Conservation RD & D Overall Objective

Develop Technologies
For
Efficient Energy Use
Compatible With Available Fuels
And The
Transition To New Sources

ENERGY EFFICIENCY

Office of Conservation
Energy Research and Development Administration

Now, this term "transition" is used in our conservation office to refer to a period of time, starting more or less at the present and extending into the future to some time when we reach a point where we have stabilized new energy sources.

(Slide 2)

The transition goal is to reduce total energy use in general, and oil and gas use in particular.

The intent here is, as far as possible, to stretch our domestic supplies of oil and gas and to reduce our dependence on imports.

(Slide 3)

We have defined 11 strategic objectives to further focus our conservation program. Seven of these objectives are directed towards what we have defined as the three major energy use sectors; transportation, residential and commercial, which is primarily energy used in buildings, and the industrial sector.

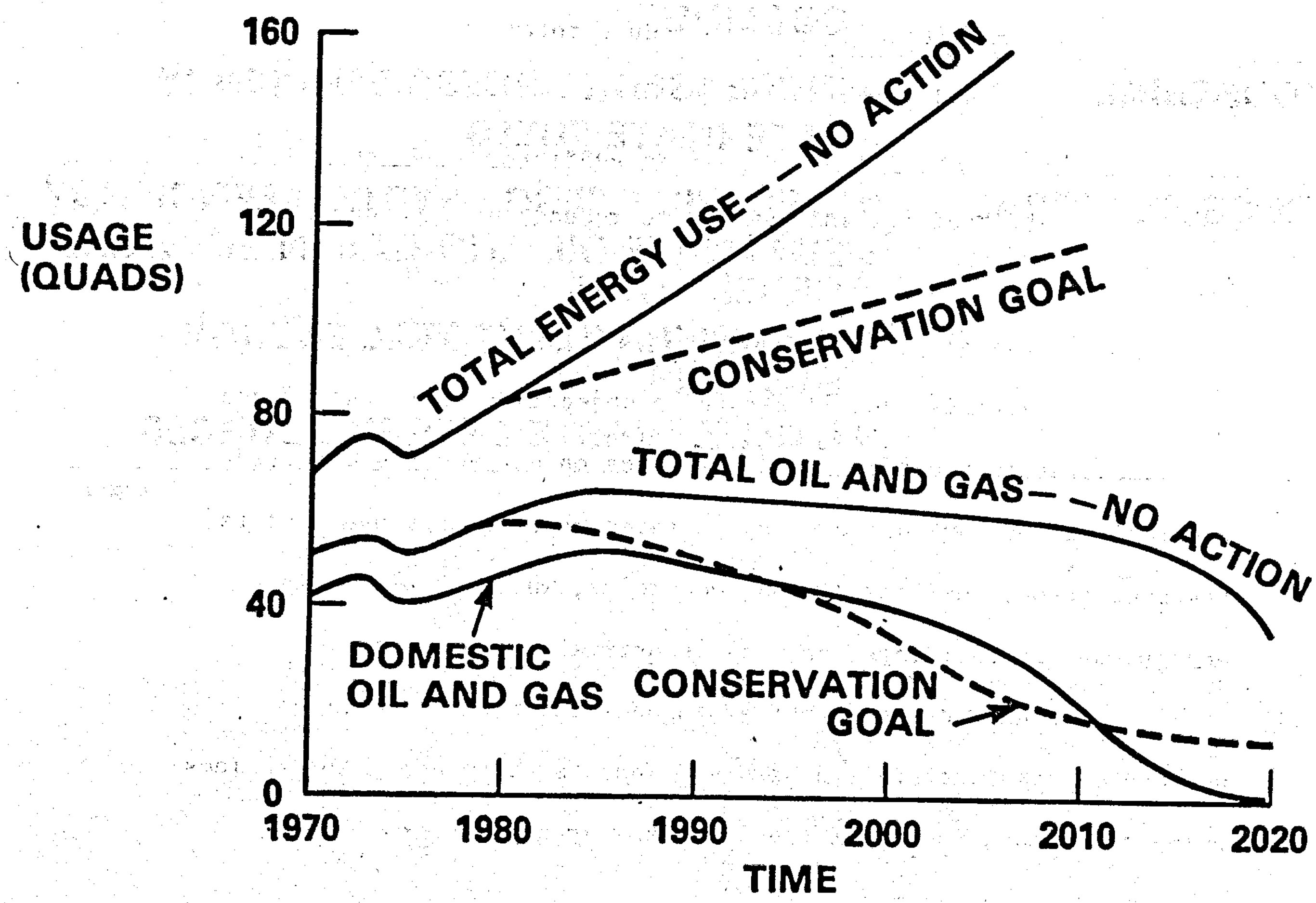
We have defined four additional strategic objectives, which are cross-sectoral in nature. That is, they apply to problems which are common to all of the three energy use sectors.

(Slide 4)

The organization of the conservation office is related to the strategic objectives. We have three program divisions which correspond to the three energy use sectors. Buildings, industry,

[redacted]

THE TRANSITION GOAL



ACCOMPLISHING THE GOAL — THE STRATEGIC OBJECTIVES

TRANSPORTATION	• INCREASED EFFICIENCY • ALTERNATE FUELS
RESIDENTIAL/ COMMERCIAL	• UPGRADE BUILDINGS • INCREASED EFFICIENCY HVAC, APPLIANCES • ALTERNATE SOURCES FOR HEATING/ COOLING
INDUSTRIAL	• INCREASED PROCESS EFFICIENCY • ALTERNATE FUELS
CROSS-SECTORAL	• ELECTRIC ENERGY SYSTEM EFFICIENCY • ELIMINATE OIL AND GAS IN ELECTRIC GENERATION • COGENERATION/TOTAL ENERGY SYSTEMS • UTILIZE WASTE ENERGY SOURCES

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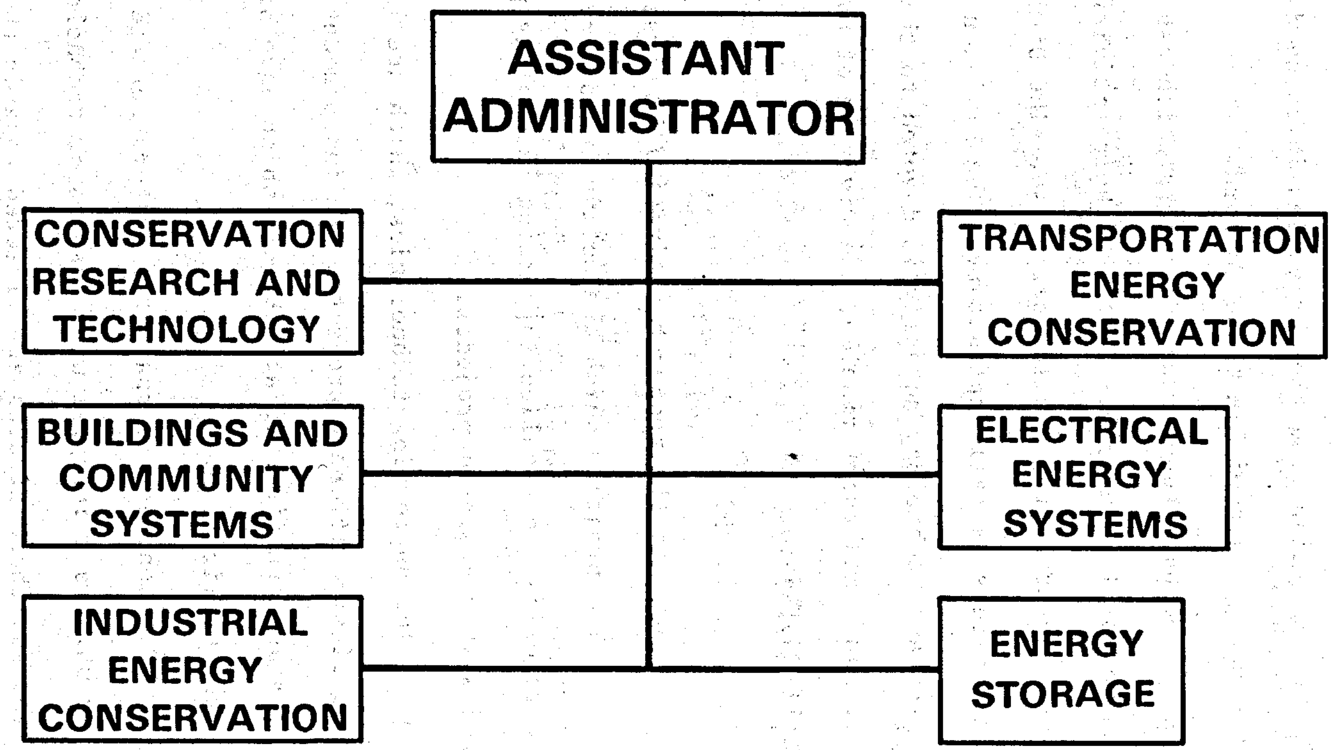
ERDA OFFICE OF CONSERVATION

PROGRAM DIVISIONS



and transportation, and the activities in these divisions are focused on the energy uses within those sectors.

We have three other divisions which can be regarded as cross-sectoral in nature. That is, their activities are focused on the more general problems in energy use. The Division of Electrical Energy Systems is self-explanatory. The Division of Conservation Research and Technology actually is devoted to the area of energy conversion. And then, finally, the Division of Energy Storage again is self-explanatory.

(Slide 5)

Now, to the research activities in conservation.

The projects which are active in conservation fall into two categories: one called supporting technology projects, the other called systems-related projects.

The supporting technologies, which are listed there and consist of six different projects, are independent, applied research projects and are directed at subjects which have broad applications in energy utilization.

In contrast to that, the systems related projects are efforts which are integral with systems or technology development programs and these efforts are directed towards the particular technologies which are being developed under those programs.

Now, I have listed here only a few examples of these systems related projects. In fact, every technology development

Conservation Research Projects

Supporting Technologies

- Aerodynamics
- Combustion
- Fuels Research
- Heat Transfer
- Materials
- Tribology

System-related Projects

- Battery Electrochemistry
- Heat Engine Component Design
- Fuel Cell Electrocatalysis
- Thermionic Power Generation
- Physical Energy Storage
- Chemical Energy Storage
- Thermal Energy Storage

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program in conservation to some degree has a research activity associated with it.

In the next few slides I will focus only on these supporting technology projects for two practical reasons. One is that these are primarily research activities and so they are most appropriate to the subject of the meeting, but secondly, they are more easily defined because the activities there are entirely research and the budgets and scopes of those projects are very clear.

The total effort in these supporting technology projects in FY'77 is $2.1 million. That is slightly more than 1 percent of the total conservation budget. So again, I remind you that I am dealing with a very small fraction of the total conservation effort.

