B	C	A + B + C
ERDA/DOD	0.46	.22	.14	.22	.20
ERDA/NSF	0.29	.14	.06	.11	.11

*FY76

TABLE 7

FEDERAL SUPPORT FOR FIVE MAJOR
UNIVERSITY MATERIALS RESEARCH CENTERS (UFY77)
(Millions of Dollars)

	A	B	C	Q	R
ERDA (%)	0.05 (3%)	7 (90%)	0.5 (8%)	0 (0%)	.1 (5%)
Other	1.61 (97%)	1 (10%)	6.4 (92%)	4.1 (100%)	2.3 (95%)
TOTAL	1.66	8	6.9	4.1	2.4

Source: Institution Private Communications probably many other first-rate institutions, have a great deal of high-technology research talent that could be brought to bear on ERDA problems. Progress in this regard is being made, (An institutional arrangement between ERDA and one of these universities is now bringing more faculty to ERDA's research programs. The University Research Program under the Fossil Energy Program now involves about 150 universities, compared to only 23 in 1976.) but I believe the university potential is just barely being tapped.

Let's examine this hypothesis in a particular research area of direct concern to the fossil energy program; materials. Table 7 shows the division between ERDA support and other federal support at five of the major centers for materials research established at these universities over a decade ago as part of a national "centers of excellence" program. The institutions are designated as in Table 3. Institution A also has other materials research, including a significant amount from ERDA, which is not funded through it's materials center. Center B is part of an ERDA laboratory, and is funded almost entirely by ERDA. However, in both Centers B and C practically all of the investigators are regular faculty at their institutions, and the "workers" are Ph.D. students. Thus, these two are quite similar in structure and capabilities, but one is heavily supported by ERDA and the other only modestly. Institutions Q and R also have good materials programs; one is very close to another ERDA laboratory, but neither is an ERDA laboratory; the ERDA support for each is very small. One can draw two conclusions from these data. First, universities with an in-house ERDA laboratory have been able to switch their efforts to energy research much more rapidly than have those which do not operate ERDA laboratories. Second, there is a great deal of capability in materials research that as yet is not being exercised on ERDA problems.

Let me close this analysis of the Fossil Energy Program with the comment that many university people have perceived (correctly or incorrectly) that the attitude towards university research varies greatly among the Program Divisions. In particular, the Division of Magnetohydrodynamics makes extensive use of several universities, and has given universities responsibility for some very large-scale experiments. In contrast, the Division of Coal Conversion and Utilization makes practically no use of universities, which could make some very important contributions through, say, applied research on combustion in a large-scale combustion research facility. The Division of Materials and Exploratory Research has an excellent and growing university research component, and I have heard a number of compliments about the way their program is being handled (as well as expressions of dismay at the small size of the Division budget!).

I would like now to discuss the special requirements for conducting quality research in the university environment, as these may shed some light on why some of the most highly regarded universities have not become involved with ERDA as rapidly as others.

A critical mass of activity in the general area of the research is most desirable; while there are a few instances of the lone professor and his student doing outstanding work in an isolated situation, the best work seems to come from departments in which there are a number of good people, and good students, working on similar problems, surrounded by good supporting departments.

Flexibility in the details of the work is highly desirable, especially in the most basic research; a research team which keeps the general objectives of the sponsor in mind should have the freedom to make mid-course adjustments in the details of the research if this serves the objectives of the program.

Deadlines should not be too tight. Strict deadlines, which are essential in development programs, are not conducive to good research, and can force the taking of data before an experiment is fully debugged. In the interest of quality research this pressure should be avoided.

A research team should have a support commitment for a period of several years; three-year grants and contracts are most preferable, since this is the length of time that a typical Ph.D. student spends on a research project.

Stability of support is essential. The larger the research team, the more stable the support needs to be. Transfers of support from one agency to another, from one set of contract monitors to another, from one set of long-term objectives to another, which we have seen in the energy area over the past several years, are very disruptive, often leaving periods of months during which research teams do not have adequate funding. An industrial research organization might absorb such discontinuities by transferring people from one department to another, or by reducing the technical staff, but universities cannot operate this way; universities cannot fire students and faculty one month and hire replacements three months later, or transfer students and faculty from Physics to Electrical Engineering on short notice.

Finally, support must allow for inflation and other appropriate cost increases.

Critical mass in a research area usually requires more than one faculty member, and a number of Ph.D. students. Table 8 shows the total budget for a hypothetical research team consisting of four faculty members, 2 research associates, and 16 Ph.D. students. There would be a continual flow of students in and out of the program at the rate of about 6/year. With funds for salaries, equipment, travel, and the inevitable indirect costs, the total annual research budget for this team might be about $600K. This might be provided by 1 large contract at $200 K/year, 2 medium contracts at $100 K/year each, and 4 small grants at $50 K/year each, perhaps from 4 different funding agencies. The group's research would be in a coherent area, such as high-temperature materials, superconductivity, MHD, combustion, or catalysis, and might span a spectrum from very basic research through applied research, perhaps even including a modest amount of prototype development.

Research activities in many large universities are conducted by teams and sub-teams of this general size. A team working in, say, catalysis could decide to turn some of its attention to problems of special interest in the ERDA fossil energy program. What would induce a team or one of its members to do this? The obvious first thought is a need for funding. But, I have heard repeatedly that the good people at the good institutions are fully committed. They have momentum in their research, and well-developed relationships with their sponsoring agencies. So, an alternative source of equivalent funding would hardly seem sufficient to capture their attention. If ERDA seriously wants to involve the best university minds in fossil energy research, then ERDA will have to present them with funding opportunities and procedures that are at least as attractive as those offered by the other agencies.

With this problem in mind, let's examine the University Program of the Division of Fossil Energy Research. According to ERDA 76-10, most of the university programs involve at least three years of support. This shows excellent sensitivity to one of the most important criteria for good university research, and Dr. Alex Mills and his staff are to be congratulated for this sensitivity. Second, the size of the contracts reflected in ERDA 76-10 shows similar awareness of what good research requires; funding levels range from \$25 K/year, which is a bit on the low side, to about $800 K/year, which should be quite adequate for a substantial team effort. For about half the contracts the spending rate is in excess of $80 K/year, and about one-third are at the rate of $150 K/year or more. This general balance seems consistent with the model of Table 8.

TABLE 8

TYPICAL BUDGET FOR A UNIVERSITY RESEARCH TEAM

I.	SALARIES (and Benefits) 4 Professors 2 Research Associates 16 Ph.D. Students Technical/Secretaries		$290 K
II.	TRAVEL, MISCELLANEOUS		10 K
		SUBTOTAL	$300 K
III.	INDIRECT COSTS		150 K
IV.	EQUIPMENT		150 K
		TOTAL	$600 K

Output: Will produce 6 Ph.D.s/year.
Sources of funding: 1 large contract at $200 K/year, 2 medium contracts at $100 K/year each and 4 small grants at $50 K/year each; 4 agencies.

In an attempt to stimulate new fossil energy research in universities, the Division of Fossil Energy Research early this year announced a program of Starter Grants in coal research. Areas of interest mentioned in the program announcement were "research directed toward...converting coal to liquid and gaseous fuels...coal combustion, and...materials...for coal processing equipment." The Starter Grants were limited to $20 K; the program budget was $400 K/year for 2 years.

I believe that the $20 K grant size in this starter program was too small. Grants of this size may be appropriate for the new Professor, just starting to build his research program. But I do not believe that this will prove to be enough to entice many established Professors, perhaps members of productive research teams of the type shown in Table 8, to alter the nature or funding of their research.

However, this program may have received some proposals from good faculty who, for one reason or another, are "between agencies." In reviewing these proposals, ERDA might look carefully for this opportunity. If such cases are detected, ERDA should make a prompt on-site assessment of the capabilities of the group involved, work with them to identify the research that will be conducted, and move swiftly to provide the necessary additional funding to keep the good team together and get them moving on ERDA activities (<u>before</u> the starter work is finished!).

As the work under the rest of the starter program progresses, ERDA will undoubtedly become aware of some special opportunities to help young groups build up productive research teams. When these are identified, ERDA should budget for a phase-up of these activities to a good level of support. It is unlikely that a $40 K grant following a $20 K starter will produce the desired results; the second awards should be closer to $100 K, and should be designed to increase the number of people working in the team. Care must be taken that the program does not expand beyond the supply of good Ph.D. students.

What might ERDA offer to the well-funded, established teams as incentives for participation in ERDA's programs? Opportunities to obtain expensive special equipment, or to upgrade facilities, or to add more supporting staff, might be considered. Let me offer a specific suggestion that I know many "saturated" departments would find attractive; the opportunity to add junior faculty. In the 1950s universities were able to respond to the needs of NASA and the DOD by faculty expansion, but today the faculties of most of our universities have reached steady-state limits imposed by physical and budgetary constraints. Many institutions will not have many retirement vacancies over the next dozen years, but then retirements will begin to come in rapid succession. Then it will be possible to add new faculty who can work in areas of interest to ERDA. It would be a bold step of leadership for ERDA to act <u>now</u> to guide these replacements, say by providing <u>interim</u> funds, on a cost-sharing basis, to support advance replacements. A program to provide $500 K per year for five years would support half of the base salary of 50 new young professors. If allocated to productive institutions, where each professor carries $100 K per year in sponsored research, ERDA would have planted the capacity to handle $5 <u>million</u> annually in university research in areas of ERDA's choosing.

In summary, there are active steps which ERDA could take to bring more of the best university talent "on-board" the ERDA fossil energy program. I believe that steps such as those suggested would strengthen the research base for the program, and that it would be very much in the long-term interests of the program to take these actions now.

I would like now to examine the balance between basic research, applied research, and development in the ERDA fossil energy program. To begin, let's look at the balance in the oil industry (Table 9). The industry spends about half of its R&D budget on research. Industry-wide, approximately 5 percent is devoted to basic research and 44 percent to applied research. The four largest firms together spend considerably more on basic research (almost 9 percent of their total R&D expenditures). Note that the total spent on basic research by the industry is comparable with the high-technology research budgets of single universities.

TABLE 9

R&D EXPENDITURES OF THE OIL COMPANIES
(Millions of Dollars - 1975)

	Basic Research	Applied Research	Development	Total
4 largest firms	24.7 (8.9%)	138.7 (49.8%)	114.8 (41.3%)	278.2 (100%)
all others	8.8 (2.6%)	133.9 (39.1%)	199.5 (58.3%)	342.2 (100%)
industry total	33.5 (5.4%)	272.6 (43.9%)	314.3 (50.7%)	620.4 (100%)

Source: David Teece, Stanford

The basic mission of ERDA is to accelerate the implementation of alternative energy technology. ERDA does this by becoming a partner with industry in major development activities, and by supporting the research needed to provide a sound scientific and engineering base for future technological development. This is not the same as the mission of the oil industry, and so one would not expect the percentages in Table 9 to apply to the ERDA fossil energy program. Economists argue that the social benefits of basic research far outweigh the private benefits, which is a way of saying that industry invests less in basic research than it draws from the national pool of basic research. The larger firms are able to sustain a higher proportion of basic research, as Table 9 shows; but it falls upon the government to be the primary supporter, and the universities to be the primary performer, of the basic research which ultimately supports technological development. Therefore, I would argue that a government agency which matches industry 50-50 for development costs should be spending considerably more than does that industry on basic research. In view of the numbers in Table 9, it would seem appropriate to spend something like 10 percent of the total R&D budget of the fossil energy program on <u>basic</u> research in areas likely to contribute significantly to future fossil energy development. For a $500 million program, this suggests a basic research component of the order of $50 million per year.

The oil industry figures might provide a better guide as to the amount of applied research that is necessary to support future technological development in fossil energy. The oil figures suggest that an agency which matches industry 50-50 for development costs should be spending about as much for applied research as it spends on the development projects. For the fossil energy program, this would translate to about $360 million per year.

My assessment (The FY77 Budget Authorization Legislation document was used as the basis for this compilation. Each project was reviewed and the NSF definitions of each type of activity were applied (these definitions were also applied in Table 9). In the case of the Basic Energy Sciences program, the fraction of each area applicable to fossil energy, as estimated by ERDA, is given in the document. ERDA 76-10 was used in some cases to guide the classification of a project.) of the breakdown in the ERDA fossil fuel program is shown in Table 10. The amount shown under the Basic Energy Sciences program is deceptively large; I have shown the dollar amounts for research which could be applicable to fossil energy. Much of this also could be applicable to solar, geothermal, and other ERDA energy development programs. Therefore, had I instead identified each project in the Basic Energy Sciences program with only one of the ERDA development programs, the basic research total in Table 10 would only be about $12 million as shown in the bottom line of this table. Thus, from an overall agency point of view, the funds allocated to basic research

TABLE 10

ERDA Fossil Energy R&D
FY77 Budget Outlay Estimates
(Millions of Dollars)

	Basic Research	Applied Research	Development
Fossil Energy Program			
Coal	--	43.1	314.9
Petroleum and Natural Gas	0.2	1.6	30.4
In Situ Technology	--	2.3	17.8
Basic Energy Sciences*			
Materials	29.5	--	--
Molecular Sciences	17.2	--	--
Geosciences	2.6	--	--
Math/Comp.	2.1	--	--
Conservation			
Heat Engine System	--	1.0	--
Improved Efficiency	--	4.3	--
Environment and Safety			
Coal	--	1.8	
Oil and Gas	--	1.2	
TOTALS	52.6 (11.2%)	55.3 (11.7%)	363.1 (77.1%)
GRAND TOTAL $471.0			

Based on FY77 Budget Authorization Documents; does not include equipment.

*Non-additive analysis: the additive numbers are tabulated below.

Additive Analysis	12.6 (2.9%)	55.3 (12.6%)	363.1 (84.2%)
GRAND TOTAL $431.0			

in support of the fossil energy program are more like 3 percent than 11 percent of the total fossil energy expenditures. Note that applied research constitutes only about 12 percent of the total program.

These numbers support two opinions that I have heard from many colleagues. The first is that too much emphasis is being placed on development, and not enough on research, in the ERDA program. The second is that there is a "gap" between the basic research programs and the development programs, that applied research is not receiving sufficient emphasis.

There is other evidence to support this position. Table 11 shows the support for basic research in the physical sciences and in the engineering sciences as estimated by the NSF for FY76. Except for the materials area, the ERDA emphasis on basic research clearly has been in the physical sciences. This is due to the fact that ERDA also has responsibility for support of high energy and nuclear physics. In view of this responsibility, it is not inappropriate that ERDA spends more on basic research in the physical sciences than does the NSF. However, in view of ERDA's mission in energy technology, the difference between NSF and ERDA support for basic research in the engineering sciences is alarming.

TABLE 11

SUPPORT FOR BASIC RESEARCH, BY AREA - FY76
(Millions of Dollars)

	Physical Sciences			Engineering Sciences			
	Chemistry	Physics	Other	Chemical Engineering	Mech/Aero Engineering	Materials/ Metallurgy	Other
DOD	10.8	34.5	10.8	1.8	5.4	33.0	35.4
ERDA	63.8	180.8	3.5	0.2	0.0	16.2	3.0
NASA	55.4	193.6	217.7	0.0	22.7	7.7	11.3
NSF	48.2	72.5	36.8	8.5	10.2	16.3	26.9

Source: NSF-75-323

The "gap" is further demonstrated by Table 12, which shows support for applied research in the physical sciences and engineering sciences for FY76, as estimated by the NSF. Note that ERDA, which has a total budget comparable to that of NASA, spent far less on applied research in the engineering sciences. I regard this as very alarming for an agency with a primary mission to implement and advance high-technology energy systems over an extended period of time.

TABLE 12

SUPPORT FOR APPLIED RESEARCH, BY AREA - FY76
(Millions of Dollars)

	Physical Sciences			Engineering Sciences			
	Chemistry	Physics	Other	Chemical Engineering	Mech/Aero Engineering	Materials/ Metallurgy	Other
DOD	32.7	96.5	37.8	26.4	562.7	80.7	519.6
ERDA	30.8	147.0	5.4	38.2	5.1	14.3	43.5
NASA	1.5	5.9	5.1	1.9	495.6	70.7	68.8
NSF	4.3	2.3	0.1	1.1	1.1	4.3	22.8

Source: NSF-75-323

The FY78 ERDA budget proposal includes increases for research in the engineering sciences of combustion, coal chemistry, and fuel-forming catalysis in the Basic Energy Sciences Program. An analytical research chemistry and coal carbonization laboratory is proposed by the Fossil Energy Development program. These are positive signs that the scientists and developers are moving to fill the gap.

What basic and applied research might ERDA be doing that it is not doing now? There have been a number of workshops devoted to identifying critical problems that require research, especially as related to coal. These have led to very detailed recommendations for basic and applied research in materials, coal chemistry, coal combustion, and coal planning analysis, and identified a great deal of needed research in these areas. I think that more might also be done in the area of high-technology underground mining, to name just one other possibility.

There are four areas within my own specific expertise which do not seem to be receiving sufficient attention. Others with different expertise undoubtedly can identify areas that they feel are neglected. My suggestions for additional emphasis are:

1) Basic boundary layer heat and mass transfer in high-temperature systems. This would provide needed information for future systems.

2) Recirculating and separated flows. Low efficiencies in turbomachinery and associated equipment are generally associated with flow separation; recirculation is usually the key to high-performance combustion.

3) Scaling to larger sizes. Problems are always encountered when one scales results obtained in an experimental situation to the much larger sizes associated with commercial devices.

4) Combustion

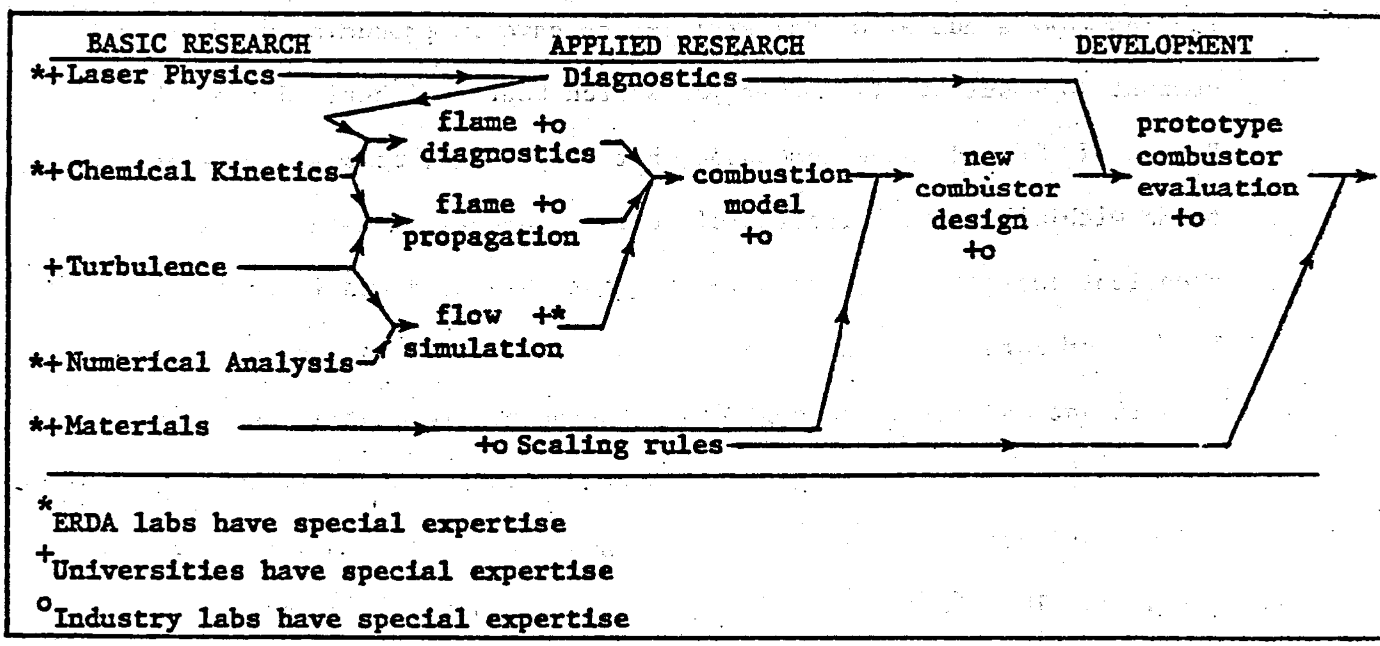
There are a number of universities with engineering departments well-qualified to do research in these four areas, as well as a few industrial research centers, but to the best of my knowledge these areas are not within the special competence of the ERDA laboratories. However, there are special instrumentation and computation capabilities in the ERDA laboratories which could be very useful in an integrated ERDA/university/industry attack on these problems.

Let me now concentrate on the research opportunities in combustion. Certain ERDA laboratories, with their high concentration of scientific talent, have developed some remarkable tools for combustion diagnostics and computational chemistry and fluid mechanics. However, they have not as yet had much experience in practical combustion systems, and, as Table 2 shows, they do not have the track records that a number of universities do have in producing useful combustion results. (The Energy Research Centers inherited from the Bureau of Mines do have some good, but very small, combustion research teams with substantial records of accomplishment.) The labs have excellent tools to apply to problems, but they need considerable input from more experienced combustion groups as to what problems are significant and likely to contribute to the development of new energy technology. Universities, certain Energy Research Centers, and certain industrial concerns, are in a good position to provide this guidance. The mutually beneficial interplay that has recently developed between researchers at the LBL and faculty in the Department of Mechanical Engineering at Berkeley is perhaps a paradigm of the university/agency cooperation that could give ERDA the beginnings of an excellent coordinated program in basic and applied combustion research. Figure 1 shows the spectrum of combustion research and areas in which university laboratories and industry could contribute.

I believe that the ERDA fossil energy program would benefit from a set of carefully-developed research plans and record of ongoing

FIGURE 1

POSSIBLE R&D SPECTRUM IN ONE FOSSIL ENERGY AREA



research. These plans should be developed by teams of experts from universities, industry, the ERDA laboratories, and the fossil energy programs. They should be published as a guide to organizations seeking to participate in the program, and updated continually as some research needs are covered and new needs are identified. The plans should include both basic and applied research. In the materials area, many of the elements of such a plan now exist. But plans must be developed in the other areas as well.

In addition to the plans, the groups in ERDA which support these programs should develop competency files, and then seek out the most qualified groups or combinations of groups to work on the problems identified. The ERDA laboratories should have to compete for funding with universities and industrial research laboratories on an equal footing, with the research output, significance, and quality, and not agency budgetary responsibilities, being the primary deciding factors. The ERDA laboratories should be encouraged to team up with university researchers to provide balanced research teams; laboratories strong in basic research should seek cooperation from university people strong in applied research, and vice versa. The universities will have to contribute to such joint efforts from positions of strength; they must be given good financial support, and not merely "bones" tossed by the laboratories.

Each research program area should have an external Technical Advisory Committee consisting of individuals who are capable of evaluating and assessing the research. One would expect that these committees would have good representation from active university researchers in the field. The General Technical Advisory Committee for the Fossil Energy Development Program is an excellent group to provide overall program advice, but is not the best possible group to critique the specific research programs.

The integrated research plan for fossil energy research would not only identify the work that is needed, it would tell how much should be budgeted for basic and applied research. I would not be surprised if the fossil energy research plan showed that the basic research component should run at about $50 million per year and that the applied research component should be about $200 million per year.

Let me close with a suggestion about the administration of research within ERDA. Funding for applied research is at present centered in the development programs. The longer-range character of this research renders it vulnerable to the shorter range urgencies of the development programs. It is natural for those charged with meeting demonstration deadlines to concentrate on the near-term needs at the expense of the longer-term research which is the life-blood of future technological development. Many industrial firms have solved this problem by separating organizationally and budgetarily the research from the development activities. Such a separation may be necessary to redress the balance between basic research, applied research, and development in ERDA's energy program.

With the coming of the Department of Energy, an opportunity exists to take this step. The Moss Amendment to HR 6804 requires the establishment of an Office of Energy Research (OER), the Director of which will administer the Division of Physical Research (DPR) program transferred to DOE from ERDA. The amendment permits the Secretary of Energy to assign the OER Director the responsibility for supervision and support of research activities carried out by any of the Assistant Secretaries. The Director of the OER would report directly to the Secretary of Energy, and therefore could defend the long-range interests of the national energy R&D program before the senior authority. I believe that it might be a very good idea to give the Director of the OER this responsibility and concomitant budgetary control. The Director would then be in the position to administer a coherent, purposeful program of basic and applied research, involving universities, government laboratories, and industry, that is necessary if we are to continue to be the world leader in energy technology development.

To summarize, I believe that the research program that supports fossil energy development in ERDA is seriously underfunded, especially in the area of applied research, particularly in the engineering sciences. There is a gap between the very basic research supported by DPR and the work of development programs, and this gap should be filled now in the interests of future development. With the creation of DOE and OER there are new opportunities for coordinated planning and support of fossil energy research activities; there is much that the universities can contribute to both the planning and conduct of this research.

3. <u>Summary</u>

The major points that I have made today are as follows:

1. Much university expertise could be brought to bear on fossil energy problems.

2. Active steps could speed the rate at which the best university groups are brought on-board the fossil energy program.

3. Research funding levels are insufficient to support the long-term fossil energy program objectives.

4. The gap between basic research and the hardware development projects needs to be filled now by a significant increase in the funding for applied research.

5. A fossil energy research plan is needed to give structure and direction to the programs.

6. Universities can assist in formulating the research plan and in performing much of the basic and applied research required to meet the long-term program objectives, and can assist in some of the development activities.

7. Consideration should be given to the possibility of resting the responsibility for the quality and support of both the basic and applied research programs with the Office of Energy Research in the Department of Energy.

DR. PHILLIPS: Thank you very much. This platform is open for comments and discussion. Dr. Mills?

DR. MILLS: I would like to address two aspects: obviously there were a number of very interesting points you were making.

I must say, in fossil energy, we have struggled hard, and then get the message back that we are not really in tune with the universities.

Just a couple points. ERDA supports on-campus research, $160 million; the largest health and safety; the second largest division of physical research; the third largest in fossil energy; and the on-campus research doesn't include the Montana activity, 22 million.

We are trying to build this up. We are letting contracts for three and four years. We have some of $600,000 or more per year of; M.I.T., Utah, Penn State, Cal Tech, and one or two others.

So we are struggling with universities to come to a mechanism to meet our joint needs and opportunities. And apparently, we are part way there, but far from what is satisfactory. So that's one point, just to put a couple numbers in there.

Now there is another point that I would like to make, and this is perhaps not so pleasant. We are turning down nine out of ten proposals from universities as being inadequate.

One gets back to the situation that coal has not been a very attractive university activity, and therefore, it's taking a long time to attract people to provide interesting activities.

A related question is, where is it best to do basic research? Is it in the industry, is it in the energy research centers, is it in the national labs, or is it in institutes?

I could remind you that many of the big progresses which were made in the past were at the Max Plank Institute; Burgess, Peer, and so on, who were winners--Burgess won a Nobel Prize for his work--were not at a university.

One of the questions is universities versus nonuniversities. And the other is basic research versus non.

You said that funding opportunities are not as attractive to the university community from ERDA as others. I am sure you have some specific points on that as to what it is we should do differently in order to provide this attractiveness.

DR. REYNOLDS: Thank you, Dr. Mills. I am sorry if I sounded critical of your activity. I certainly didn't mean to, only trying to give you some help.

I was trying to reflect a lot of comments that I have heard from colleagues around the country about what they perceive. Now, this may or may not be fact. It's what they perceive.