Next slide, please.

(Slide 6)

All of these supporting technology projects are discussed to some degree in the handout which you have. I will only talk about three of them here in order to give examples of the nature of these activities.

The combustion project in conservation is concerned with increased efficiency and fuel switching in four categories of equipment; internal combustion engines, continuous combustion engines, boilers and furnaces, and industrial heaters.

At the present time we've activated efforts in only three areas under this overall project and yet we feel we can point to

Combustion

Objectives:

- Increase Efficiency
- Increase Fuel-switching

Strategy:

- Improve Current Equipment
- Evaluate New Concepts

Status:

- Active IC Engine Projects
  - Lean-burn Engine
  - Direct Injection Stratified Charge
- Active CC Engine Projects
  - Improve Current combustors

some rather significant accomplishments. For example, we have initiated a cooperative research project in the area of direct injection stratified charge engines for automobiles, and this project involves researchers from universities, national laboratories and one of the major automobile manufacturers. The significance of this project, we feel, is that it brings together the research community and the automobile community periodically to review their combined efforts and achieves both a degree of coordination of the work and ready technology transfer.

A second accomplishment in this combustion area is the initiation of a research project under the International Energy Agency, which brings together researchers in the various government agencies in the IEA countries to coordinate their research activities and therefore stretch the research dollars of the various countries as far as possible.

The next slide, please.

(Slide 7)

The combustion project offers many opportunities for additional research in all the areas to which it is addressed. However, we have to be very selective in the activities that we undertake because of our budget limitations.

We estimate that if we were to attempt to pursue all of the new concepts and research opportunities that we have identified, we

Combustion

Additional Research Opportunities:

- IC Engine Research
  - Dual-chamber Stratified Charge
  - Diesel Combustion
- Continuous Combustion Engine Research
  - Premixed, Prevaporized Fuel Injection
  - Catalytic Combustion
- Boiler and Furnace Combustion Research
  - Pulsed Combustion
  - Feedback Control
- Industrial Heater Combustion Research
  - Recovered Heat Utilization
  - Oxygen Enrichment

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would require a budget of the order of $15 million per year. Our budget this year is $650,000.

Next slide, please.

(Slide 8)

The fuels research project is directed towards utilization of two groups of alternate fuels. We speak of principal alternative fuels as those which have been or will be derived from coal or shale. We speak of secondary alternate fuels as biomass and industrial waste materials.

The focus in this project is on the fuels and their combustion properties. That is, what does the designer of combustion equipment need to know about a fuel in order to design his equipment to accommodate new fuels that are coming in the future.

So far, we've activated efforts in this project in areas of hydrocarbon fuels research and we have a rather active program now in the area of wood fuels. I would just comment on that by saying that there is a rapidly growing awareness and interest in utilization of wood residues in certain regions of the country. Obviously not in Arizona, but in areas such as the northeast and the southeast and the northwest. There is a growing awareness that wood residues, I don't mean timber quality wood, but wood residues from various sources can make a significant impact on energy supplies in certain regions.

Next slide, please.

(Slide 9)

Fuels Research

Objective:
- Develop technology base for switching from premium fuels to alternates

Strategy:
- Identify fuel combustion characteristics which influence equipment design and performance
- Measure combustion characteristics of alternate fuels
- Obtain data base for hardware design

Status:
- R&D plans developed
- Project activated in

  Alternate hydrocarbon fuel kinetics

  Industrial wood residue combustion

  Residential fuelwood fire box combustion

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Fuels Research

Additional research opportunities

- Characterization of fuels from
  - Processed biomass
  - Industrial wastes
  - Coal and shale
- Develop criteria for conversion of secondary fuel sources
- Develop design and performance criteria for combustion equipment for alternate fuels

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The fuels research project also offers innumerable research opportunities in such areas as characterization of alternate fuels, definition of desired properties of fuels as they emerge from various conversion processes, and the development of special equipment for combustion of alternate fuels. And again, wood is a good example of that last opportunity.

Next slide, please.

(Slide 10)

The last project area that I'll discuss is heat transfer where in this project the effort is directed primarily towards improved heat exchanger technology to enhance the energy conservation potential in all use sectors and in particular to enhance the potential for the recovery of waste heat. We have efforts in this project activated in four areas which are shown on the slide.

Next slide, please.

(Slide 11)

The heat transfer project, like the others, offers a variety of additional research opportunities. We feel the most dramatic possibilities for improvement lie in heat pipe applications and in enhanced surface heat exchangers. The potential for recovery and utilization of waste heat through unique types of heat transfer equipment is truly very significant.

Next slide, please.

(Slide 12)

Heat Transfer

Strategy:

- Improve Component Effectiveness
- Increase Reliability and Life
- Reduce Costs

Objective:

- Improve Energy Conservation Through Improved Heat Exchanger Technology

Status:

Active Projects in:

- Tube Vibration
- Tublar Ceramics
- Fluid Bed Heat Exchangers
- Ceramic Heat Pipes and Recuperators

Heat Transfer

Additional Research Opportunities:

- Heat Exchanger Fouling and Corrosion
- Low-cost Alloy Fabrication Techniques
- Heat Pipe Materials
- Enhanced Surface Heat Exchangers

Summary

Status of Conservation Research:

- Active Projects in Selected Supporting Technologies
- Active Projects Related to Energy Systems Development

Research Opportunities:

- Improvement of Current Systems
- Development of New Design Concepts
- Utilization of Unused Energy Resources

In summary, let me say that the conservation program includes active research in two general types of projects; supporting technologies, of which I've described three examples, and a wide variety of applied research activities as a part of our systems development projects in areas such as batteries, fuel cells, heat engines and so on.

The budget at the present time, that is in FY '77 and FY '78, for this applied research effort, that is in both types of projects, is approximately 10 percent of the total conservation budget.

The source of that information is clear in the case of the supporting technologies projects because their budgets are spelled out separately. As far as the quantity or the level of research in the systems related projects, that information, which is in your handout, by the way, came from an inventory of research activities conducted approximately a year ago and is based on the program manager's estimate of how much, or what fraction of his program will be devoted to applied or basic research.

I think that the budget estimates for the systems development research projects is perhaps a bit soft or uncertain, but I think the 10 percent estimate is the right order of magnitude.

The second conclusion evident is that research opportunities in conservation are abundant. The pursuit of these opportunities is limited only by the budget. In the meantime, the program managers in conservation are making every effort to stretch the budgets that we have in three ways.

First of all, by assessing the benefits of each potential research project as closely as possible and selecting those which appear to have the greatest benefit at the earliest possible time.

The second method of stretching budget dollars is to initiate cooperative efforts such as the cooperative effort in internal combustion engines which I mentioned we have set up with the automobile industry.

And finally the third mechanism is to coordinate our efforts with other agencies. We're all aware that there is an extensive amount of energy-related work and conservation-related work going on in other agencies in this country and elsewhere. We are making every attempt possible to take advantage of work being done elsewhere and to minimize the duplication of effort.

Can I have the slide off, please?

I'd like to make a few closing remarks in the form of good news and bad news. The good news I think you've heard. That is, conservation, in the context of this meeting, has initiated some independent research projects and the budgets for these projects are likely to increase in FY'78.

I personally feel that conservation should be commended for this effort. Here is an area of independent research activity in support primarily of the overall conservation effort.

Then the bad news. It is my opinion that these research activities will not survive. Two weeks ago I attended a meeting here in Washington sponsored by the AAAS which some of you also may have attended. The subject was funding of R&D in the federal budget.

A variety of messages came from that meeting. But one which was very clear is that research budgets are controllable. Controllable is a euphemism meaning vulnerable to cost-cutting. Unfortunately, we have an immediate example of that in our own program.

Rumor has it that our supporting technology activity, which you have heard described here, has been cut by the House-Senate Conference Appropriations Committee by $5.4 million for FY '78. That is more than half of the intended budget for that activity.

Because of this sort of experience, the supporting technology activity will not appear in the conservation budget as an explicit item after FY '78. We don't feel we make ourselves vulnerable to budget cutting by having applied research activities appear explicitly in the budget.

That doesn't mean the activities will be gone, but they will be buried for budget purposes. However, it's likely that they will be buried organizationally and ultimately they will disappear.

My conclusion is that the outlook is not bright for applied research in the conservation program. And I don't think the outlook will improve until some mechanism for research support is provided.

In the words that were spoken yesterday, I don't think the outlook will improve until the career of some assistant administrator or division director is tied to the quality of research in the conservation program.

Thank you.

(Applause.)

DR. PHILLIPS: Questions or comments?

MR. OETERMANN: Oetermann, General Electric. I note that you do not address cogeneration. Is that because you don't believe there is research required in that, or is it out of your organizational component?

DR. BASTRESS: I did not explicitly address cogeneration because it happens we don't have an applied research project in conservation which is specifically directed to that subject.

However, cogeneration is a substantial activity in conservation. As you can see, it was one of our 11 strategic objectives and it is supported by the activities of several different branches and programs. The combinations of cogeneration are numerous--they can involve either heat engines or fuel cells and a wide variety of heat recovery devices, bottoming cycles, topping cycles and so on.

So it's a broad area which permeates several of the divisions in conservation with coordination at the top. So I would say in the context of this discussion, which is applied research, cogeneration is addressed specifically in those subjects such as heat transfer and combustion as well as certain systems related projects such as heat engines and fuel cells, but we don't have a research activity labelled cogeneration.

Personally, I don't think it really fits in a generic way along with things such as materials, aerodynamics and so on. It doesn't mean we're not doing it. It's very important activity in conservation.

DR. PHILLIPS: Could you use the microphone, please. The reporter tells me he can't pick up the voices.

MR. GUINAN: Guinan, Pullman-Kellogg.

I was just wondering how this bad news will affect your fuel cell program?

DR. BASTRESS: The bad news applied only to applied research. That is, the independent research programs in conservation. My understanding is that the overall conservation budget is likely to increase rather than decrease and in particular the fuel cell program is strong and healthy.

DR. RAMSEY: I first heard of the virtues of the stratified fuel injection with Dick Arwin's study about seven years or so ago. It sounded in about the same state as reported here and I wondered why things were that slow in securing a high level push at that time and is it making much progress since; or how long before we get results?

DR. BASTRESS: You're not asking why are we working on it. We get that question frequently. I'm driving a stratified charge engine made in Japan; why is ERDA worrying about this?

That same question could be addressed to many types of technology. There's room for improvement in nearly everything, but that doesn't answer your question, however.

DR. RAMSEY: My question is the reverse --

DR. BASTRESS: The question is are we making any progress?

DR. RAMSEY: Why does it take so long?