And this is not particularly fossil fuels, your program. This is a general sort of perception of the agency. It's highly fragmented; the approach to university research in one group is quite different than another group, and the statement has been made to me about the fossil energy program in particular, that you have to know a top guy to get any action on their proposal.

In many cases there are monthly letter reports that are due. These are not characteristics of the agencies that have been supporting most university research.

I would have to get personally specific to cite instances, and I don't think I'd better do that in this forum, but I would be happy to talk with you more about that.

MR. DEVLON: Mark Devlon from Argonne Laboratories.

I think you have a very good point on your last vugraph. Your point 6 was a desire for larger university and laboratory partnership.

My question to you is: Some of the national laboratories are operated by consortia of universities who have boards of directors who have responsibilities for planning. Do you look at that as an adequate or an appropriate way for this partnership to take place, or do you have some other approach?

DR. REYNOLDS: I am thinking more of partnerships at working levels. There is an excellent cooperation now between LBL and the Department of Mechanical Engineering at Berkeley, in the combustion area. I think this is a paradigm of what ought to happen.

There is an exchange of people in the department, Mechanical Engineering Department--they know the applied research needs, they know what combustion research is all about and how to do useful combustion research.

People in the laboratory know how to get good measurements and do good calculations. Putting these two together in a very constructive way; that's more of what I mean.

I would like to see, for example, the proposals that come from the laboratories for support be asked to see if they have the right mix of university support. I would like to see universities be encouraged to go team up with laboratories to get hold of some of the expertise that is there.

DR. PHILLIPS: Any other questions or comments?

DR. BARON: I think we have come here to consider the efficiency of ERDA's research. And I propose that we keep that in mind when we use such words as "basic research" and "applied research" and what not.

There are lots of ways to use them, and I guess all nomenclature is to some extent arbitrary. But when you are asking specifically; is some research efficient or not, I suggest that an entirely different definition of the work "basic" should be applied.

When that is done properly, very great light can be thrown on the efficiency of research.

Let me give a brief illustration. I am in charge of a party of gold prospectors, but I am stuck in Nevada. The commercial objective is to find gold in California. The problem is to get across the Sierras.

By the way, if I were in Hawaii, the problem would be to build a boat. So you can have different problems corresponding to the same objective, depending on where you are.

Now, there are two ways of doing this, one which I would consider corresponding to basic research, and the other to something else called exploratory, or some other way.

The one that would correspond to basic research would be to hire the National Geographic Society and ask them first to make a geological map of the Sierras, then make an elevation map of the Sierras.

And then you hire the National Botanical Society, and they would make a map of vegetation and so on and so forth.

And on the end, you would have all these maps, and you could clearly then find the suitable mountain pass, especially if you had maps of hardness and rock formations, and what not.

Now this corresponds to basic research. In fact, the very word "basic" means that everything you found is already based on some other foundation. That's why basic and fundamental research are the same synonyms of each other.

Now the other way of doing it, which in this case we all would do, I am sure, is to hire Jim Bowie and say find me a mountain pass.

This is exploratory research. The reason that we would do it this way is simply that we all know intuitively that in the first case, we would have to find an awful lot of knowledge which is unrelated to our problem.

So whether you use basic research or not is simply a question of how much of the knowledge that you must discover is related to the problem that you are addressing.

I am submitting to you that it's best to think of basic research as a method competing with other methods of doing it, and at an efficiency and a deficiency of any research program, be it Exxon's or Shell's or ERDA's, should be assessed on the criteria of what part of the total knowledge that is acquired by doing this research in fact addresses itself to the problem.

And only when you do that can you answer, should we do this in a basic way or some other way.

DR. PHILLIPS: Thank you.

Alex Zucker.

DR. ZUCKER: I just can't let that one go. This is great if you know exactly what the future holds.

But let me illustrate something that has come to mind just recently about utilization of research where you have no idea that the problem really even exists.

It turns out that nuclear accelerators have been built, oh, for the past 50 years, with the idea of examining properties of nuclei. It now turns out that they form one of the great foundations for many of the high technology areas of the future.

No one would have accused Cocroft and Walton, or Lawrence of looking at producing energy by fusion. But in point of fact, accelerators seem to offer a way for inertial fusion that could not have been foreseen.

In a similar way the whole accelerator technology is important for the ion implant game, and the production of small calculators.

The whole question of producing fissionable isotopes--breeding fissionable isotopes by accelerators offers a new, nonproliferating nuclear technology.

The situation is such that the basic science uncovers those areas which we cannot predict. Jim Bowie's trip would have been totally useless if it hadn't been for the science of cartography. He could not have come back and told the guy where California is.

So the whole question of measuring in a short term what you are getting is misleading. It would lead, for example, in the 19th century to a great science of pulleys and belts rather than developing electric motors.

And it is just a totally blind alley.

DR. PHILLIPS: I believe this is very exciting and romantic to search for gold in California, and not know where California is and things like that, but I believe it's a little bit off our subject now.

I declare it slightly out of order, although very interesting. Other questions at this time?

MR. SMITH: I wanted to ask Alex Mills a question earlier as a result of Bill Reynolds talk. I am ready to ask him.

One of the curious things I noticed about that map, where you had contracts with universities, was a total absence of dots in the Boston area and the Palo Alto-Berkeley regions. Is there any particular reason for that?

DR. MILLS: We have a large project at M.I.T., which is not in Boston, but Cambridge, if you will accept that.

(Laughter.)

MR. HILL: Let me respond a bit to that. We have been trying for years to subvert bright, university types into coal research.

Ten, fifteen years ago, I think there were three, maybe four universities that had a medium level of effort or a high level of effort.

The Electric Power Research Institute, in cooperation with Alex's shop, prior to that incorporation with NSF-RANN, tried to funnel money into coal research sponsorship, and found the very thing you say is true, Bill, that established research groups with their own pattern looking at dirty, old coal had a very hard time getting excited about it, particularly since there wasn't a format that gave the longevity to contracts.

I can't help mentioning, when I got my first contract with OCR years ago, Bill Cochran, bless his heart, said, "Hey, we've never had any contract with universities before, let me see, if you will, the contracts you've had from other agencies."

Stupidly, I gave him the contract from ONR, AEC and Air Force Office of Scientific Research. And the contracts people, bless their hearts, succeeded in putting together every restriction that each of those contracts had, including monthly reports, permission to talk had to be obtained by getting written permission from the office before you could talk about your research.

Well, that was backed away from. And then when I was here in Washington, we really backed away from it, and I think you've got a good system now.

But the point I'm making is that it has been a case of trying to get people to come into the field from the purer fields. And this requires a lot of effort.

We had to set up a department, a program area, to receive proposals from universities, because everybody wanted to study the kinetic formation of methane. And that wasn't one of the things that EPRI, for example, had interest in.

And so we had to have somebody that would work with the professor and turn his proposal to where it would pass peer review, And in that way--what do you have, 150 different sites that were not doing work before.

And they are not the big ones, because they are already established by and large, except M.I.T.

DR. PHILLIPS: Other questions or comments?

Yes. I think this will have to be the last comment.

MR. CANONICO: Domenic Canonico, Oak Ridge National Labs.

I would just point out something that Dr. Mills said earlier that over almost 50 percent of his unsolicited proposals come from universities. And I would hate to leave us here today with the idea that the universities are not interested in fossil energy research.

DR. PHILLIPS: Very good point.

Very well, we will now go on to our last paper, which will be a short one concerned with production of research manpower in the fossil energy area, by Ricki Kobayashi.

DR. KOBAYASHI: Thank you, Gerry.

On the way back from lunch, you said you would give me five minutes, so if you will push the warning button, I will get started.

DR. PHILLIPS: Go.

DR. KOBAYASHI: There are many comprehensive documents and papers such as:

(1) A Study of NASA University Programs, (NASA SP-185, 1968),

(2) The University and Environmental Quality (Report to the President's Environmental Quality Council, Office of Science and Technology, September, 1969),

(3) Fossil Energy Technical Manpower: Forecasts of Supply and Demand, (Prepared by Bernard S. Friedman for ERDA, October, 1975), and

(4) Engineering College Research and Graduate Study: A Ten Year Statistical Analysis by W. J. Fabrycky and I. D. Moon, Engineering Education <u>66</u>, 452 (1976).

and similar compilations provide statistical data, both historical and projectional, on U.S. scientific and technical manpower.

Rather than delve into a mass of statistical data, I shall present a few comments regarding manpower needs to meet "national" energy goals.

Although our activities in fossil energy exploration have been international in character for several decades, we have not been engaged in the optimum utilization of oil and gas in foreign lands except perhaps in Canada. The sudden change in proceeding towards a near optimum production and utilization of oil and gas in the OPEC nations could not be capitalized until after the oil embargo in 1973. Since that time scientific back-up and engineering work for and in the OPEC nations have increased several fold. Our ultimate involvement in foreign lands will cover all the fossil energy areas as we develop expertise in shale, tar sand, and coal utilization and advanced recovery methods for oil in the years ahead. Thus, a serious assessment of our manpower needs must include our deep involvement in fossil energy projects throughout the world as well as those designed to improve our fossil energy posture here at home!

As recently as 1974-1975, we actually experienced a rather severe decline in the number of bachelors degrees in engineering awarded. Engineering enrollments increased sharply, however, in 1975-1977, so that enrollment in engineering schools throughout the country has increased drastically in the last two years. The Arab oil embargo followed by the declaration of Project Independence and the general shift towards the pursuit of professional degrees are probably the main reasons. At any rate, a mass shift from the pure science to the applied areas of engineering has taken place. An imbalance of scientists to engineers and of bachelors degree to Ph.D. degree recipients will almost surely occur in the coming years.

The burgeoning enrollment in engineering schools throughout the country is now a fact. Enrollments in the earlier years in engineering schools throughout the country have increased up to a factor of four, depending on the curriculum and the university. This has, however, immediately led to the shortage of qualified personnel to teach them. The teaching problem during the first two years of their careers starts in the physics and chemistry and math departments, particularly in the all important teaching assistantship and tutorial type of relationships. A general laxity in the teaching of the language skills has reversed itself and even there a greater amount of instruction will be needed.

In chemical engineering alone, approximately 100 new faculty positions have sprung open in the last year and a half. Although exact figures are not yet available, probably two to three times that many new faculty positions have become available in all of engineering. Many of the positions, as our own, will have to be filled by temporary instructors, because we are unable to find or competitively bid for candidates possessing the requisite qualifications. The academic demands for Ph.D.'s together with similar increased demands of industry has led to a dearth of new Ph.D.'s in all areas of engineering. The shortage will only be reduced as a result of a combination of the following factors:

(1) the job market tightens for the B.S./M.S. graduates,

(2) a more favorable differential salary scale between the B.S./M.S. engineers and the Ph.D. develops,

(3) substantial infusion of traineeships and research funding becomes available to draw trainees from the swell of undergraduates, and/or

(4) retraining of Ph.D.'s from the scientific disciplines with an applications bias.

The point is that all the agencies: NSF, DOD, NASA, etc., have essentially phased out their support of graduate research simultaneously: In the sixties, the NASA university programs alone were responsible for training over one thousand graduate students per year. In contrast, the Energy Sector, which impacts almost 40 percent of our GNP, has just begun a rather feeble training program.

Disciplines of education are interdependent. The basic disciplines of education: science, literature and the arts, are interdependent. Since the ultimate goal we seek for individual development is interdisciplinary, the symmetry among the various disciplines in our educational institutions should be largely preserved. The weakening of one discipline in relation to another will ultimately lead to weakening of them all.

One of the quickest ways to transmit enthusiasm and ideas to the university campuses would be to provide summer faculty appointments to fossil energy-oriented research facilities at governmental and private research and development centers throughout the country. Existing fossil energy research centers are amongst the most sophisticated research centers in this country. A cooperative program to stimulate faculty members who in turn would transmit new understanding and enthusiasm to students is in order. In some cases appointments up to a year may be advisable, keeping in mind that the university teaching load has increased drastically.

On the occasion of the receipt of the 1972 Redwood Medal of the Institute of Petroleum, Professor Fred Rossini gave an address entitled "Chemical Thermodynamics in the Petroleum Industry" in which he summarized his involvement in the study of the thermodynamics of chemical compounds encountered in the petroleum industry over a period of over three decades. In retrospect, realizing that his studies were closely related to

(1) the production of petroleum,

(2) the transport of petroleum,

(3) the refining of petroleum,

(4) the production of petrochemicals from petroleum, and

(5) the environmental problems associated with the petroleum industry, would we not consider his studies as mission oriented? His work not only represents good basic science but also served to help direct a multitude of successful missions. A corollary observation is that a futuristic view might lead to the conclusion that a given research endeavor was very basic, or abstract, while an historical view of the same endeavor would class it as obviously mission oriented. Many, many similar examples could be made of other "basic studies." The point I wish to make is that we should take heed not to define the work "mission" too narrowly.

In his address to the Columbia University Graduate School of Business in May, 1968, James E. Webb, then administrator of NASA, delivered a series of talks entitled "Goal Setting and Feedback in Large Scale Endeavors." We are, I presume, engaged in a "large scale endeavor" or "endeavors." One of the most important points made by Mr. Webb is that care should be taken in assessing the relationships between the primary goals and the accompanying sub-goals or "sub-missions" in our case. He claims that the second- and third-order effects, good and bad, must be better evaluated to predict the total impact of large endeavors on society. We have seen and are beginning to see some of the secondary effects of the space program on our society. The secondary effects may even become as large as our primary goals in the years ahead.

In concluding my talk, I quote from an address to the Educational Section of the International Congress of Mathematicians in 1912, by A. N. Whitehead, "I recur to the thought of the Benedictines, who saved for mankind the vanishing civilization of the ancient world by linking together knowledge, labor, and moral energy. Our danger is to conceive practical affairs as the kingdom of evil, in which success is only possible by extrusion of ideal aims. I believe that such a conception is a fallacy directly negatived by practical experience. In education this error takes the form of a mean view of technical training. Our forefathers in the dark ages saved themselves by embodying high ideals in great organizations. It is our task, without servile imitation to exercise our creative energies."

DR. PHILLIPS: It is open for discussion. Any comments or discussion?

Dr. White.

DR. WHITE: I want to comment on the question, but I certainly second your enthusiasm for the appointment of faculty people for summer employment in the ERC's. As far as I personally am concerned, I urge my fellow directors to do everything they can within budget limitations. I think that it is not a useful exercise unless it is possible to give that man coming in a really meaningful assignment. And it seems like that should be easy, but if you got 10 or 15, then to go to 20 or 30, it becomes a real challenge in a laboratory which is, as some of them are, relatively small with relatively small supervisory staffs. I just mention that side of that problem. If you feel we are not doing enough, it may be that it is not just money or not willingness, but a conviction that quality is equally important to quantity.

DR. KOBAYASHI: I certainly agree with that.

DR. PHILLIPS: Thank you. Any other questions or comments?

Are there any general comments or discussion anyone wants to give in regard to today's program?

DR. WHITE: I guess we will have a session tomorrow on ideas, but sometimes you have conflicts in times for meeting. I just wanted to mention a thought I had in the shale area.

There were a number of points up there about the engineering aspects of retorting. There are other ways of getting the material out of shale than just retorting. I know back when I was at AMOCO on hydro retorting, also solvents, and these sort of things can be done, and they are in some ways very attractive.

One of the things, for example, the hydro retorting is clear enough so that in order to begin to talk intelligently and listen intelligently about some of the claims, I suggested to one of the fellows, I think it is one kind of thing that might be done in the university.

We had a Fisher-Assay for a pyrolysis step in trying to assay Western shales. We don't have anything equivalent, any hydro retorting step, which is a standardized test procedure that you can say, well, if you treat it by this test, you will get 50 gallons a ton, or 20, or whatever it might be. One of the interesting things is this, Eastern shales, Devonian types, which are no good at all for normal retorting; they don't respond and they are very low Fisher-Assay, but you give them hydro retorting and they produce some very surprisingly high volumes of reasonable liquid yield.

Now, these are the sort of areas that we don't understand, what are the differences, but I know in some of our work, some of the solvents are intriguing. Now that may be entirely impractical to use commercially, but, on the other hand, maybe some further basic work there could give some useful answers.

Another problem that is similar, isn't related at all, sort of in-between the shale and coal, and that is some of our heavy oils. There are some very large amounts of heavy oil deposits, not only in

California, but also in the East--excuse me, in the midcontinent, Missouri and Kansas area, which are not recoverable by any normal technique and it is a real challenge to find a way to get those out. The economics are going to be critical here.

One of the things we are trying to pound into our fellows, any time we are thinking about it is, remember, we do have to face that net energy, no matter what the dollar cost is. You may say, "Some day the cost may rise enough, so even if my method is expensive, it will be worthwhile to get those out, so go ahead and work on the method.

But if you are spending 150 Btu's to get it out, totally, and you are only getting out 100, I don't care what the price is, it's still not going to be very attractive.

DR. BARON: On that point, it is rather amazing, we plan to calculate what amount of oil will be recoverable by using only the criteria that I can't expend more energy than I am getting. I got to 60 billion barrels as opposed to the normal 20, 21 billion barrels that we talked about as being reasonable.

DR. WHITE: I never heard that figure before.

DR. PHILLIPS: I have an interesting number in regard to the geopressured gas, brines. As you know, roughly a month ago it was reported that, I guess it was 17 cubic feet, is that right, Phil, per barrel--

DR. WHITE: 20 to 50. In our current well ERDA is producing, it is running 50 cubic feet a barrel.

DR. PHILLIPS: Okay. Take my number and multiply it by about 3. However, I remember the number, it corresponds to 3.4 cents per barrel. However, that is not the number that interests me. The number that interests me is that of the gravitational energy that would have to be expended to raise the barrel from 10,000 feet to the surface, and then assuming that the second lowest value, it would take at least that much to put it back in the ground, that comes out to almost 75 percent of energy content of the barrel. It seems to me, if anything, that might prove that this is where we need an in situ technology.

We don't want to have to bring it up and put it back down. Are there other comments?

DR. WHITE: There is a real challenge.

DR. PHILLIPS: A real challenge. Very fundamental. Dr. McBride?

DR. MCBRIDE: Frank McBride, Colorado School of Mines. You have asked us to think about the basic science future of your agency, and whether what you are doing is good basic science. And I don't mean it is appropriate at the moment, but it could be improved upon.

It prompts me to ask you whether or not you or anyone else has in your laboratory a group of scientific generalists who do nothing but think about this kind of problem? As I sit here listening to these processes, I am sure that Irving Wender doesn't need my advice about any of the things he is currently doing. I suspect that some of my fellow invitees and all of the participants would say the same thing. But it might be if somebody thought very differently from Irving and had the challenge to think differently from Irving, he might come up with an answer which would surprise all of us. And thinking for only a day and a half about these problems is really not enough. You have to put your feet up on the desk with Dr. Wender and say, "Now, dammit all, if you can do this, what would happen?" That is the kind of talk you need.

I guess my suggestion to you is--it is probably a half-baked suggestion, is that you establish a scientific internal auditor gadfly group that does nothing but go around and put its feet up on the desk and say, "Now, dammit all, why are you doing it this way?" Do you have such a group?

DR. PHILLIPS: That is sort of the purpose of this meeting, as a matter of fact, Doctor.

DR. MCBRIDE: I understand that but I am suggesting to you that this meeting is probably going to be ineffective for that purpose. You need an in-house gadfly.

DR. PHILLIPS: Sure. I think you certainly must be right. However, I think our intention is to get information from the outside.

We certainly want your first cut at it. That is for sure. In fact, in that regard, I think we should close the meeting now. But I would again remind you, if you want to participate in our study groups tomorrow, please let us know by turning in one of these sheets with your name.

To Dr. McBride's discussion, we are mainly concerned with questions of balance. There is a tendency for organizations to become obsessed with the current problems and activities. Once again, that is natural, if counterproductive. When existing problems are frustrating, exhausting, little energy is left for detached appraisal. There may be room for something like a special assistant for devil's advocacy charged with the responsibility of challenges to prevailing concepts.

Through a structurally-recorded position of partial independence, he may be able to save his leader from longer-run slips, arising from every occupation, of the current problem.

Useful dissent, which might otherwise be ground in natural bureaucratic conflict, would have a greater chance to emerge.

(Applause.)

I thank all of you. We will convene again in the morning at 8:30.

(Whereupon, the meeting was adjourned at 5:30 p.m. to reconvene Wednesday, 29 June 1977 at 8:30 a.m.)

MITRE CORPORATION

and the

U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

PUBLIC MEETING

on

FOSSIL ENERGY RESEARCH

Quality Inn
415 New Jersey Avenue, N.W.
Federal Ballroom South
Washington, D.C.

Wednesday, 29 June 1977

The meeting in the above-entitled matter was reconvened, pursuant to adjournment, at 8:30 a.m. Dr. R.H. Kropschot, presiding.

PROCEEDINGS

DR. KROPSCHOT: Good morning. May I please call the meeting to order.

We would like to proceed with our presentations, and since in this program the exception is the rule, we are going to deviate slightly from our schedule again. I would like to introduce the second paper on your agenda rather than the first one. The Environmental Safety Research, that is entered under the direction of the Assistant Administrator for Environmental Safety. The Special Assistant to Dr. Liverman, Dr. George Shepherd, will present that work.

DR. SHEPHERD: Thank you. I am coping with a bout of laryngitis. If I fade out in the middle of the talk, those of you who wish to follow my remarks can read my lips. For the rest of it, I tried to make the slides self-explanatory.

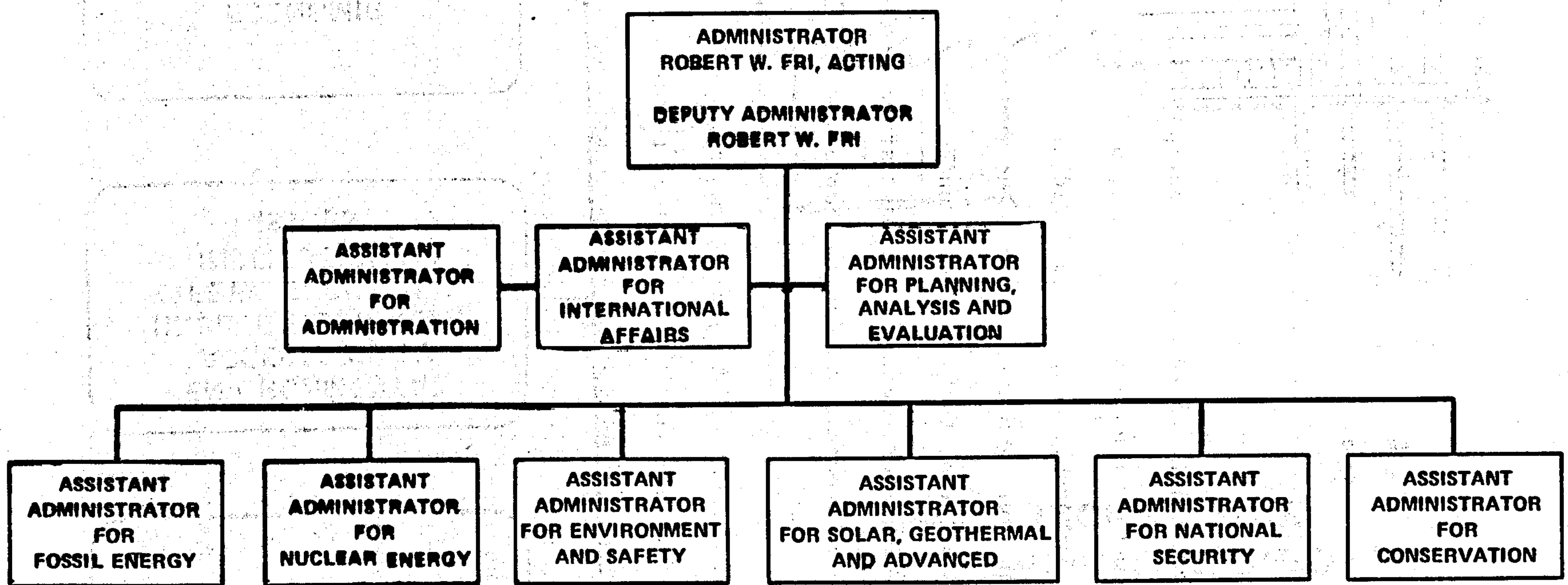
(Slide 1)

The Office of the Assistant Administrator for Environmental Safety is represented by the third box from the left.

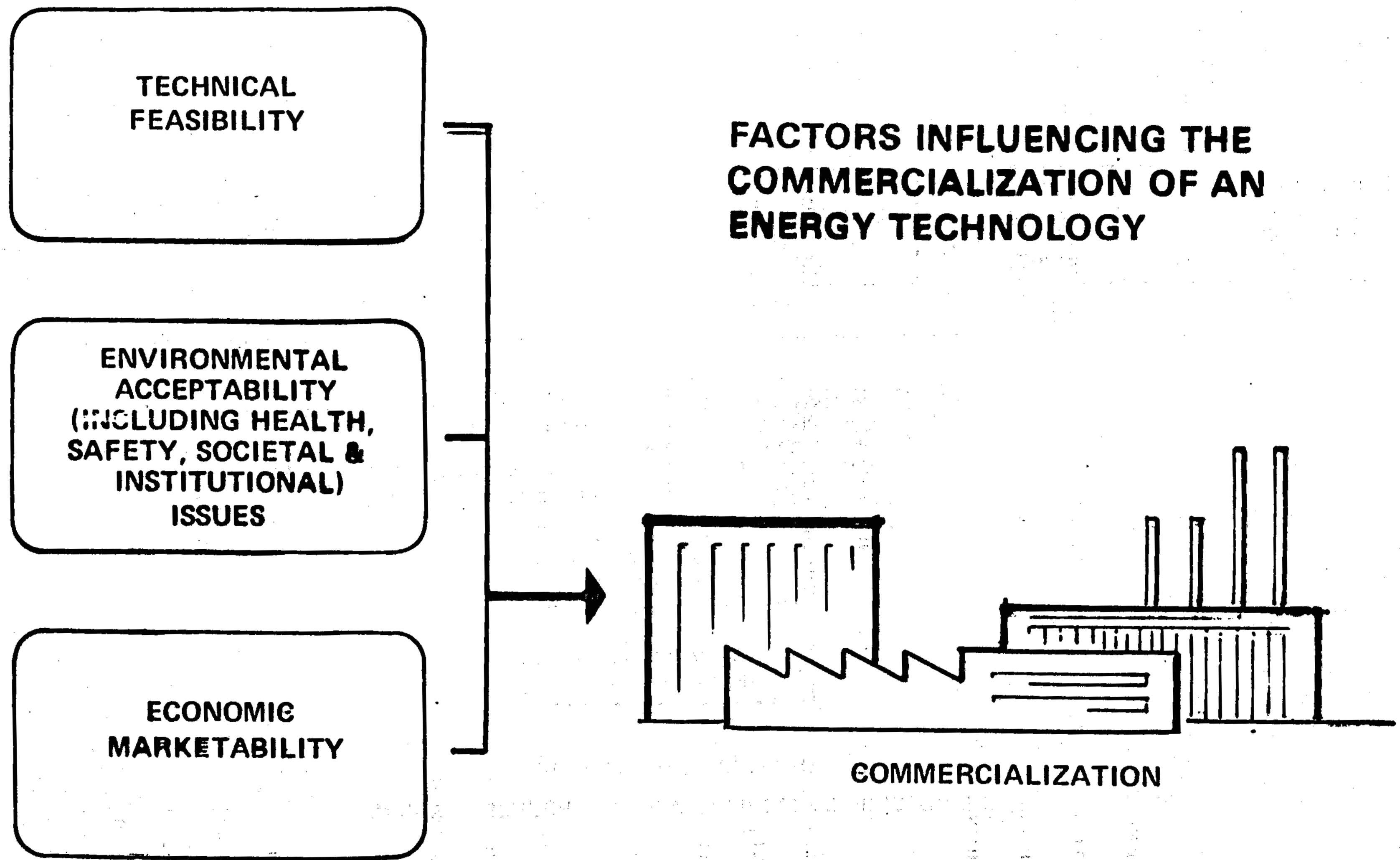
(Slide 2)

Factors influencing the commercialization of an energy technology include technical feasibility, environmental acceptability, and economic marketability. While this is an oversimplification, there is an environmental factor in acceptance of a technology.