DR. BASTRESS: I can only respond to that in a rather unsatisfactory way by saying it's a very difficult problem. The particular concept which we're pushing here is the direct combustion stratified charge engine which has certain advantages in efficiency if we can make it work.

But the problems of trying to achieve high efficiency and controlled pollutant emissions over the full operating range of an automobile is a difficult one and our approach is to try to understand what is really happening in the fuel injection process and the subsequent processes of air and fuel mixing. We're not actually, with our limited budget, as you might imagine, developing new engines. We're leaving that to Detroit.

But our role, we feel, is to focus the talents of universities and national laboratories with their resources in instrumentation and mathematical modeling and the understanding of these processes, on that one combustion concept, to try to elucidate the problems for the benefit of Detroit so that they can move a little faster in their engine development activity.

I should point out that even though these projects are labelled with hardware sounding names, the nature of the work is primarily fundamental. The work that we are supporting here is primarily in the national laboratories and universities or the research organizations of industry and we are focusing the work, as far as possible, on the fundamental understanding of problems in combustion, in fuel chemistry, in heat transfer and in the other areas to provide a stronger technical base for the engineers in industry.

MR. KELLER: Lou Keller, Oak Ridge.

Yesterday a rather interesting question about the practicality of the return to coal for residential heating came up. I wonder if that's an appropriate question for your group.

DR. BASTRESS: Well, we have discussed the various applications of coal burning with our counterparts in fossil energy and we have defined for ourselves a rather indistinct boundary between our jurisdiction and theirs which primarily says that coal applications are primarily a fossil energy responsibility. However, we are concerned about that subject because the areas do overlap.

I'm going to have to agree with the comments made yesterday about coal burning in residential applications. My view is that the development of improved combustion equipment is a relatively easy problem compared to the problems of logistics of coal supply and the control of sulfur emissions and particulate emissions.

I think you could just as well ask the same question about wood burning, which we have taken on as our responsibility. There I think that there are environmental questions and supply questions which need to be addressed, and we are addressing these. We don't think that the environmental questions are quite as difficult with wood as they are with coal and that's why we're proceeding with the development of improved technology for wood burning in residential applications.

DR. KROPSCHOT: Thank you very much.

(Applause.)

DR. KROPSCHOT: I would like to proceed now with the next two papers which describe work in research and fossil energy, the area of the Assistant Administrator for Solar, Geothermal and Advanced Energy Systems; and to lead off with these two papers, I'd like to introduce Dr. James Kane, who is the Division Director, in this case for the Division of Basic Energy Sciences.

Jim.

DR. KANE: I'm sure you must be dreadfully confused by now why a person who's in the solar, geothermal and advanced energy group is standing up here at a fossil energy meeting. I'll try to explain that to you.

The basic research that existed when ERDA was formed was largely in the old AEC and it was transferred almost intact into ERDA. The ERDA organizers looked around for a logical place to put it; they couldn't find one, so they put it somewhere anyway. And it wound up in solar, geothermal and advanced energy systems.

So the actual charter for long range, more fundamental research in ERDA resides within the Administration for Solar, Geothermal and Advanced Energy Systems. It's a very major undertaking and I'm not going to talk about all of it today. But I will allude to it just to put it in the proper framework, as other speakers have done this.

The total research program, long range, basic, exploratory, whatever you choose to call it, includes high energy and nuclear physics, which I'm not going to talk about today. That is indeed a major undertaking and as someone said yesterday, OMB and the President's office have clearly indicated that we are responsible for the high energy physics program of the United States; the executive agent for it.

We do not have that same statutory assignment for the nuclear physics program, but de facto we have much the same status. We are the major supporter of nuclear physics in the United States.

I really am convinced that it is good for all of us to have those in a package within the Agency. There are two things that have been alluded to so far in this meeting--I won't dredge up any new arguments--and I'll point out that each was the development of one of these two technologies.

The very large magnet that's been mentioned a number of times in the MHD Program was clearly an outgrowth of the high energy physics program, which has been the driving force for the superconducting industry in the United States. Now, all such magnets aren't necessarily made by the laboratories. They are designed there, but the industry has been really stimulated by high energy physics. And if we have an industry in superconductivity today, it's a result of the high energy physics program.

The second, somebody showed a picture yesterday of data which I think was X-ray fluorescence. That very beautifully resolved data was an outgrowth of the nuclear physics program. The lithium drifted detector and all of its ancillary equipment was developed under the nuclear physics program. So my point is not to boast about these--I had nothing to do with either one of them--but to point out that a sharp eye for fallout in some of these things is a good idea, that some of the products of these two very large undertakings in research are highly applicable to the type of questions that this group is talking about.

Now, from now on I'm going to talk only of the work in what we call basic energy sciences. I'm going to tell you what it is; how much we spend on it; and describe its "flavor". Then I'm

I'm going to talk more specifically about some of our research within the chemical areas. And after I'm through, Dr. Donald Stevens is going to talk about materials science. These are both in the research program.

In 1977, the amount of money in this basic energy sciences program in terms of outlays, which excludes equipment purchases and capital construction, was $121 million. In 1978, the President has requested from Congress $138 million.

First I'll tell you the charter and then how those expenditures are divided in categories. Our charter is to carry out a program of basic research in the physical sciences--that's an important point--only the physical sciences, which is supportive of all the ERDA energy technologies, both the production and efficient use of energy. That's our charter.

ERDA is a mission agency. That's the first thing to remember. We are not the NSF, and our work, therefore, must be clearly justifiable on the basis that it's relevant to the Agency's long range goals.

We do mostly basic or exploratory research. We do almost no development or directly programmatic applied science.

I'll give you an example. In material sciences, Don will talk about the extensive work we're doing on steels, for instance. Corrosion of steels, fracture of steels, the deformation properties of steels, and yet even if there's clearly an indicated need for a new steel in one of the technologies, we do not develop that new steel.

Now, let me depart a minute. I personally was responsible for a project one time which required that a new steel be fabricated in industry, and it had different properties from 316 in terms of its ability to contain hydrogen, high pressure hydrogen. And it took about 10 years before a specialty steel maker was able to turn that product out in reliable quantities.

My only point in mentioning this is that if there are requirements for new steels that, say, are able to resist grain boundary attack by a specific pollutant in coal, to pick an example, we are not doing that. We may ferret out the problems that pollutants would give. We may try to understand the mechanism by which the damage is caused, but we will not develop a new steel in terms of putting one in production.

I want to make this jurisdiction thing quite clear, because I made the point yesterday that the programs are responsible for the applied science that is required for them to accomplish their mission.

All right, how do we spend that money? We have--well, I guess one more specialized role. I'm not getting to the main part of my talk. I keep departing from it.

A role that's becoming increasingly important is the building and support for the national use of specialized facilities which are too expensive, dangerous or elaborate to logically expect at a single smaller location, such as university campus.

I'll give you examples of these, and these are all operated on what we term a user basis. One of our jobs is to build and operate facilities which are then made available to the scientific community and the scientific community organizes user groups which often controls the use of these.

This mode of operation has long been the trend in high energy physics where people talk about the big "government" accelerators and indeed are they built by the government, but the experimenters on them are largely, (usually 70 to 80 percent) university researchers who have a large say in how these facilities are operated.

And I want to point to a few of the kinds of facilities that we operate. For instance, we have fallen heir to almost all the high power reactors, steady state nuclear reactors in the United States. Experimental, of course, not power producing.

So if there's neutron diffraction done, or if there is neutron activation done that requires high beam intensity, a lot of this can be done on smaller university-size reactors, but we have reactors that have, you know, far greater beam power than anything you could locate conveniently on a university campus. And we have fallen heir to this type of thing and one of our jobs is to operate these for the benefit of the scientific community.

We have two projects now that are, three actually, under way now that are in this same category. A large synchrotron radiation source, a light source which I think will open up immense opportunities in studies all the way from molecules, clear down into the solid state and polymers; biological research. It is essentially a very large and continuous spectrum light source in which the light is generated by circulating electrons.

We fell heir to one of these, not by accident at all, but by design when the big accelerator at Stanford was built, the circular electron storage ring; it is by its nature the most powerful emitter of synchrotron radiation in the world.

We have another of these under construction at Brookhaven. It will be a user facility in which experimenters can come from universities and if we can get some of the proprietary aspects ironed out, from industry. I don't need to tell you the benefits of this kind of thing, besides basic research, if you stop and think a minute what limits the packing density of electronic components used for solid state applications like computers, where packing density is important--it's the defraction limit of light, because the masks used to fabricate the tiny elements are prepared by photolithography. By using a short wavelength, extremely intense source, we think it will be possible to reduce the dimensions of solid state components in computer microcircuitry.

So these things have tremendous practical applications.

Two more; I'll get through these quickly. I'm taking too much time on this overview.

We're starting a combustion facility. We are starting this at the Sandia Laboratory. Again, it will be user facility and we hope we can entice all sorts of people to come and use that facility to advance understanding of the processes of combustion.

And finally in joint venture with NSF, we're starting something totally different and that is a national facility for computations in chemistry. Many research projects in modern chemistry could certainly use convenient access to large, very large in this case, computers, capabilites of the class 6 type, and those are not available in general, hardly ever available except at national laboratories.

So we have a joint venture with the National Science Foundation which will again make the very large computer complex, not just the number crunching part, but the peripheral item, graphics, the remote access and all these very desirable attributes of the big systems available to the general scientific community.

Okay. Enough of that. Now, let me talk about our organization.

We have four major groups to which we allocate money. The first of these is nuclear sciences. And the budget this next year will be about $25 million. I'm not going to talk about that other than to tell you it's there. We do the cross-section measurements, for instance, of interest to fission and fusion. We do isotope preparation. We are the proprietors of the largest isotope store in the world, I think. If the medial establishment wants stable isotopes that are not provided by industry; we will supply them.

We also are the suppliers of heavy elements. And that's an interesting thing. All the isotope-using neutron generators used by the oil exploration business depend on my program. That seems a kind of surprising place for it. We're suppliers of the americium-241, for instance, that is used as the alpha source for neutron generators.

That's the nuclear science program.

Materials science program, $58 million, roughly, for next year is going to be described quite thoroughly by the subsequent speaker. My personal background is material science and I guess it's not just my prejudice, but if I had to identify a single subject in which the problems are spread almost uniformly across all of ERDA, I cannot name one that is more ubiquitous than material sciences.

The third, and the one I'm going to talk about today, is called chemical sciences; about $42 million in our budget next fiscal year. This is truly chemistry. It is atomic and molecular physics, chemical processes and chemical instrumentation. Now, there are a few things I've probably missed, but that's predominantly what's in there.

Finally, we have mathematics and geosciences. These are two very small programs. The total is $11 million between them. The math program contains very little of what mathematicians would call pure mathematics. It is mostly leaning towards numerical sciences; how we can better use our enormous array of computers, for example.