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
ORGANIZATIONAL CHART



FACTORS INFLUENCING THE COMMERCIALIZATION OF AN ENERGY TECHNOLOGY



(Slide 3)

The Environment and Safety Program goals are to ensure that energy technologies are developed with adequate considerations for environment, safety and health requirements in our operating facilities and to conduct general life science and medical applications research.

(Slide 4)

The environment and safety program, run by the Assistant Administrator for Environment and Safety, has three major components to it; energy technology, overview and assessment research, and environmental health and safety assurance.

(Slide 5)

The AES Program objectives in research are to assess the health, biological and environmental affects from energy generation; to characterize, measure and monitor energy related pollutants; to conduct studies in general life science missions; and to conduct, within ERDA, the reactor safety research programs of NRC.

(Slide 6)

The AES organization is composed of a number of organizational boxes. We are going to concern ourselves with the bottom 5; Biomedical and Environmental Research, Operational Safety, Control Technology, Safety Research Coordination and Technology Overview.

(Slide 7)

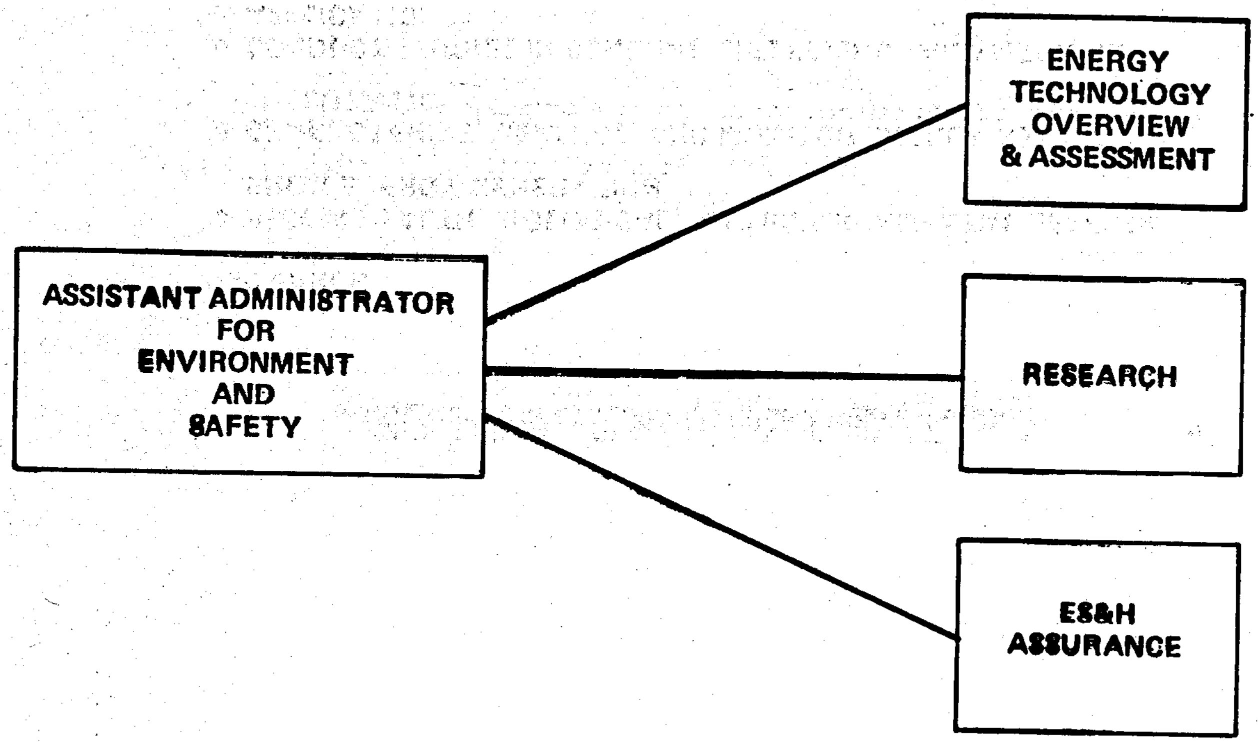
The prime responsibility of the Division of BER, Biomedical and Environmental Research, is research. The Office of Reactor

ENVIRONMENT AND SAFETY PROGRAM

GOALS:

- TO ENSURE THAT ENERGY TECHNOLOGIES ARE DEVELOPED WITH ADEQUATE CONSIDERATION OF ENVIRONMENTAL, SAFETY, AND HEALTH REQUIREMENTS FOR COMMERCIALIZATION.
- TO ENSURE ADEQUATE CONSIDERATION OF ENVIRONMENTAL, SAFETY, AND HEALTH REQUIREMENTS IN ERDA'S OPERATING FACILITIES.
- TO CONDUCT GENERAL LIFE SCIENCE AND MEDICAL APPLICATIONS RESEARCH.

ENVIRONMENT & SAFETY PROGRAM

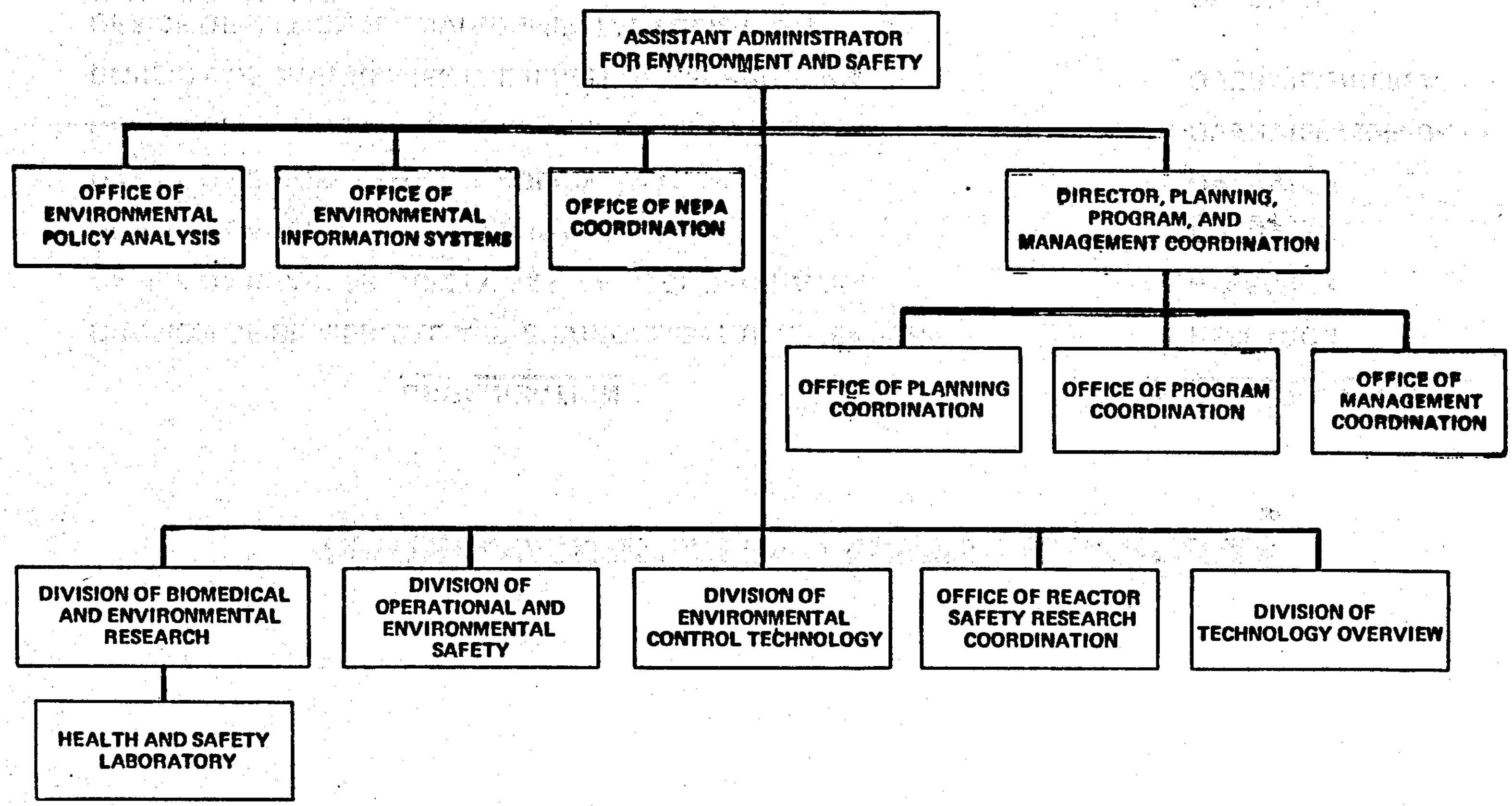


AES PROGRAM OBJECTIVES

RESEARCH

- ASSESS HEALTH, BIOLOGICAL, AND ENVIRONMENTAL EFFECTS FROM ENERGY GENERATION
- CHARACTERIZE, MEASURE, AND MONITOR ENERGY-RELATED POLLUTANTS
- CONDUCT STUDIES IN GENERAL LIFE SCIENCE AND MEDICAL APPLICATIONS
- COORDINATE WITHIN ERDA THE REACTOR SAFETY RESEARCH PROGRAM OF NRC

AES ORGANIZATION



ENVIRONMENT AND SAFETY PROGRAMS

ORGANIZATION	PRIME RESPONSIBILITY
DIVISION OF BIOMEDICAL AND ENVIRONMENTAL RESEARCH	RESEARCH
OFFICE OF REACTOR SAFETY RESEARCH COORDINATION	RESEARCH
DIVISION OF TECHNOLOGY OVERVIEW	OVERVIEW
OFFICE OF ENVIRONMENTAL POLICY ANALYSIS	OVERVIEW
OFFICE OF ENVIRONMENTAL INFORMATION SYSTEMS	OVERVIEW/SUPPORT
DIVISION OF ENVIRONMENTAL CONTROL TECHNOLOGY	OVERVIEW/RESEARCH
OFFICE OF NATIONAL ENVIRONMENTAL POLICY ACT COORDINATION	OVERVIEW
DIVISION OF OPERATIONAL AND ENVIRONMENTAL SAFETY	ES&H ASSURANCE

Safety Research Coordination, has as its prime responsibility, research. The Division of Technology Overview functions as an overview structure; that is, it determines the relevance of research program activities.

The Office of Environmental Policy Analysis is, as its name implies, a policy group which contributes policy statements and concepts to management or research programs. The Office of Environmental Information Systems, again self-explanatory, is concerned with computers, software and data management.

Environmental Control Technology has both overview and research responsibilities, and are concerned with control technology devices and the applications thereof. National Environmental Policy Act Coordination coordinates environmental impact statements operations. And Operational Environmental Safety is concerned with occupational safety and health.

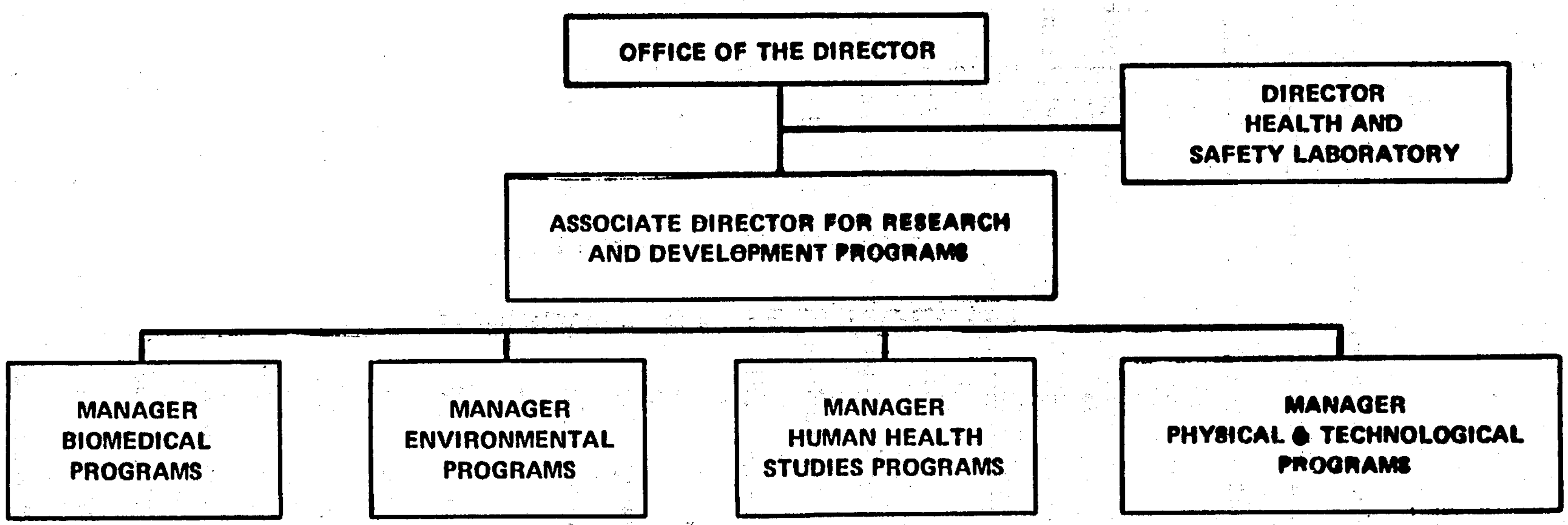
(Slide 8)

The Division of Biomedical and Environmental Research has four programs. Biomedical programs, environmental programs, human health studies, and physical and technological health studies.

(Slide 9)

The summary of the technology breakdowns in dollars for '77 and '78 are as you see here. The category "multitech" includes research programs which are relevant to two or more technologies.

DIVISION OF BIOMEDICAL AND ENVIRONMENTAL RESEARCH



AES FY 1978 BUDGET

OPERATING BUDGET

BIOMEDICAL AND ENVIRONMENTAL RESEARCH: SUMMARY BY TECHNOLOGY

(DOLLARS IN THOUSANDS)

	FY 1977 ESTIMATE	FY 1978 ESTIMATE
FOSSIL	$ 27.7	$ 34.7
SOLAR	1.2	1.6
GEOTHERMAL	2.8	3.7
CONSERVATION	2.0	1.8
NUCLEAR	54.9	57.8
MULTI TECHNOLOGY	35.3	36.3
TOTAL	$ 123.9	$ 136.0

For example, a program in cadmium toxicity might well relate to more than one technology, since this metal occurs in several Technology Fuel cycles.

(Slide 10)

If we break the fossil line down further, you find that dollars are distributed among human health studies, health effects and biological systems, environmental studies, and physical and technological studies.

(Slide 11)

If we look at environmental, we can break down fossil into extraction, combustion, gasification, liquefaction, oil and gas, and oil shale; but the dollars are as you see here.

(Slide 12)

Health Effects in Biological Systems (Fossil) can be broken down into combustion, gasification, extraction, and shale. The dollars are as you see here, totaling $10.6 million and 13.5 million for '77 and '78.

(Slide 13)

(Slide 14)

Human Health Studies can be broken down in fossil into these four categories; combustion, liquefaction, oil and gas, and oil shale.

AES FY 1978 BUDGET

OPERATING BUDGET

BIOMEDICAL AND ENVIRONMENTAL RESEARCH: FOSSIL

(DOLLARS IN THOUSANDS)

	FY 1977 ESTIMATE	FY 1978 ESTIMATE
HUMAN HEALTH STUDIES	$ 2.4	$ 3.4
HEALTH EFFECTS RESEARCH IN BIOLOGICAL SYSTEMS	10.6	13.5
ENVIRONMENTAL STUDIES	12.3	14.5
PHYSICAL AND TECHNOLOGICAL STUDIES	2.4	3.3
TOTAL	$ 27.7	$ 34.7

BIOMEDICAL AND ENVIRONMENTAL RESEARCH

OPERATING BUDGET

ENVIRONMENTAL STUDIES: FOSSIL

(DOLLARS IN THOUSANDS)

	FY 1977 ESTIMATE	FY 1978 ESTIMATE
COAL EXTRACTION, STORAGE AND PROCESSING	$ 1.2	$ 1.5
COAL COMBUSTION	7.8	8.6
COAL GASIFICATION AND LIQUEFACTION	.7	1.3
OIL AND GAS	1.5	1.7
OIL SHALE	1.1	1.4
TOTAL	$ 12.3	$ 14.5

BIOMEDICAL AND ENVIRONMENTAL RESEARCH

OPERATING BUDGET

HEALTH EFFECTS RESEARCH IN BIOLOGICAL SYSTEMS: FOSSIL

(DOLLARS IN THOUSANDS)

	FY 1977 ESTIMATE	FY 1978 ESTIMATE
COAL EXTRACTION, STORAGE AND PROCESSING	$ .3	$ .2
COAL COMBUSTION	4.4	5.0
COAL GASIFICATION & LIQUEFACTION	5.1	7.2
OIL SHALE	.8	1.0
TOTAL	$ 10.6	$ 13.5

BIOMEDICAL AND ENVIRONMENTAL RESEARCH

OPERATING BUDGET

PHYSICAL & TECHNOLOGICAL STUDIES: FOSSIL

(DOLLARS IN THOUSANDS)

	FY 1977 ESTIMATE	FY 1978 ESTIMATE
COAL GASIFICATION & LIQUEFACTION	$ 2.0	$ 2.9
OIL SHALE	.4	.4
TOTAL	$ 2.4	$ 3.3

BIOLOGICAL AND ENVIRONMENTAL RESEARCH

OPERATING BUDGET

HUMAN HEALTH STUDIES: FOSSIL

(DOLLARS IN THOUSANDS)

	FY 1977 ESTIMATE	FY 1978 ESTIMATE
COAL COMBUSTION	$ .9	$ 1.9
COAL GASIFICATION & LIQUEFACTION	.9	1.4
OIL AND GAS	.5	.1
OIL SHALE	.05	.05
TOTAL	$ 2.4	$ 3.4

(Slide 15)

Environmental Engineering. Again we are talking about the fossil energy, solar, nuclear energy and material transportation. The dollars are as you see here.

(Slide 16)

The environmental energy engineering in the fossil category breaks down into coal, petroleum and gas, and oil shale components.

(Slide 17)

Technology Overview deals with the assessment of health of energy systems, the assessment of environmental and socioeconomic impacts and the assessment of impacts of energy production in local, regional and national scales. I am sure that many of you have come in contact with some of our programs in your respective various regions.

(Slide 18)

If we look at the total funding summary, you will see that Biomedical Environmental Research, ECT, Operational Safety, and so on, have the budget outlays that you see here.

Now, where does this money go?

(Slide 19)

Our ERDA resources, dollars, are going to a variety of places, including universities, other agencies, national laboratories and energy centers. We do have funds going overseas to international

AES ENERGY RESEARCH AND DEVELOPMENT

OPERATING BUDGET

ENVIRONMENTAL ENGINEERING

(DOLLARS IN THOUSANDS)

	FY 1977 ESTIMATE	FY 1978 ESTIMATE
FOSSIL ENERGY	$ 5.2	$ 6.2
SOLAR, GEOTHERMAL & ENERGY CONSERVATION	1.2	1.3
NUCLEAR ENERGY	1.7	3.5
ENERGY MATERIAL TRANSPORTATION	2.3	3.4
TOTAL	$ 10.4	$ 14.4

AES ENERGY RESEARCH AND DEVELOPMENT
OPERATING BUDGET
ENVIRONMENTAL ENGINEERING
FOSSIL
(DOLLARS IN THOUSANDS)

	FY 1977 ESTIMATE	FY 1978 ESTIMATE
COAL	$ 3.5	$ 3.6
PETROLEUM AND GAS	1.4	1.9
OIL SHALE	.3	.7
TOTAL	$ 5.2	$ 6.2

AES ENERGY RESEARCH AND DEVELOPMENT
OPERATING BUDGET

TECHNOLOGY OVERVIEW
INTEGRATED ASSESSMENT

(DOLLARS IN THOUSANDS)

	FY 1977 ESTIMATE	FY 1978 ESTIMATE
ASSESSMENT OF HEALTH OF ENERGY SYSTEMS	$ .5	$ .5
ASSESSMENT OF ENVIRONMENTAL AND SOCIOECONOMIC IMPACTS OF ENERGY SYSTEMS	.4	.4
ASSESSMENT OF IMPACTS OF ENERGY PRODUCTION IN LOCAL, REGIONAL & NATIONAL SCALES	4.4	6.0
TOTAL	$ 5.3	$ 6.9

AES FY 1977-78 FUNDING SUMMARY

(OPERATING EXPENSES)

(IN MILLIONS)

ORGANIZATION	B/O IN MILLIONS FY 77	FY 78*
BIOMEDICAL AND ENVIRONMENTAL RESEARCH	164.7	173.0
ENVIRONMENTAL CONTROL TEHCNOLOGY	16.8	27.9
OPERATIONAL AND ENVIRONMENTAL SAFETY	5.9	7.7
OVERVIEW AND ASSESSMENT	18.0	18.0
REACTOR SAFETY RESEARCH COORDINATION	21.0	21.6
	226.4 1/	248.2

*PRESIDENTIAL
BUDGET (DOES NOT INCLUDE POSSIBLE CONGRESSIONAL ACTIONS)
1/ INCLUDES RESTORATION OF DEFFERAL FUNDS (8.9M)

ERDA RESOURCES
$

→

UNIVERSITIES
OTHER AGENCIES
NATIONAL LABS
ENERGY CENTERS
RESEARCH INSTITUTES
COMMERCIAL CONCERNS
STATE ORGANIZATIONS
LOCAL ORGANIZATIONS
PUBLIC INTEREST GROUPS
NATIONAL ACADEMIES
INTERNATIONAL BODIES
OTHER COUNTRIES

→ ERDA R&D NEEDS

bodies, and we may expand this further through the Agency for International Development.

(Slide 20)

I tried to break down as best I could the distribution of dollars by national laboratories, colleges and universities and others for our entire budget, for research and development. While the National Laboratories are carrying a large part of the load, a fairly good proportion of our resources go into colleges and universities.

Earlier today I was asked how we determine our priorities, how we determine what is relevant and what our needs are, and how we avoid overlapping what people in other agencies are doing?

ERDA conducted in '74, '75, and '76, and is conducting in 1977, a federal inventory of energy-related environmental and safety research. I have here, a copy of our 1976 executive summary. Additional copies are available from the National Technical Information Service. We asked agencies to provide us with descriptions of all of their projects dealing with environment, safety, and health-related energy research. In the next slide, a listing of responses from various agencies may be seen.

(Slide 21)

DR. RAMSEY: Is the response defined as a project?

DR. SHEPHERD: The response is defined by a project. For example, you might find that the Department of Agriculture, where

399

AES ENERGY RESEARCH AND DEVELOPMENT
OPERATING BUDGET

OPERATING BUDGET

(DOLLARS IN THOUSANDS)

	FY 1977 ESTIMATE	FY 1978 ESTIMATE
NATIONAL LABORATORIES	$ 79.1	$ 87.2
COLLEGES AND UNIVERSITIES	31.8	36.7
OTHER	39.6	50.8
TOTAL	$ 150.5	$ 174.7

INVENTORY OF FEDERAL ENERGY-RELATED ENVIRONMENT AND SAFETY RESEARCH (FY1976)

FEDERAL AGENCY RESPONSES

	NO. OF RESPONSES
DEPARTMENT OF AGRICULTURE (DOA)	7
DEPARTMENT OF COMMERCE (DOC)	93
DEPARTMENT OF DEFENSE (DOD)	3
DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE (HEW)	263
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT (HUD)	1
DEPARTMENT OF INTERIOR (DOI)	80
DEPARTMENT OF TRANSPORTATION (DOT)	9
ENVIRONMENTAL PROTECTION AGENCY (EPA)	305
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION (ERDA)	1467
FEDERAL ENERGY ADMINISTRATION (FEA)	20
NATIONAL SCIENCE FOUNDATION (NSF)/RANN	18
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)	5
NUCLEAR REGULATORY COMMISSION (NRC)	200
TENNESSEE VALLEY AUTHORITY (TVA)	65

there were seven projects, also submitted a total input of $7 million. You might find that ERDA, which deals with principal investigators and less with aggregates, in the health area, reported a large number of $10,000 to $50,000 projects.

(Slide 22)

Next, we analyzed these projects according to their individual relevance to R&D needs in environment, safety, and health for fossil energy.

(Slide 23)

Now, if we break down what is going on in the Federal Government in environment and safety research by each of these departments, you will find, for example, that we can break it into fossil, inexhaustible, nuclear and others. This is a fairly recent slide put together yesterday; we just didn't have the data before then. This is going to be available as an ERDA publication sometime in August.

Using this inventory analysis, we can go back and identify each of these programs and find out what a given agency is doing.

(Slide 24)

This information went into a data base at Oak Ridge and is available on an interactive or batch basis. Other agencies are tied in through RECON, and this information is essentially available to the public.