Some of you may not know this, but ERDA has the largest computational capability in the free world in terms of instructions per second or some measure of very large computation capability.

So most of our effort goes into applied math. We support the Courant Institute quite heavily, for instance, on how we can do better numerical calculations.

Geosciences is a technology that cuts across this entire Agency. The nuclear people are very concerned about making sure they can put their waste in a spot that is going to be inaccessible on geological time scales. They are interested in siting their facilities in places that are seismically satisfactory and so forth.

By the way, the uranium people need to know how much resource is out there. If there is certainly a critical problem in nuclear power in the United States, it's how much uranium oxide is out there at a certain price. That's a major question; the need and timing of the breeder reactor kind of hinges on that.

As I move across the ERDA organization chart, almost every technology has need for geosciences. I don't have to tell you about the importance to geological understanding for fossil energy.

CHEMICAL SCIENCES

TECHNOLOGY RELATED—%

	FY 73	FY 75	FY 77
FOSSIL	0.5	7	13
GEOTHERMAL	0	0.1	0.4
SOLAR	2	4	7
FISSION	18	13	8
FUSION	1	3	5
CONSERVATION	0.5	4.9	5.6
ENVIRONMENT & SAFETY	4	4	5
IMPORTANT TO MANY ENERGY TECHNOLOGIES	7	9	9
IMPORTANT TO LONG-TERM ADVANCEMENT OF ENERGY SCIENCES	67	55	47
	100.0%	100.0%	100.0%

Okay. Who are the performers? The performers are largely universities, national labs and to a much smaller extent industrial labs. How much industrial participation? In the past, it's been small. We have some interaction with the not-for-profits and the high technology kinds of corporations. We have really a relatively small interaction with the big industrial corporations that do the ongoing bulk of really good industrial research. We don't have many connections with them, although we talk a lot to some of them.

There's lots of reasons that we don't. I don't want to go through them here, but I don't want you to be discouraged by the fact that the numbers appear small.

Now to the fossil energy basic research program. Could I have the first slide, please?

(Slide 1)

I told you we were responsible for all technologies and I thought you would be interested in understanding just how we spend our money. The slide shows two-year intervals. You see it's fiscal '73, '75 and '77. Those are percentage numbers. Research has not grown in proportion to the rest of the Agency and that's due, of course, to the Agency focusing on short-term problems. I'm not taking issue with that. I just want you to understand that our program has grown at a rate of about the cost of living plus a few percent.

So in order to achieve the growths you see there, we've had to cut into some of the other areas. And you can see we cut back on fission quite appreciably and we've had to make some pretty hard decisions on what areas we'd get into.

Now, the two at the bottom, those really could be lumped together in some ways. I'll give you an example of a problem that is important to many technologies, and that could be, for instance, hydrogen embrittlement.

You see the rather large category of important to long-term advancement of energy sciences--let me just pick an example off the top of my head. Molecular beam work that tries to understand what the cross-section for reaction between a molecule in a particular energy state. You'd have a hard time attributing that to one of those technologies above. Certainly if you choose a molecule that's in combustion gases, why then you can say that's combustion. But we don't usually do our research that focused in those kinds of things. The molecular beam research looks at what is convenient and gives the most basic information.

I could give you many such examples. I won't.

Could I have the second slide, please?

(Slide 2)

I have it in my notes that you were supposed to notice the rate of change. There was a large rate of change in fossil energy. There was a decrease in these unspecified things.

Here is the major component of our program in fossil energy; the chemical sciences.

CHEMICAL SCIENCES

FOSSIL ENERGY RELATED RESEARCH

	FY 73	FY 75	FY 77
CHEMICAL SCIENCES	$0.4	$2.1	$5.6
CATALYSIS* (HETEROGENEOUS)	0.1	0.3	1.6
COAL CHEMISTRY (CHARACTERIZATION, ORGANIC CHEM., REACTION KINETICS, MECHANISMS)	0.2	1.2	2.2
ANALYTICAL CHEMISTRY (MASS & OPTICAL SPECTROSCOPY, CHROMAT.)	0.1	0.3	0.5
COMBUSTION	0	0.3	1.3

* DOES NOT INCLUDE MATERIALS SCIENCE RESEARCH ON CATALYSTS.

M$ B/O

You can see in FY77 it's $5.6 million. We think it's truly fossil energy-related, and we can point to it as highly relevant.

And by the way, most of our research in fossil energy does have a habit of being related to specific problems--it's far easier to tie it to specific goals. I'll get to those in a few minutes. You can read as well as I can, and I don't imagine you're surprised by a single item on that list.

This program is well integrated. The first two topics with fossil energy--Alex Mills's program and others. In the last topic, combustion--we have a three-way organization going. Karl Bastress, the speaker you heard this morning from Conservation, Andre Macek who works for Alex Mills, and one of my people responsible for combustion, coordinate an overall combustion program.

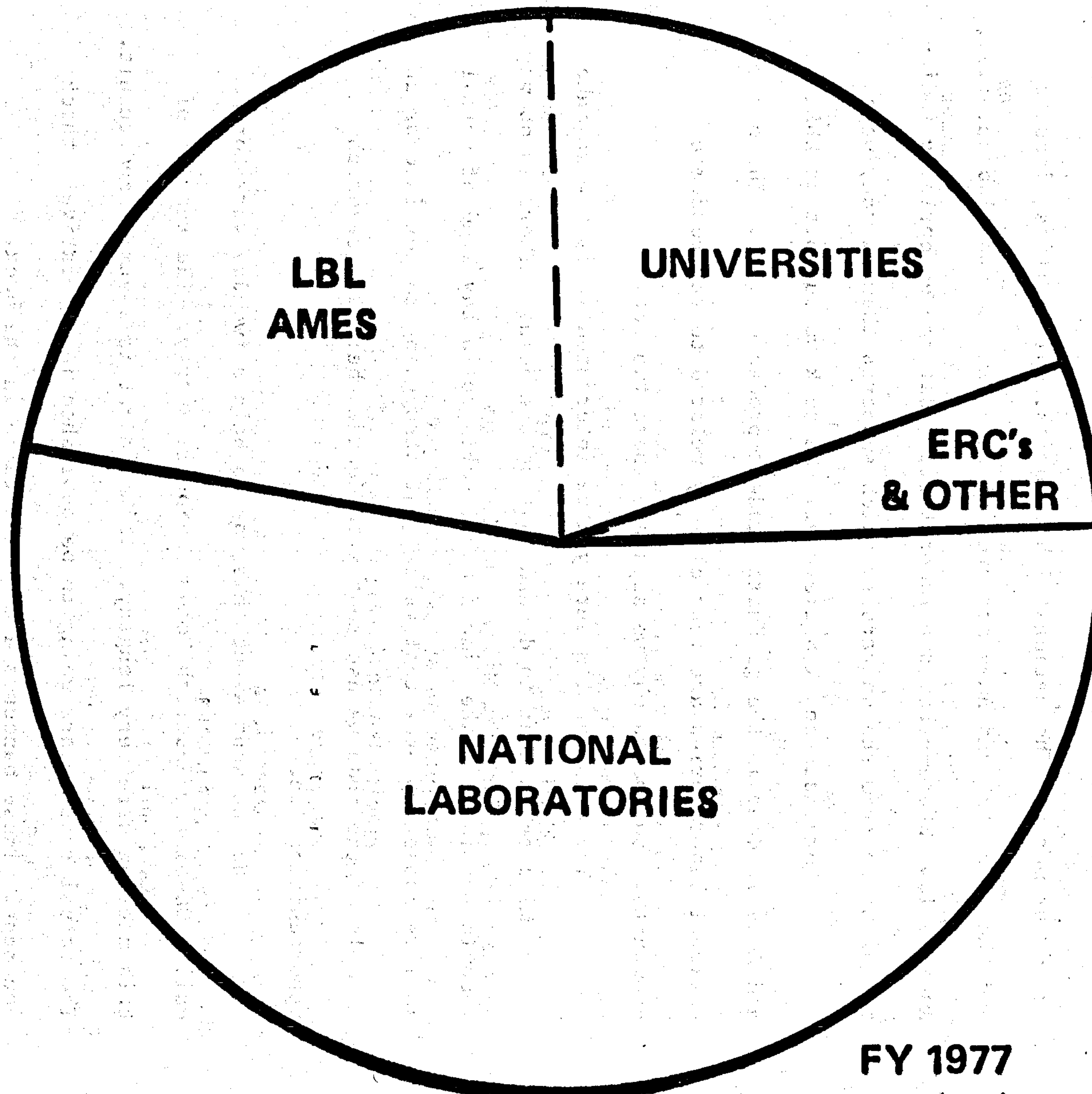
My people are interested in the molecular level interaction part of it: the cross section of the individual reactions, the kinetics of the reactions, and in the fundamental understanding of the turbulence phenomena.

Karl and Andre, the other two people, are more interested in relating combustion research to real world situations like the stratified charged engine or like a fluidized bed combustor or like a MHD burner.

Okay, the next slide, please.

(Slide 3)

CHEMICAL SCIENCES
FOSSIL ENERGY RELATED RESEARCH



FY 1977
5.6 M$ B/O

Who does it? This slide shows a breakdown of where we spend our money. The national laboratories, universities, industry and the ERCs, LBL and Ames are special cases in national laboratories, Ames is Iowa State--they are laboratories that are essentially indistinguishable from the university which supports them in many ways.

For instance, I believe all the work we support at LBL and Ames is done in the graduate student-professor mode. The other national laboratories are less closely related to the academic community. So that's why we separate those two out.

The question I'm sure you're interested in is how we make up our mind as to what to do and what we are doing. There is no way I could possibly in the time I have, tell you in any kind of detail, so I've chosen an area that we're just struggling to get into as an example of the mode we use to try to decide where the research opportunities lie.

How we went about this was to hold a two-day workshop, called Chemistry Research Needs in Fossil Energy. The results of this meeting were very lengthy. This handout is a summarized result. The actual results are going to be published in a relatively thick document. These handouts are on the table in the back.

The handout contains what we found out by sponsoring this two-day workshop. We invited people. I don't have a breakdown here in front of me, but it was universities, national labs, with the energy research centers represented. Those are really our link into the business.

You understand that a lot of our effort has been to redirect some of the national lab work into ways that are productive for the fossil energy problems. And the national labs, as you've heard, are very good for some things and at other things they are totally inexperienced. So if we do use them, we have to make sure we're using them for things that are productive.

The point of the workshop was to find out what things in the opinion of the community were needed and what should we settle on. And it turned out that the participants--it was a rather extensive meeting; it lasted two days and there were 30 or 40 participants --settled again on areas which I'm sure won't surprise you. They're in the next slide.

(Slide 4)

The handout that you can pick up describes these three areas. Can we really understand coal and the primary decomposition products of coal, the asphaltenes, the other fractions that come off when you degrade it in various ways? How can this be related to the other properties that are observed?

Somebody yesterday, I believe it was Alex, showed a very elaborate coal molecule, a polycyclic, aromatic molecule of some kind, and he pointed out that it would be of great benefit if you could cleave it selectively in certain places. I'm sure this has occured

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CHEMICAL SCIENCES

CHEMISTRY RESEARCH NEEDS IN FOSSIL ENERGY

CHARACTERIZATION OF COAL AND COAL DERIVED SUBSTANCES

CHEMICAL REACTIVITY AND MECHANISMS

CATALYSIS

to everybody that's studied coal for the last 100 years, and some of you coal experts are probably chuckling at my presumptiveness here. But if you could cleave them in certain places, you would leave a very large residue having a favorable carbon to hydrogen ratio.

So rather than take it apart with a sledge hammer, if you could really learn what the sensitive points of attack are in this complicated system, there would be a big payoff.

And finally, catalysis, for reasons which again I'm sure are totally familiar to this group. I think the reasons were probably best brought out in Alex's slides of yesterday in which he pointed out the effect of capital cost on product cost. I think he even had a slide in which he showed what the price of the product would be if you could put twice as much through the same plant.

Of course, it was a dramatic effect, obtained by increasing throughput.

May we have slide 5, please?

(Slide 5)

These are some examples of things we're doing. I'll leave it for you to gaze at a minute and go into another topic, which is, problems carrying out the program. I really haven't told you much about it yet, but let me tell you a couple of our problems. First, as mentioned yesterday, there really aren't that many performers that are anxious to get into those particular areas we've pointed out.

CHEMICAL SCIENCES

EXAMPLES OF FOSSIL ENERGY RELATED RESEARCH

- CHEMICAL STRUCTURE OF COAL BY CHEMICAL OXIDATION TECHNIQUES USING GCMS. ANL
- ANGLE-RESOLVED PHOTOELECTRON SPECTROSCOPY OF ADSORBED SPECIES ON CATALYTIC SURFACES. LBL
- LABILE SO_2 COMPLEXES FOR REVERSIBLE SCAVENGING OF SO_2 FROM GAS STREAMS. LASL
- MULTIPLE PULSE, MAGIC ANGLE SPINNING NMR OF HYDROCARBON SOLIDS. AMES
- CATALYST POISONING MECHANISMS BY AUGER CHARACTERIZED SURFACE REACTION STUDIES. DELAWARE, NBS

Now that may surprise a lot of you, not that we have great amounts of money, and we do have a lot of proposals we turn down. So I may be overdoing this point. But how are we going to entice the really top-notch young scientist who is very much these days enamored with figuring out polymers and DNA and all that sort of thing? How are we going to entice them into the coal business, because I'm convinced until we get that type of intellect working on this problem, we're just wasting our time.

So there is a big problem in doing this. One of my people who works with proposers and talks to the proposers and discusses research with them, told me that he thinks that it's going to be an evolutionary process, that we're not going to be able to get the established generation of scientists. They've already made their mark in one of these other fields that has a high glamor coefficient. He thinks it's going to be the young people just getting out of school that are really going to plunge into this whole business of coal, understanding it from a very much more basic viewpoint than it has been understood in the past.

The other problem, of course, is budget. Again, this is not a plea. My budget in fossil related research is one of my highest priority areas and I'm going to double it again next year. It's been doubling about every year and that can't go on forever, but we really are very concerned, and we'll do this at the sacrifice of other areas, if necessary, to get more money into fossil energy.

Let me give you a few examples. I picked several of these to show you how we are being selective in some of the uses of the national labs. They have, in some cases, extraordinary capabilities which were built for other reasons, but are very well suited to fossil energy research.

Now that first title sounds rather pallid because it's a gas chromatography-mass spectrometry combined and I'm sure there are many of those instruments, but this one is unique. I guess Argonne has one of the finest mass spectrometry setups that I know of in the United States.

What they're trying to do is to focus their attention on what molecules come off when coal is degraded by a variety of degradation means and what information you get out of this.

The second one is a very interesting one. In fact, that particular piece of work was done on the SPEAR facility because they couldn't get photons in sufficient intensity and at the right wavelength anywhere else to do that photoelectron spectroscopy. For the first time, I believe, they were able to actually prove that carbon monoxide sitting down on the surface of the catalyst was sitting with one end down. Well, now, I forget which end.

VOICE: The carbon end.

DR. KANE: The carbon end was sitting down and precessing around, and they could get its dynamics on the surface using synchrotron radiation. Now, I don't know what's going to come of that, but I'm sure that that kind of knowledge is going to be useful to us.

The third one is one that grew out of LASL, as you probably know. I'm not sure it even came this way, but I'll use it as an example and I hope I'm right. LASL has for years been interested in chelating complexes, the whole heavy element business; separation of heavy elements has been highly dependent on chelating compounds.

Now, obviously you want a chelater that grabs the SO_2 and then releases it again, and that means that it's got to have a certain heat of binding, obviously, to make that happen. So if you had to develop chelating compounds, which are big organic molecules, can you characterize the heat of bonding in some simple measurement without actually measuring it reversibly?

LASL thinks they may have developed a technique whereby they can by infrared measurements of the molecule infer the heat of bonding to SO_2. This would greatly reduce the effort needed to develop chelating agents.

This is again just a gleam. It's not proven technology.

The fourth one represents research by Professor Gerstein at Ames, who is really an outstanding pulsed NMR scientist, and he's turned his efforts toward coal. Now, Ames is an interesting spot. Iowa's got a lot of coal in it. The whole State of Iowa's getting very coal-conscious. I think you're going to see a transition of that Ames Laboratory, at least to some extent into the coal business. They will approach it through the university and I have great confidence that they'll do it in a very basic sort of way.

Finally, a project we have on catalysis poisoning. I'm over my time. I know I've run over and there'll probably be questions. Why don't I just stop right there.

I'll point out that one meeting we had in which we tried. There was a similar meeting to get these fossil energy research needs held on heterogeneous catalysis last fall. And those results are available, too. Not here today, but if you want to contact me, I'll see that you get a copy.

Thank you very much.

(Applause.)

Dr. KROPSCHOT: Questions:

DR. REYNOLDS: Jim, you mentioned that your charge is to deal with the physical sciences, and I think you meant probably exclusive things like life sciences. Where do engineering sciences fit into the picture?

DR. KANE: I have recently reorganized, and one of the new boxes on my organization chart is engineering sciences--that doesn't mean engineering development--it means engineering sciences.

I have a few little pets that I put in that, but I don't think I'm smart enough to say what ought to be there. We're now in the process of developing what things ought to be in there, whether it's modern, say, process control; that might be an example. Or I could think of a great number of engineering sciences topics.

I think ERDA, and particularly we, have been very deficient in ignoring this subject and we're hoping to make amends, but all I can give you is promises right now. We're looking at that.

DR. HOLLOWAY: Jim, I want to ask you a mean question.

Suppose one of the distinguished universities came to ERDA with a proposition for some work on fundamental combustion and they said look, we'd like to do some theoretical work. We'd like to do some modeling work and we would like to do some experimental work in this area.

And ERDA came back and said well, the theoretical work's fine, the modeling work is fine, but thank you on the experimental work, we'll do that in the national laboratories.

What would you think of that?

DR. KANE: I hope we wouldn't do that, Dr. Holloway.

DR. HOLLOWAY: You did.

(Laughter.)

DR. KANE: Did we do it?

What can I say?

(Laughter.)

DR. KANE: That was a mean question.

Let me spend a minute on that. We probably did. In fact, if you say so, I'm sure we did.

I think I would like to clear up what we're trying to do at Sandia, because I think if there's any one thing that's gotten me a bad reputation with the universities, it's been what I did at Sandia. I was largely responsible for that.

Sandia, because of weapons requirements, starting about, oh, eight or nine years ago, developed a very sophisticated dynamic gas analysis technology, not aimed toward combustion at all, analyzing the mixture of gases in a very short time, schlieren and pulsed laser diagnostics and so on. They, over the period of years, acquired some, I think, extremely competent people in combustion and convinced me that we should have a combustion diagnostics facility in which we centralized the development of the very expensive pulsed lasers that it will take to do this.

That meant that we gave, in my opinion, a disproportionate amount of our experimental attention to Sandia. That probably was the reason we did what you said we did.

If we did it, well, maybe we had a right to. Maybe we knew that somebody else was doing it better. I think the answer "because we'll do it in our national labs" would be very poor. If we could have said we are already doing that work somewhere else that would have been a better answer. I hope we said it that way.

MR. HILL: George Hill.

The concern you expressed about getting bright young men and women into the field: I don't see how in the national laboratories you can develop a mechanism that matches quite the university matrix mechanism.

Are you going to shift more to university center support like you have with Ames and so forth, where the post-docs generally spend their time?

DR. KANE: George, I guess I don't know the answer to that right now. I have no plans for a dramatic shift to the universities. I've been thinking of an experiment and that would be to get a couple of Jerry Phillips and Dick Kropschots to come from outside ERDA and look at that question for me and help me on it during the next year.

But I don't envision a dramatic shift. In a constant budget arrangement which is what I'm sure I'm faced with, it's a very difficult thing to make major moves into the universities. We could place our support in bigger chunks than we have though.

MR. SCOTT: Paul Scott.

What's your success ratio for new proposals from universities? Can you give us an idea if somebody comes in new with a proposal, say fossil energy-related? For instance, catalysis, what is it?

DR. KANE: There's a couple of people in the audience I think could better answer. I think our gross rejection rate is, like 7 to 8 out of 10.

Now, there's lots of duplication in the system. People mail them to both us and NSF, so maybe it's not quite as bad as it sounds.

How about Elliot Pierce? Could Elliot give a quick answer to that?

Could you go to a microphone, please, so everybody will hear you, Elliot?

DR. PIERCE: Overall success rate of university proposals in the chemical sciences is on the order of 8 to 10 percent.

MR. SCOTT: 8 to 10. That's other than renewals?

DR. PIERCE: That's right.

DR. REYNOLDS: I just want to remind folks that there was a program that the National Science Foundation had a couple of years ago where they put out a forgivable loan program and the students were paid for going to school and getting an education, and if they went into teaching, the loan was forgiven.

Maybe you could do something like this to get people into the labs in coal.

DR. KROPSCHOT: I will set the clock for 15 minutes for a coffee break and be back then.

(Recess.)