INVENTORY OF FEDERAL ENERGY-RELATED ENVIRONMENT AND SAFETY RESEARCH (FY1976)

SUMMARY OF ANALYSIS

FEDERAL AGENCY	PROJECTS REPORTED		EQUIVALENT PROJECTS	
	No. Proj.	$Millions	No. Proj.	$Millions
DEPARTMENT OF AGRICULTURE (DOA)	7	7.6	18	11.2
DEPARTMENT OF COMMERCE (DOC)	93	41.0	145	50.6
DEPARTMENT OF DEFENSE (DOD)	3	1.4	3	1.4
DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE (HEW)	263	22.6	426	31.5
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT (HUD)	1	(a)	1	(a)
DEPARTMENT OF INTERIOR (DOI)	80	25.9	114	26.4
DEPARTMENT OF TRANSPORTATION (DOT)	9	0.4	9	0.4
ENVIRONMENTAL PROTECTION AGENCY (EPA)	305	63.0	421	68.8
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION (ERDA)	1467	197.5	2330	349.4
FEDERAL ENERGY ADMINISTRATION (FEA)	20	1.7	23	1.7
NATIONAL SCIENCE FOUNDATION (NSF)/RANN	18	1.2	13	1.2
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)	5	1.3	14	3.0
NUCLEAR REGULATORY COMMISSION (NRC)	200	77.5	210	84.5
TENNESSEE VALLEY AUTHORITY (TVA)	65	11.8	71	21.4
TOTAL	2536	452.9	3798	651.5

(a) = less than $0.05 Millions

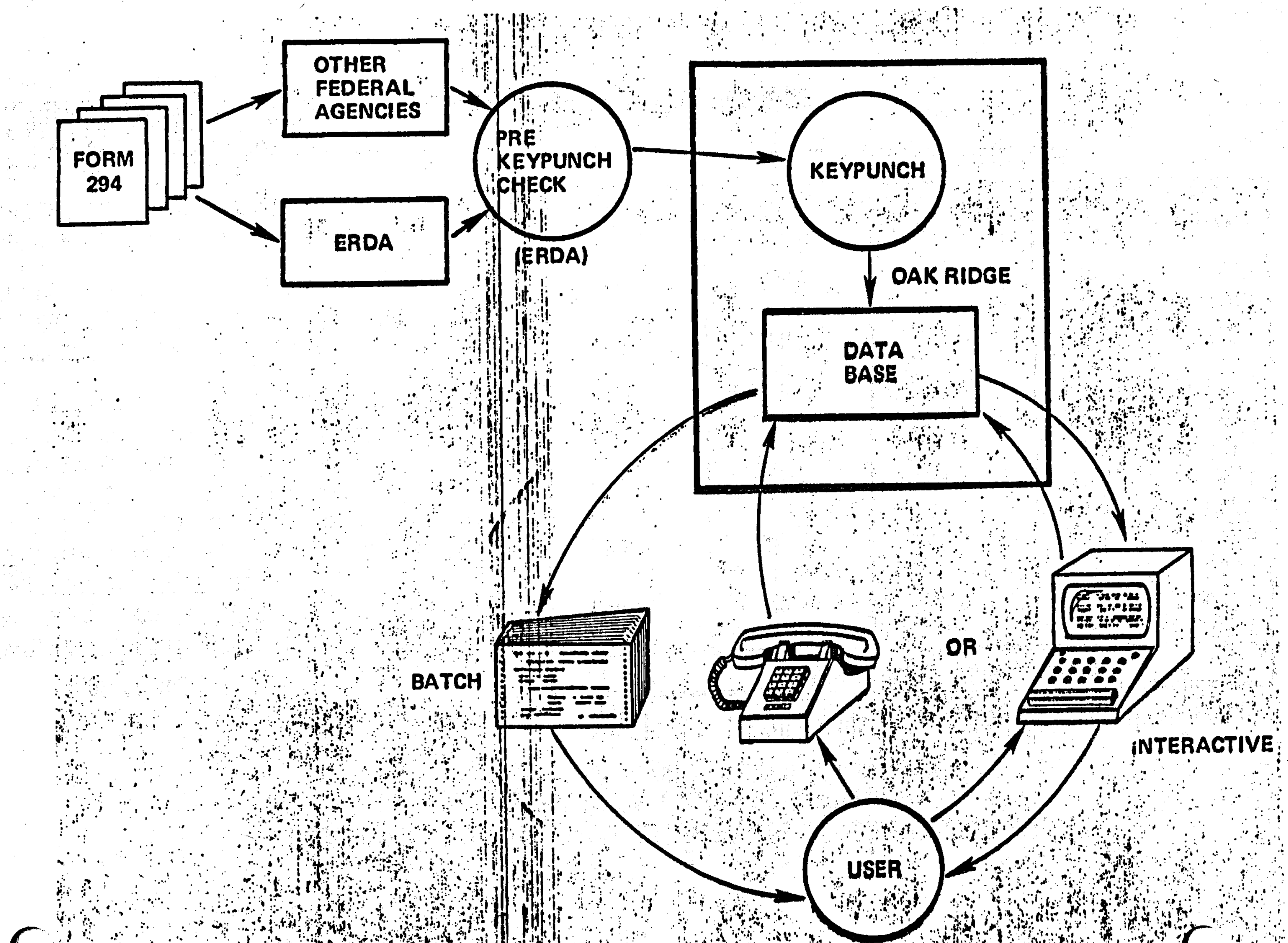
INVENTORY OF FEDERAL ENERGY-RELATED ENVIRONMENT AND SAFETY RESEARCH (FY1976)

SUMMARY OF ANALYSIS BY ENERGY TECHNOLOGY

FEDERAL AGENCY	FOSSIL FUELS (1)	INEXHAUSTIBLE FUELS (2)	NUCLEAR FUELS (3)	OTHER (4)	TOTAL
	(NUMBER PROJECTS/$ MILLIONS)				
DEPARTMENT OF AGRICULTURE (DOA)	16/11.0	-	2/0.2	-	18/11.2
DEPARTMENT OF COMMERCE (DOC)	73/41.0	2/0.1	36/3.8	32/5.8	145/50.6
DEPARTMENT OF DEFENSE (DOD)	1/0.1	2/1.3	-	-	3/1.4
DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE (HEW)	305/20.8	13/1.0	21/1.5	87/8.2	426/31.5
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT (HUD)	-	-	-	1/(a)	1/(a)
DEPARTMENT OF INTERIOR (DOI)	61/12.3	11/1.4	18/4.3	24/8.4	114/26.4
DEPARTMENT OF TRANSPORTATION (DOT)	-	-	-	8/0.3	8/0.3
ENVIRONMENTAL PROTECTION AGENCY (EPA)	288/45.2	28/5.1	30/4.8	75/13.7	421/68.8
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION (ERDA)	1119/138.8	175/21.4	710/149.4	326/39.6	2330/349.4
FEDERAL ENERGY ADMINISTRATION (FEA)	9/0.2	5/1.0	1/(a)	8/0.3	23/1.5
NATIONAL SCIENCE FOUNDATION (NSF)/RANN	1/0.2	4/0.2	-	8/0.7	13/1.1
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)	9/2.3	2/0.4	2/0.2	1/0.1	14/3.0
NUCLEAR REGULATORY COMMISSION (NRC)	10/0.8	-	126/28.9	74/54.8	210/84.5
TENNESSEE VALLEY AUTHORITY (TVA)	32/16.7	7/0.9	7/0.3	23/3.5	71/21.4

(a) - LESS THAN $0.05 MILLIONS

(1) COAL, OIL & GAS, OIL SHALE
(2) SOLAR, GEOTHERMAL, CONSERVATION
(3) FISSION AND MAGNETIC FUSION
(4) GENERAL SCIENCE AND PROJECTS NOT APPLICABLE TO ISSUES AND REQUIREMENTS



FORM 294
OTHER FEDERAL AGENCIES
ERDA
PRE KEYPUNCH CHECK
(ERDA)
KEYPUNCH
OAK RIDGE
DATA BASE
BATCH
OR
INTERACTIVE
USER

(Slide 25)

We can retrieve from this base in a variety of ways. This just gives you one example of a recovery matrix.

(Slide 26)

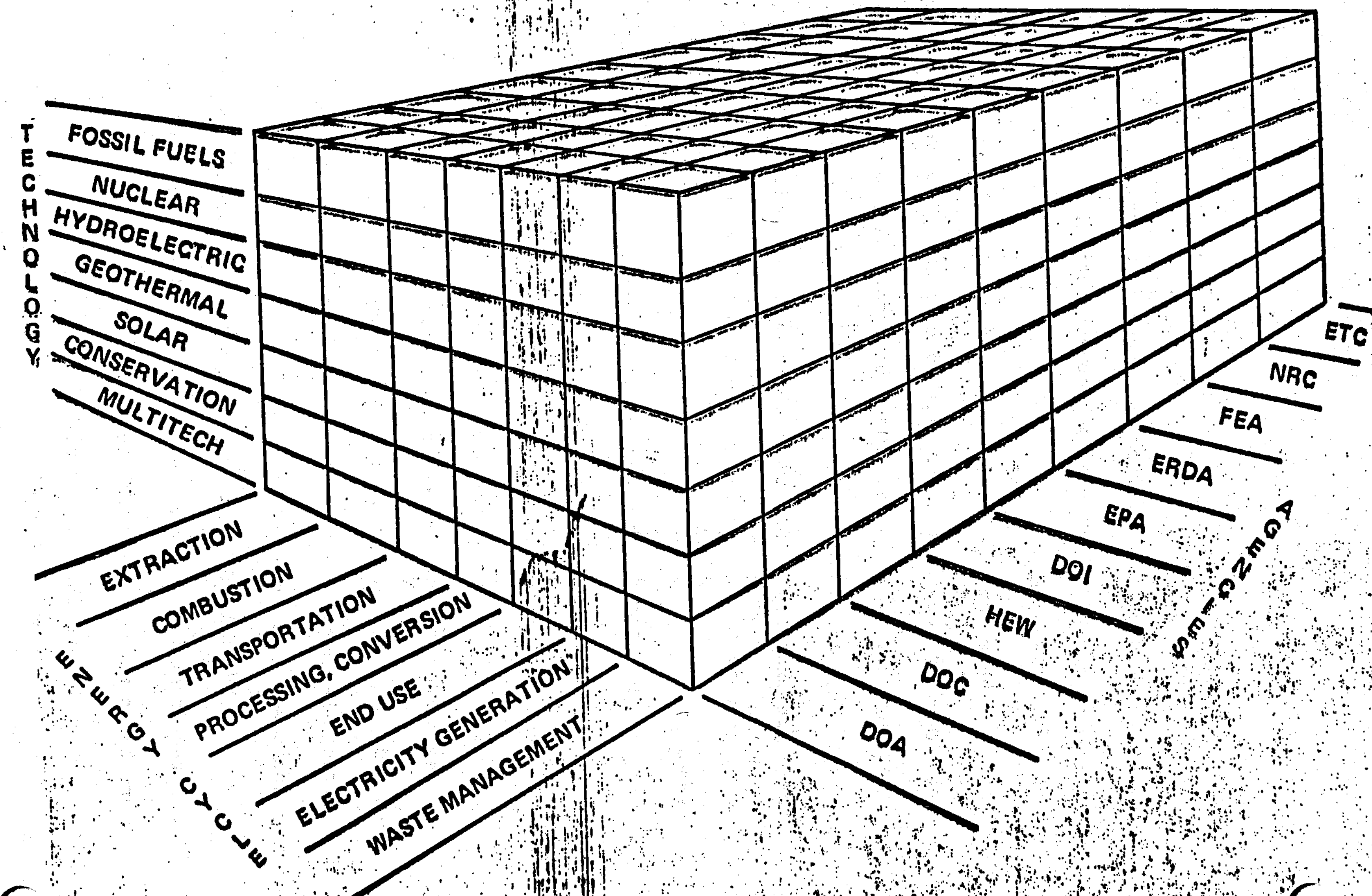
Here are examples of issues for oil shale on the left. The corresponding requirements are listed on the right. The issue is something that concerns us, while the requirements are the sorts of things you need to do in order to satisfy or take care of that issue. These are examples of the tools we are using to ensure that our R&D program activities are relevant and do not overlap those of other agencies.

DR. WHITE: Can you leave that on a second? I am bothered about something there. The issue is degradation of air quality, but I don't see anything in the requirements that says you are going to improve it or lower the release of emissions. You are going to get better standards, you are going to assess the information, base line data maybe, and see what happens after they leave, but in terms of cutting them down, which seems to be the primary requirement of oil, I don't see it there.

DR. SHEPHERD: I am giving you the March 22 list of issues and requirements, which we developed with you people. That requirement has since been added to this list.

DR. WHITE: Yes. Okay.

DATA BASE RETRIEVAL CONCEPT



INVENTORY OF FEDERAL ENERGY-RELATED ENVIRONMENT AND SAFETY RESEARCH (FY 1976)
ANALYSIS OF OIL SHALE RELATED PROJECTS

ISSUES

- DEGRADATION OF AIR QUALITY
- DEGRADATION OF WATER RESOURCES
- EFFECT OF REDUCED AIR/ WATER QUALITY ON MAN
- EFFECT OF REDUCED AIR/ WATER QUALITY ON ECOLOGICAL SYSTEMS
- LAND RECLAMATION AND ENVIRONMENTAL IMPACT OF PROCESSED SHALE
- OCCUPATIONAL RISKS

ISSUE: DEGRADATION OF AIR QUALITY

REQUIREMENTS

- ASSESS AIR QUALITY INFORMATION FOR SPECIFIC SITES
- DEVELOP IMPROVED STANDARDS FOR POLLUTANT MONITORING
- ACCUMULATE BASELINE DATA NEAR EXPERIMENTAL AND COMMERCIAL FACILITIES
- ANALYZE CHEMICAL CONSTITUENTS RELEASED DURING RETORTING OPERATION
- CHARACTERIZE CHEMICAL TRANSFORMATION OF ATMOSPHERIC RELEASES
- IMPROVE ATMOSPHERIC TRANSPORT AND DISPERSION MODELS
- PROVIDE ADVISORY RESPONSE TO MAJOR ACCIDENTAL RELEASES

DR. SHEPHERD: What we have now is a revised set which has your most recent inputs, as well as those of other Federal agencies. Those are now being put together. They should be ready at the end of this week.

DR. HOLLOWAY: While you are being interrupted, what do you do about the fact that the air quality in Colorado and the oil shale area is already above health requirements.

DR. SHEPHERD: That is a fairly complicated question. We are talking here about research and development, and I think the answer I would give you would have to relate to research and development. Your specific question might require a number of things including monitoring regional air quality. It would require doing research to determine the nature of the material being monitored. If you don't see such activities here, perhaps they should be added.

DR. HOLLOWAY: My point is that the natural conditions already exceed the federal conditions.

DR. SHEPHERD: I understand. In this context, I am afraid I can't give you the answer you are looking for.

DR. WHITE: EPA knows the problem.

DR. SHEPHERD: That's right.

DR. WHITE: And they are wrestling with what to do about it. They have sort of got themselves in a Catch-22 situation, I am afraid.

DR. SHEPHERD: Next slide, please.

(Slide 27)

We have slotted programs against those issues and requirements. We have given examples of ERDA, EPA, Department of Interior, and NSF programs dealing with a particular requirement.

(Slide 28)

Now if we look at the issue, degradation of air quality, and look at the requirements, we can break out for each of the agencies the numbers of projects and the nature of activities for each. Of course it is not sufficient to simply say that we know how many dollars apply to one particular issue or one particular requirement. You must also determine whether or not those projects and those dollars are being applied in a manner which satisfies those requirements.