DR. KROPSCHOT: We would like to proceed with a description of the program in material sciences that is being conducted in the Division of Basic Energy Sciences, and I would like to introduce the assistant director for the Materials Sciences Program, Dr. Donald Stevens.

DR. STEVENS: Dr. Kane has given a fairly complete description of the mission of the Division of Basic Energy Sciences, so I will not go into great depth on that.

May we have the first slide, please?

(Slide 1)

But I would like to show you the goals of the Materials Sciences Program. It is a program to develop the understanding of materials properties and phenomena as a basis for the development programs, to chart a better course, to provide information to anticipate materials problems and to help when the unanticipated materials problem comes along in the future. Invariable, in high technology, as advanced technology systems development, we will have materials surprises. That has been classic throughout all systems development for the past 20 to 25 years.

We do not develop materials. We develop understanding of materials.

The program supports research in the areas of metallurgy, ceramics, solid state physics, chemistry and chemical engineering as they apply to materials problems. We have six permanent staff members. And, fortunately, we have two people from universities with us on sabbatical who have played a very important part in an activity that I'll describe later on.

What is the composition of the materials science program?

(Slide 2)

This is a pie chart that shows in one way how the subject content of the program can be broken down. Of course, one can go into phenomena, one can go into materials classes, one can go into

MATERIALS SCIENCES

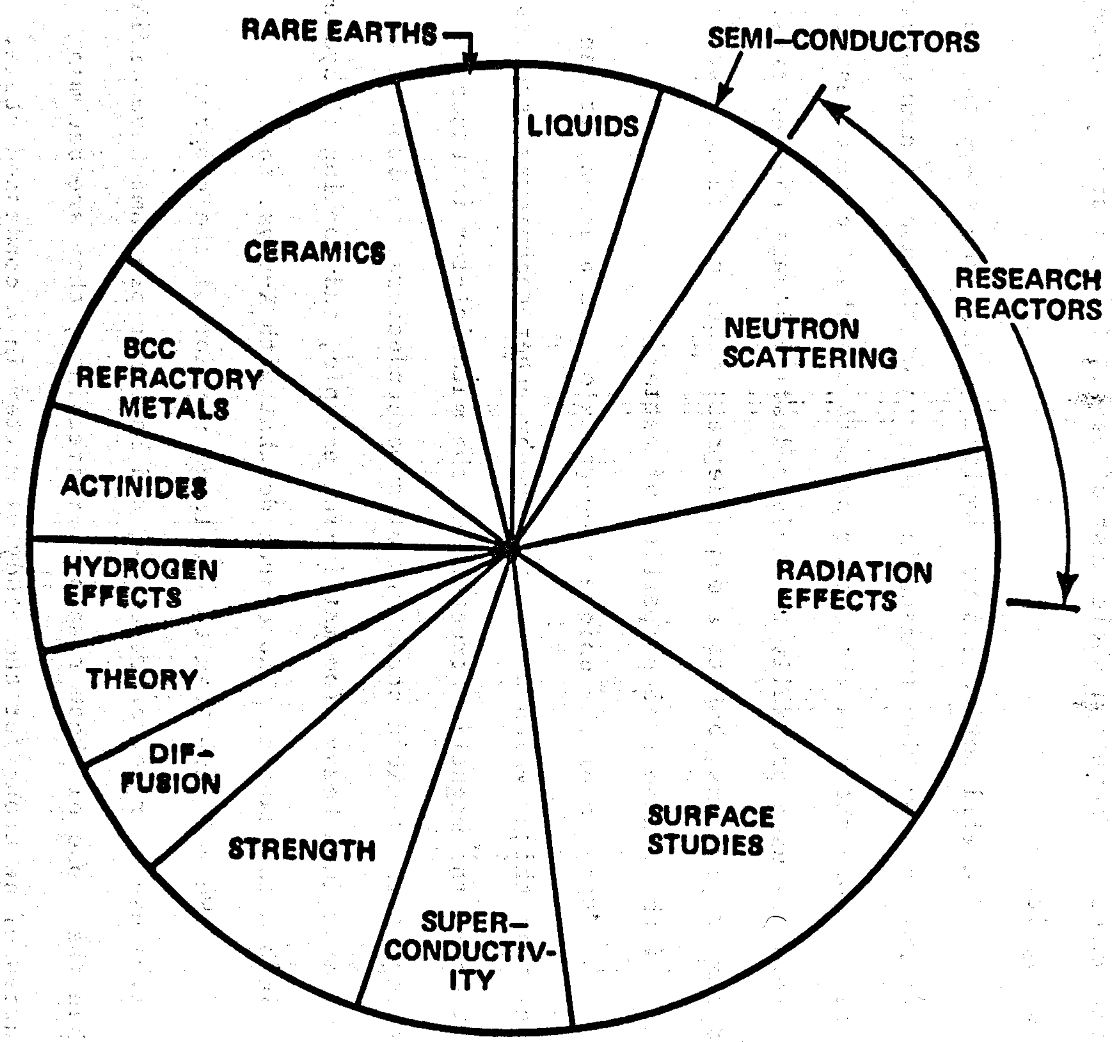
GOALS

- TO ADVANCE THE UNDERSTANDING OF BASIC STRUCTURES AND MECHANISMS GOVERNING PROPERTIES AND BEHAVIOR OF MATTER IN THE CONDENSED STATE.

- TO PROVIDE A FOUNDATION FOR MATERIALS TECHNOLOGY THROUGH THE DEVELOPMENT OF BASIC KNOWLEDGE IN MATERIALS-RELATED ENERGY PROBLEM AREAS OF INTEREST TO ERDA.

- TO EXPLOIT THE UNIQUE CAPABILITIES AND FACILITIES EXISTING IN ERDA LABORATORIES FOR CONDUCTING NATIONAL MATERIALS SCIENCES PROGRAMS.

MATERIALS SCIENCES FY 1977 FUNDING BY TOPICAL AREA



OPERATING BUDGET (CONG APPROP) – $52.8M

environments. There's a whole host of ways. This is simply one way of doing it.

You will notice, as was implied in Dr. Kane's speech, we have a rather heavy involvement in the area of the use of neutrons. Those neutrons shown in the sector of this pie chart called research reactors are used partially to study radiation damage for the fission and fusion programs, but to a major degree, neutrons are used as a probe of the fundamental properties of matter.

Because of the unique properties of the neutron, it can do certain things which cannot be done by other techniques, such as looking at the magnetic structure of the material-for instance, looking at the fluxoid structure of superconductors, to look at a light atom in a heavy atom matrix-for example, and looking at hydrogen in a metal matrix. You cannot do that with X-rays, too.

We see here then that a large portion of the program involves use of research reactors, and as other programs have diminished their use of these reactors, increasingly they are becoming sources of neutrons for the study of matter in a condensed state.

We have a large program in surface properties and ceramics. These programs have grown considerably, particularly since the formation of ERDA.

As Jim pointed out, we were part of the AEC program and when ERDA became operational, our responsibilities greatly broadened from basic research pertaining to the nuclear technologies to basic research to all energy technologies.

So surface and ceramics research particularly have grown in these past several years; also hydrogen effects, work in the BCC area and, of course, in the semiconductor area as it relates to the solar problems.

The budget for the Fiscal '77 is $52.8 million, and as Dr. Kane pointed out in the request before Congress there is $58.45 million requested for the Materials Science Program.

Where is the work performed at the present time?

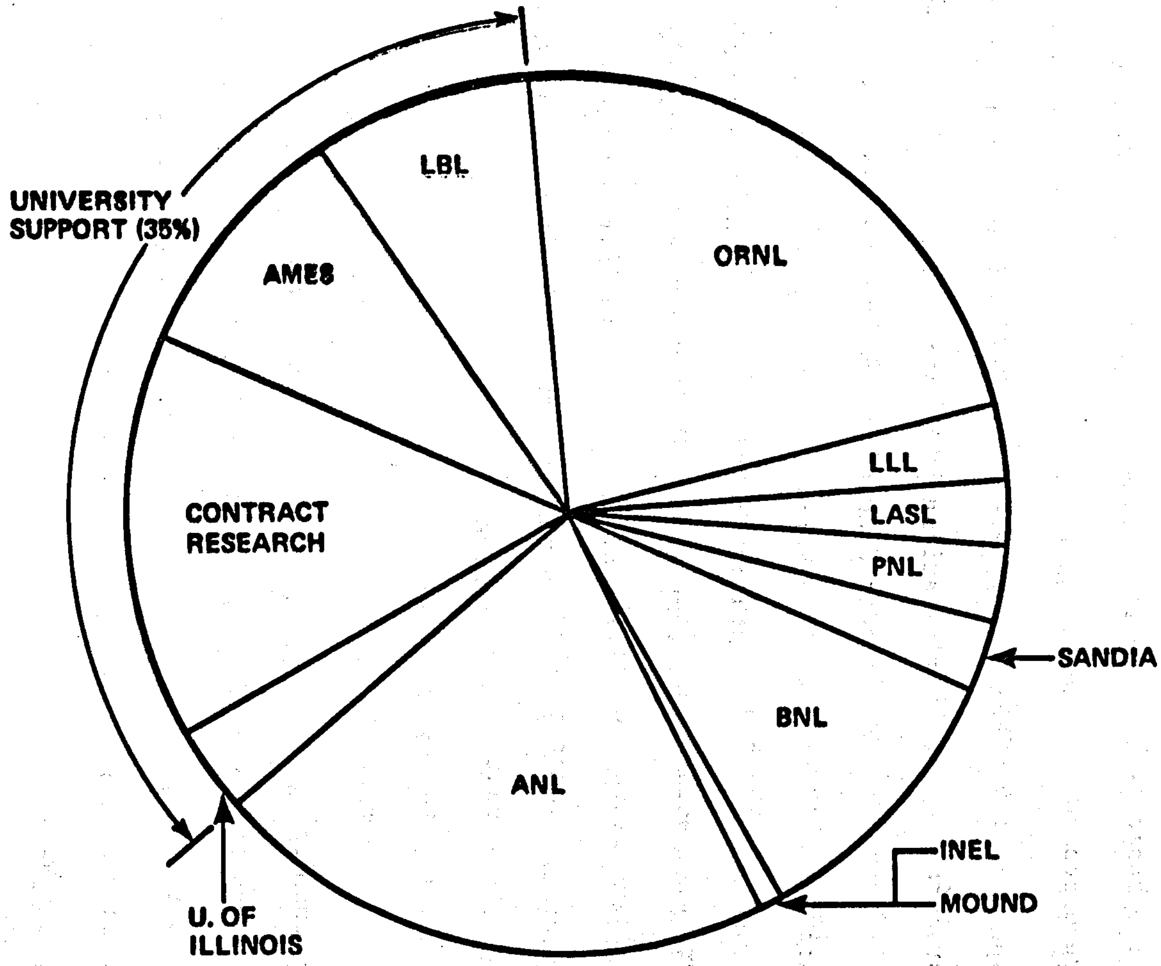
Next slide, please.

(Slide 3)

This pie chart shows, as Jim pointed out in his talk on chemical sciences, that a large portion takes place directly in universities including the Ames and Berkely Laboratories, where the work is carried out primarily by professors and graduate students. We have a large program at the University of Illinois. This is part of the Federal Interdisciplinary Materials Laboratory Program started in the early '60s, when there was heavy involvement at universities by the Department of Defense and the AEC. Subsequently, those large DOD projects have been transferred over to the National Science Foundation.

So about 35 percent of our funds go to the support of professors, post-docs and graduate students, directly in universities.

MATERIALS SCIENCES DISTRIBUTION OF RESEARCH BY LABORATORY & APPROXIMATE PERCENTAGE OF BUDGET



FY 77 OPERATING BUDGET (CONG APPROP)—$52.8M

And there is a heavy involvement in the national laboratory programs by students who come to do their research and professors who come and spend summers and, further, there are graduate thesis advisors of students coming to the national laboratories.

The two largest contractors, as you can see, are the Argonne and the Oak Ridge National Laboratories. This is partially historical, because both of those laboratories have very large metallurgy programs, very large solid state physics programs and very large chemistry programs, all sited contiguously. Because of this interdisciplinary mix, the research that can be conducted at these laboratories can be of a more complex, a more involved nature than is possible, say, with a $40,000 contract at a university.

The contact research program constitutes about 15 percent of the program, and is carried out at universities. I say "primarily," because out of that pot of money also comes the support of workshops, symposia, and things like that, of general broad interest to the scientific community, which are also important to ERDA. There are a few contracts with private industry and not-for-profit institutions in that section, but they constitute just a small portion that I expect will grow in the future.

The next question is what are our program interactions? How do we plan our program? Where do we get the input?

Next slide, please.

(Slide 4)

MATERIALS SCIENCES

PROGRAM INTERACTIONS

- ERDA MATERIALS COORDINATING COMMITTEE
- TOPICAL WORKSHOPS INVOLVING TECHNOLOGY REPRESENTATIVES AND BASIC RESEARCHERS
- CO-SITING OF APPLIED AND BASIC RESEARCH
  - EROSION (ANL, LBL)
  - HYDROGEN ATTACK (AMES)
  - CORROSION (ORNL, LLL)
- ATTENDANCE AT ERDA TECHNOLOGY PROGRAM REVIEWS/WORKSHOPS
  - STRUCTURAL CERAMICS
  - FAILURE PREVENTION IN COAL CONVERSION SYSTEMS
- PARTICIPATION IN COMAT
  - MATERIALS FOR ENERGY STUDY
  - MATERIALS R&D INVENTORY

Immediately after ERDA was activated on the initiative of the Materials Science Program, there was set up within ERDA, the ERDA Materials Coordinating Committee. This committee consists of members from each division or majority entity in ERDA that has an involvement in materials R&D with their senior man sitting on this coordinating committee.

The Committee meets once a month, and information about program content, problems which are arising, new directions, budgetary matters, et cetera, are exchanged around the table. Problems of common interest and sources of assistance for the solution of specific problems are identified.

So, number one, at the ERDA Headquarters level, there is the coordinating committee where information is exchanged about problem areas.

Number two, there are topical workshops which are set up both by the Materials Science Program and by the applied programs. For instance, in our program we set up a workshop on stress corrosion cracking which involved scientists from the technologies and scientists from the industrial contractor community. We sat down for three days and analyzed the problem and decided where best to go and who should be doing what. There was then heavy fossil energy involvement in this workshop. It has led to a further activity of the ERDA Materials Coordinating Committee--a continuing subcommittee has been set up to further develop the plans of the agency as a whole.

The third area of interaction is down at the site where the work is done. Perhaps the best coordination, the best program development, takes place down at the working level, where to the extent possible we try to collocate basic research contiguous to applied research. This facilitates the flow of information to the basic people, what the applied problems are, and it facilitates the flow of the new information from the research community as a whole into the applied program.

We have many cases where that is taking place at the present time. It's growing, of course. There is erosion work going on at Argonne and Lawrence Berkeley Laboratory, which is supported both by us and by the Fossil Energy Program; hydrogen attack at Ames; corrosion at Oak Ridge and Lawrence Livermore.

I would like to site a recent specific example of this close interaction. The Ames Laboratory at Iowa State University, with our support, has come upon an economic means of recovery of aluminum oxide from flyash. A patent has been applied for, and very recently, the Fossil Energy Program has come in and put in some money beside ours to further that effort.

Participation of COMAT (COMAT is the Committee on Materials of the Federal Council for Science and Technology) is the high level materials coordinating committee of the Federal Government consisting of high level representatives from each agency having an interest in materials R&D. COMAT has carried out two studies of interest to their audience. One is materials for energy. This was a very exhaustive study, which looked at the materials aspects of the energy technologies, both in the short-term and the long-term. The reports of this very extensive study are just becoming available.

Another study carried out by COMAT is an inventory of the total federal expenditures in FY-1976 for materials research and development. That inventory has been completed. The activity was headed by the Department of Interior with Battelle Columbus as its contractor. COMAT is now going to attempt the horrendous task of attempting to make an inventory of all materials R&D that's going on in the private sector. I wish them luck on that one.

But some interesting things did come out of the Federal materials R&D inventory. The Materials Science Program was deeply involved in this one. We, and all programs, of course, were involved in the general study on materials for energy.

If I may have the next slide.

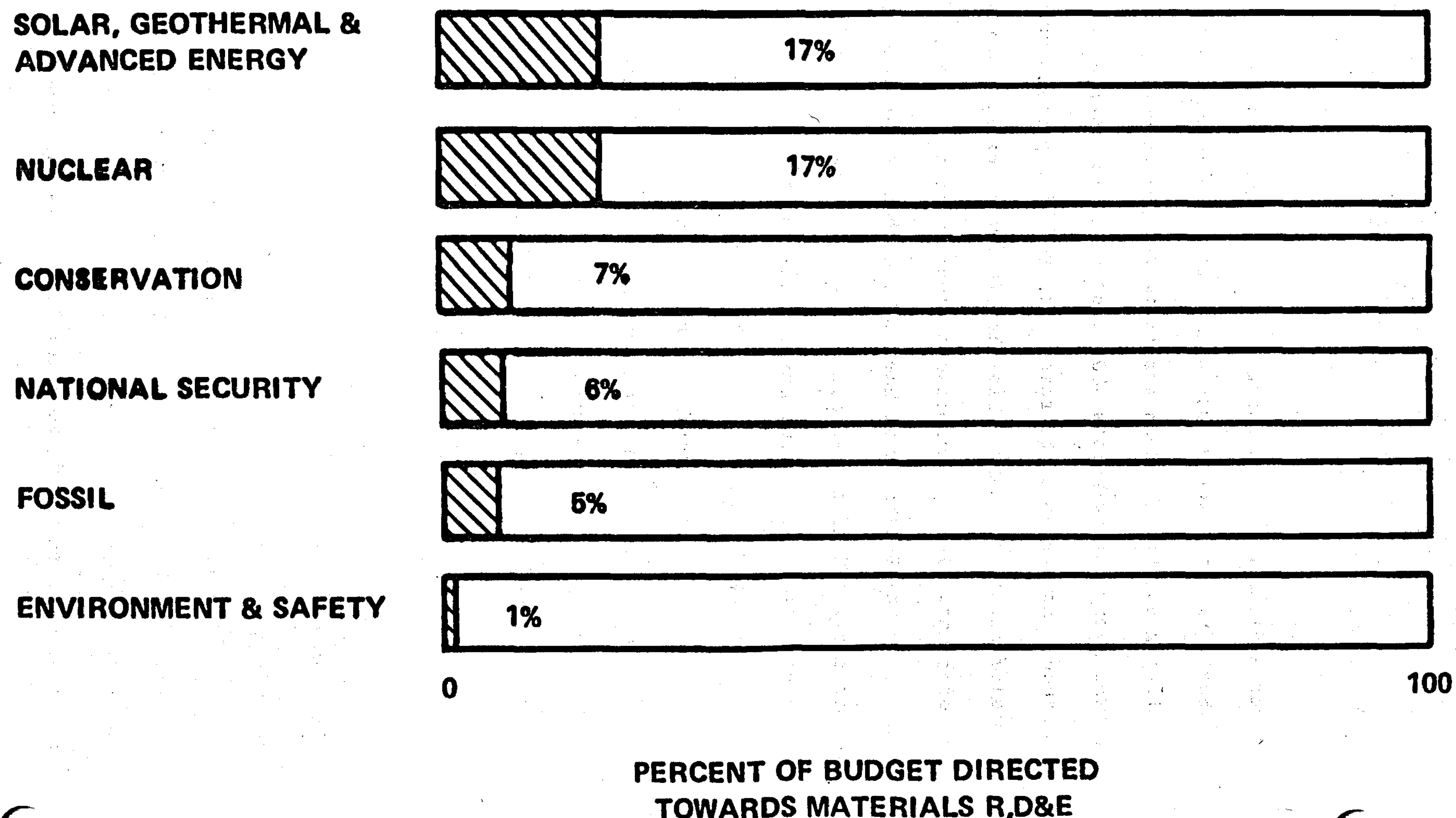
(Slide 5)

As a result of that inventory, we developed information that the total expenditure in 1976 for materials R&D by ERDA was approximately $314 million.

If we then look at the various program areas within ERDA, we find that in the Solar, Geothermal, and Advanced Energy Systems area, 17 percent of the funds available for that program, or those programs, was used for materials R&D. This was the sum total of the

MATERIALS R,D&E IN ERDA

REFERENCE: COMAT INVENTORY OF MATERIALS R&D IN THE FEDERAL GOVERNMENT FY 1976



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money spent in Basic Energy Sciences Magnetic Fusion Energy, in Solar, and Geothermal for materials R&D. In the nuclear area, about 17 percent of the funds available for development of fission energy was spent for materials R&D; conservation, seven percent; national security, six percent; fossil energy, five percent; environment and safety, one percent. This then shows generally how the expenditures of $314 million were spread throughout the agency.

Let's look at how the Materials Science Program has changed over the past four years.

If I may have the next slide.