We have just gone through that process, and we are putting together, if you will, an analysis of the content of the sufficiency of Federal R&D by specific Fuel cycle and the needs of each. The results should be ready by August. This is the means by which we are determining the relevance and the applicability of our R&D programs that we are funding both in universities and national laboratories.

DR. KROPSCHOT: Question or comments?

DR. PHILLIPS: I guess I am interested in knowing what is on the intellectual content of these requirements, how does one critique that? In other words, who are the intellectuals that make the intellectual judgment?

INVENTORY OF FEDERAL ENERGY-RELATED ENVIRONMENT AND SAFETY RESEARCH (FY1976)
ANALYSIS OF OIL SHALE RELATED PROJECTS

ISSUE: DEGRADATION OF AIR QUALITY

(Number Projects / $ Millions)

Requirements	DOA	DOC	DOI	EPA	ERDA	NASA	NRC
• Assess air quality information for specific sites	-	-	-	2/0.7	1/0.2	-	-
• Develop improved standards for pollutant monitoring	1/2.1	1/0.2	-	12/2.3	18/2.1	2/0.6	
• Accumulate baseline data near experimental and commercial facilities	1/0.5	-	-	4/0.9	1/0.2	-	-
• Analyze chemical constituents released during retorting operation	-	-	-	4/0.6	3/0.3	-	-
• Characterize chemical transformation of atmospheric releases	-	-	-	1/(a)	1/0.1	-	-
• Improve atmospheric transport and dispersion models	1/0.5	-	1/(a)	-	8/0.9	-	1/(a)
• Provide advisory response to major accidental releases	-	-	-	-	3/0.1	-	-

(a) - less than $0.05 millions.

INVENTORY OF FEDERAL ENERGY-RELATED ENVIRONMENT AND SAFETY RESEARCH (FY 1976)

ANALYSIS OF OIL SHALE RELATED PROJECTS

ISSUE: DEGREDATION OF WATER RESOURCES

REQUIREMENT: DEVELOP IMPROVED STANDARDS FOR POLLUTANT MONITORING

No. 012003 (NSF)
WATER QUALITY ASSURANCE AND INSTRUMENTATION

No. 054038 (DOI)
ENERGY SUPPORTING RESEARCH, INSTRUMENTATION

No. 070028 (EPA)
GROUNDWATER RESEARCH MONITORING OF – –

No. 087668 (ERDA)
TRACE ELEMENTS IN NATURAL WATERS

AGENCY: ERDA
FY 1976 FUNDS: ERDA $55,000
TECHNOLOGY: MULTITECHNOLOGY
PROJECT DESCRIPTION: TO UNDERSTAND METAL FLUXES IN THE ESTUARINE SYSTEM
APPROACH –
RESULTS –
KEY WORDS –

DR. SHEPHERD: That is a good question. For this last analysis we brought in approximately 40 scientists from the environmental and health science fields from the national laboratories. We also had participants from other agencies. We sat them down in a room with a packet of projects from coal combustion and the issues and requirements for coal combustion, and asked them to (1) slot the projects according to issues and requirements and (2) provide a written analysis of whether or not the projects under a requirement actually satisfy that requirement.

By and large, the projects that we have found are not wholly satisfying the entire spectrum of needs under each requirement. There tends to be fashions in science, as you know, and we tend to find things lumped and aggregated. According to these fashions, we have gaps and we have some overlaps between agencies, in the judgment of these professionally trained people.

Does that satisfy your question?

DR. WENDER: Did they take a vote or did you average them out? How did you get an answer?

DR. SHEPHERD: They sat down and argued these things out among themselves. We had people from our organization sitting in with them, helping to resolve these problems. They argued very strenuously, and in some cases had a majority and a minority opinion.

DR. NELSON: What was the primary opinion from this exercise?

DR. SHEPHERD: The primary inputs from these 40 for thi. exercise were the abstracts as reported in this federal inventory, which represent the SIE.

DR. KROPSCHOT: Could I remind the questioners to identify themselves in asking questions?

DR. HOLLOWAY: I have two questions. The first one, you had a chart that indicated that a project should be technically feasible, economically feasible, and environmentally and healthwise feasible, something to that effect. From the discussion yesterday, I got the impression people in fossil are responsible for the technical feasibility and to some extent, the economic, but you are responsible for environmental and health. Is that the correct impression?

DR. SHEPHERD: Overall that is a correct impression. We share these responsibilities with fossil and we try to work together with them. We do have cooperative programs going, and I think Dr. White would testify that they work very closely together in this area.

Do you want to address the technical aspect?

DR. WHITE: Jim and I have talked about this. And the way we generally tried to divide this is that technical work on pollution control up to the point of leaving the perimeter of the facility is something we have to worry about. Characterizing what is in there, and doing research on how to remove it.

Also the effect that may take place as it gets out into the air stream or the water stream on human health or biological effects or aquatic effects; but they also have the overview of whether we are doing our proper responsibility or our part of the job. And this sometimes leads to a little bit of discussion back and forth, and we kind of work it out.

DR. HOLLOWAY: I didn't see much in there for overview in dollars.

DR. WHITE: There is plenty. They don't need much. They can overview with a few fellows.

DR. HOLLOWAY: The other question I have dealt with, your relationships with other agencies such as EPA and HEW. Let's take, for example, coal combustion. One of the necessary features of combustion might be a stack gas scrubber. Who is responsible for seeing that there are satisfactory scrubbers or new developments in stack gas scrubbers?

DR. SHEPHERD: Again, that is not simple question, and there are two parts to it. Let me address the first part, which is; What are our relationships with EPA, HEW and other agencies? While you are probably speaking of the regulatory end, let me provide you with an example of interaction involving the President's Energy Message and his Environmental Message. The Energy Message said the President was going to appoint a special commission to determine the adverse impacts of increased coal utilization.

The President's Environmental Message directed that HEW, EPA and ERDA work together to determine the adverse environmental impacts of advanced coal technology. The accompanying fact sheet added "as well as the adequacy of federal RD&D." Recently we received a letter from President Carter asking Mr. Fri to take the lead to get the environmental message response moving. We have scheduled meetings with Secretary Califano and with Administrator Costle of EPA and their representatives on July 8 to discuss this matter. The result is a lot of close cooperation going on now.

The responsibility for control technology in this country is split. Phil's fossil energy people have a very real interest in this because it must be part of their technology. They cannot build something that is environmentally safe and socially acceptable if they don't know the environmental control technology options and design for those options.

We in AES have a program which exercises oversight over this activity. I think there is a major responsibility for ECT control technology in EPA for their regulatory purposes and they are developing programs of which you are aware.

Industry, of course, has a major interest in this area and has a fairly large budget for developing different kinds of control technologies. If I were sitting in your chair, I would ask how all these things are going to be put together. I don't have an answer to this problem.

MR. HILL: George Hill. Two questions. One you just touched on. Who decides the jurisdictional disputes where you do have obvious duplication? And second, throughout this whole thing, I haven't seen in the tabulation anywhere what is being done outside of government. There is, I think, quite a bit of overlap and duplication here.

DR. SHEPHERD: Those are two very good points. Who decides jurisdictional disputes when there are overlaps? In government we try to settle our disputes between agencies at the lower, working levels. Disputes which cannot be resolved are referred to higher levels. We have had to settle some problems by reference to the Executive Office of the President, via CEQ and OMB.

I think the other question you asked is a good one. It is something that concerned me, and I would be very happy to have some input from you.

Somebody has the responsibility for determining, I think, whether or not R&D in the entire country, (industrial, academic and federal, as well as state, regional and local) is satisfying the problems that we perceive. We need participation of all these segments of the R&D community in defining needs and in providing the R&D data base for analysis. I think we need to include in our inventory the kinds of projects you are referring to. We are not taking enough cognizance of industrial research in this inventory.

DR. RAMSEY: Since CO_2 is common to essentially all fossil fuel things, are you doing much to look at the possible long-term effects of CO_2?

DR. SHEPHERD: Yes sir. We have a major increase in our program for next year on that particular question, climatological changes, long-range weather changes as a result of increased CO_2 production.

DR. NELSON: Going back to the question of coordination, as you know, there was in the last nine days of OST, a committee for the coordination of environmental health research. That committee was succeeded by a shadow, an effective shadow; the HEW Committee on Toxicology program. As far as I can see it has been most effective. Information has been exchanged at this level.

DR. SHEPHERD: We are members of that Committee.

DR. NELSON: I know you are. I think that is very good. Nevertheless, it has the punch that comes from good will, rather than authority. I think it has been quite effective. There has been urgings on Dr. Press to reestablish, on the broader base, some permanent organization to give oversight and to help chide OMB, which, after all, is the final and most forceful group for determining priorities. And my question is, is there any evidence of life in that push to develop again a government-wide coordinating group which would talk to OMB?

You may not feel just like answering at the moment.

DR. SHEPHERD: It is a good question. It is a touchy one, of course. Let me say, first of all, that one of the options we are considering in our response to the President's Environmental Message is asking Dr. Press's office if they are interested in working with us in putting these things together as an overview group.

As you know, CEQ is staking out a claim in this area. And, as you know, there is soon to be announced a Presidential appointee for the Toxic Substances Control Act, with his entire staff put in place and running. And they will be staking out a fairly major role, perhaps the coordinating role you mentioned. Until this coordinating role is better defined, however, we in ERDA have a responsibility for those toxic substances and impacts of fossil energy and other energy technologies developed by ERDA.

DR. WHITE: I might be able to answer that a little further. There is the rebirth of the Federal Coordinating Council on Science, Engineering and Technology, which was beginning to be reactivated, but with Guy's departure, things are sort of in a holding pattern. I'm on one of those committees, not the environmental one, but the research one -- and waiting for Press to see how he wants it handled. I would guess this would be at least one mechanism that would be used for this coordination purpose, because that is exactly what it is there for.

DR. NELSON: Yes. EPA doesn't want to assume a dictatorial role.

MR. CANONICO: You indicated a major task in the area of reactor safety research coordination. Can you explain?

DR. SHEPHERD: I would like to do this, but am limited in this presentation to fossil research.

MR. CANONICO: I would argue against that because I think that is one of the major problems in the future as far as commercialization of fossil energy, but I think reactor safety is going to be a question we will have to address ourselves to eventually.

DR. SHEPHERD: All I can say is that we do have major programs in reactor safety, and if you are not familiar with them at Oak Ridge, you do have on-site the best library and our program available.

MR. CANONICO: You have the HEC program where the metallurgy program is attached to. I am just wondering where your coordination in that comes through.

DR. SHEPHERD: Generally through Hal Hollister's shop. The Environment and Safety Group, as one part of it, for the occupational safety; and through our reactor safety and research group for the actual physical and mechanical aspects.

DR. KROPSCHOT: One more question.

MR. STANFORD: I was hoping you might give us a little more insight how the CO_2 problem will be addressed.

DR. SHEPHERD: Well, I can give you the name of the person that can give you the specifics. I think that would be the best use of my remaining 30 seconds. Dr. Swinebroad is the Manager of the Environmental Program at ERDA. And he has working with him Dave Slade, who has ERDA's responsibilities for atmospheric, long-term research and CO_2 work.

We are also working with NASA in this area, as you probably know. We do have some satellite and atmospheric monitoring programs which we are going to be getting into.

DR. KROPSCHOT: Thank you very much.

(Applause).

DR. KROPSCHOT: Sorry to have to cut off this very interesting discussion but I would like to now proceed to the next presentation of the programs on fossil energy research being undertaken in the area of conservation under the Assistant Administrator for Conservation with ERDA, and introduce Dr. Karl Bastress.

DR. BASTRESS: Good morning.

My title is Chief of the Combustion and Fuels Technology Branch in the Division of Conservation Research and Technology.

The activity in my program is principally applied research, and I think it is that reason for which I was asked to make this presentation. Also, my part of the conservation research activity is perhaps most closely tied to the interest of fossil energy research.

I am very happy to make this presentation on behalf of the conservation office because of my interest in general in the research activity here at ERDA. I think I would like to start by posing two questions. The first would be: Why am I here, or more specifically, what can I contribute to this meeting on fossil energy research? And secondly: What can this meeting do for the conservation research program?

The answer to the first question: Why am I here?, is rather easy. That is because the conservation program is or can be regarded as complementary to the fossil energy program in many ways. We think of the conservation program as being concerned with the use of fossil fuels, whereas we think of the fossil energy program as primarily concerned with the supply of fossil fuels.

It is difficult to separate the areas of technology in the two programs. In fact, we at the program manager level find it necessary and desirable to coordinate our efforts frequently and closely with our counterparts in the fossil energy office. I must say, that this activity proceeds very satisfactorily. Therefore, I think it is very appropriate for conservation to have a spot on this agenda, since the conservation activity, in a sense, can be regarded as an extension of the general subject of fossil energy research.

The second question, is: What can this meeting do for the conservation program?, I think this can be answered by saying that the conservation research activity also needs to be addressed, as we are addressing the fossil energy research work. We can characterize the conservation research program perhaps in the same way that the fossil energy research program was discussed or described yesterday.

The applied research activity suffers from low funding, and there is a gap, quite perceptible, between the research activities in conservation and the basic research activities in the Division of Basic Energy Sciences. So I would, in answer to the second question, request of both Dr. Phillips and Dr. Kropschot, that the output of this meeting as far as possible be addressed to conservation as well as to fossil energy.

Our conservation program is quite analogous to the fossil energy program in ERDA. We have in the conservation office, six program divisions with a widely varying program of activities. In 20 minutes I cannot begin to describe anywhere near all that goes on in the conservation program. Therefore, to be consistent with the theme of the meeting, I will discuss only the research activities. Therefore, please keep in mind I am addressing a very small fraction of the overall conservation program. You will not hear anything of the major thrusts in the technology development areas of conservation this morning.

(Slide 1)

The overall objective of the conservation effort is the development of improved technology for energy utilization meeting these requirements: Increased efficiency, compatibility with available fuels, and compatibility with the transition to future energy sources.