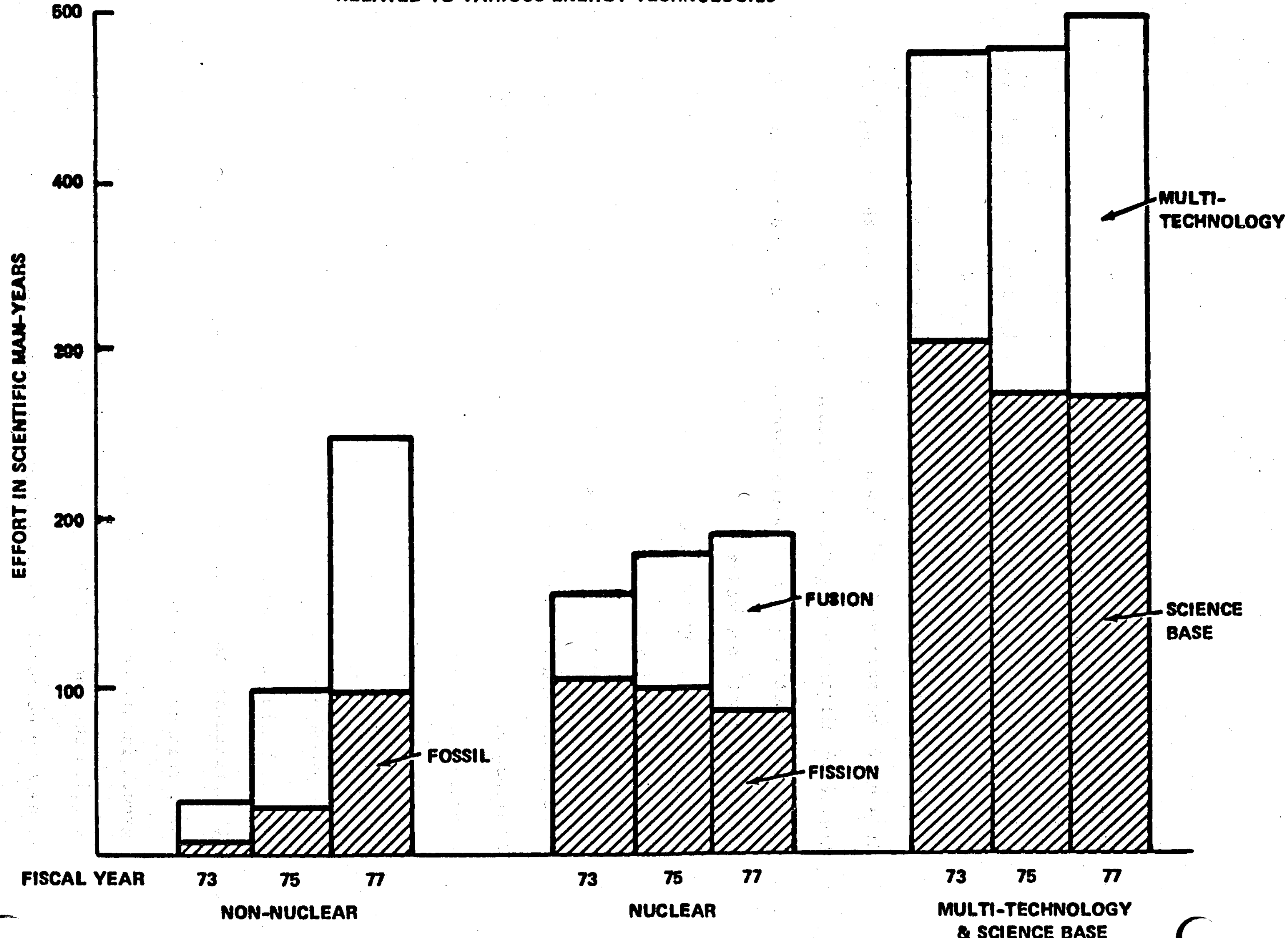
(Slide 6)

We are nearing the end of an exhaustive study calling upon the laboratories to provide us raw data, to analyze the Basic Energy Science Program, in terms of how it has changed from before ERDA, at the beginning of ERDA, and as we are in 1977.

This slide shows the raw data which was just put together this past week on how the Materials Science Program has changed in this four-year period.

You can see that there was very little research going on that pertained to the nonnuclear technologies in 1973. As you can see, this area of research has grown faster by far than the total growth in all other sectors, and one sees in the crosshatched section the amount which is clearly related to fossil energy. One sees a reduction in the amount of research related to fission

MATERIALS SCIENCES PROGRAM EFFORT
RELATED TO VARIOUS ENERGY TECHNOLOGIES



energy, an increase, small increase in the amount of research related to fusion energy.

And then one goes over to the bar charts on the right. I'd like to explain those briefly. By multi-technology research we mean research that has application or pertinence to several technologies. It doesn't make sense then to signify it as totally for one or for the other. Superconductivity is a good example of this. The Math Sciences Program is a major supporter of basic research in superconductivity. We are spending on the order of $4 million on it this year. This research pertains to fusion, to MHD, to energy transmission, and it pertains also to some advanced concepts in exploration-squid devices which I will briefly mention. It really doesn't make sense then to break superconductivity and say so much of it is for fossil, and so much for this, or so much for that. That's what we mean by multi-technology research.

"Basic science" is research which is not clearly discernible as closely related to any given technology. An example of that might be the use of neutrons to study the magnetic structure of, say, the ferroelectrics. It isn't clear that the structure of ferroelectrics is significantly important to any technology. It's that type of research, then, whose purpose is to increase our general understanding of materials, and which provides the basis for our understanding the unexpected when it comes along in the course of technology development.

One sees in this four-year period the amount of "Science base" research has gone down. The amount of multi-technology research has gone up slightly. But, clearly, the areas of greatest growth have been in the area related to the nonnuclear technologies and, specifically, the fossil energy program.

(Slide 7)

The next slide lists research that we are carrying out, which has, we feel, a direct relationship to the fossil energy program. Under coal characterization, we are looking at the physical properties of coal, using, for example, the electron microscope. One finds that coal is a very porous material, and in each of these pores -- they look like wormholes -- there is a small piece of something which apparently is a natural catalyst. I think Dr. Mills mentioned in his comments yesterday about minerals having catalytic properties.

On sulfur effects, we have several things going on. Some recent work at the Argonne National Laboratory has shown that Western oil shale can serve as an absorbent for sulfur dioxide released in its combustion in a fluidized bed. It isn't completely clear why, but it is better than dolomite -- possibly because of its porosity. This information has been turned over to the Morgantown Energy Research Center for further investigation and to see what the useful aspects of that might be.

I will show another example of sulfur effects, in a succeeding slide.

MATERIALS SCIENCES

SUBJECT AREAS OF INTEREST TO FOSSIL ENERGY

	FY 1977 (K$)
COAL CHARACTERIZATION	280
SULFUR EFFECTS	650
CATALYSTS	1,560
EROSION/CORROSION	1,660
MHD MATERIALS	560
HYDROGEN ATTACK & EMBRITTLEMENT, STRESS CORROSION CRACKING	760
CERAMICS	330
	5,800

Dr. Kane mentioned catalysis in his talk. We are concerned with the solid. We are concerned with the structure of the surface and how and why the structure of the surface, is catalytically active. Whereas, in the chemical science program, they utilize the catalytic activity to study reactions and to further the development of catalysts.

Erosion and corrosion is clearly an area we have gotten into, because of the fossil energy program. Erosion was of no significant interest to the Atomic Energy Commission. Erosion is a major problem in the fossil energy area. It's a major problem for topping cycles. It's a major problem for geothermal.

We started early in the game when ERDA was being planned, to set up erosion and corrosion research. There is coal related work on erosion at Argonne and Berkeley. I'll show you an example of this research in a subsequent slide also.

MHD materials, ceramic materials, high temperature materials, and further hydrogen attack and embrittlement, stress corrosion cracking.

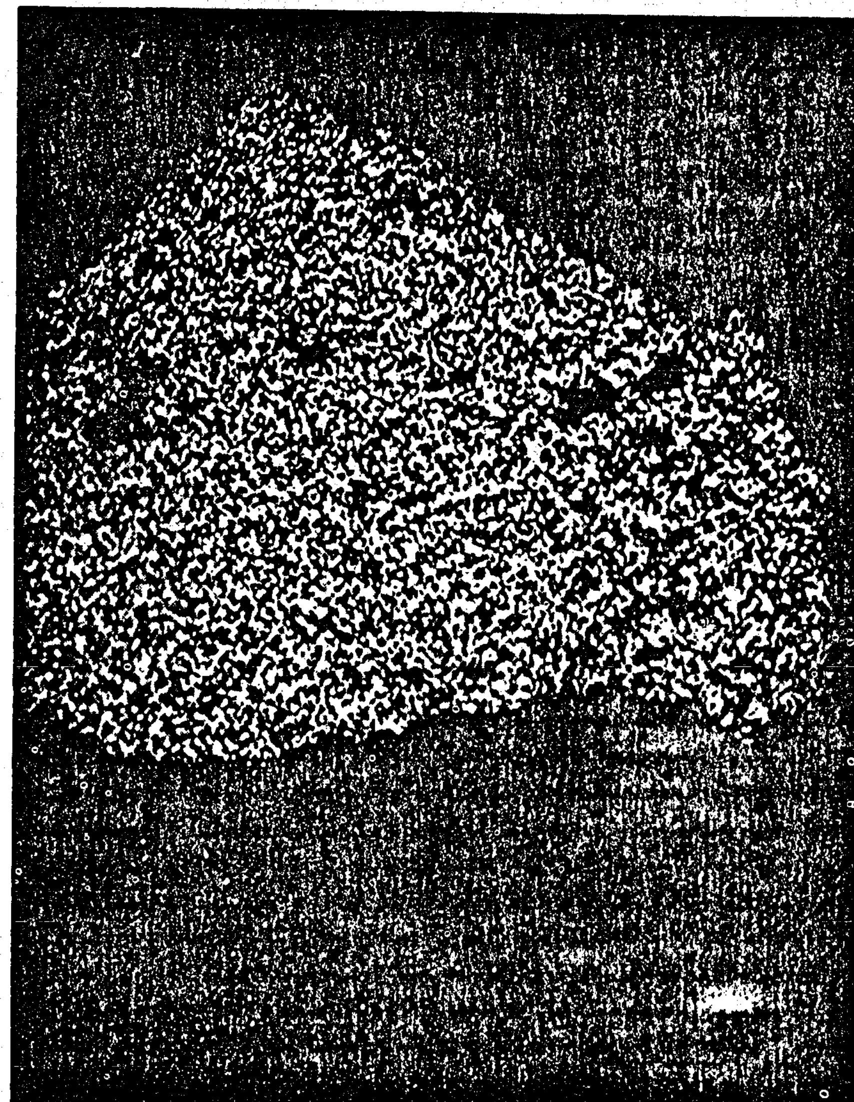
These are examples of research supported by the Materials Sciences Program directly related to fossil energy problems.

If I may have the next slide.

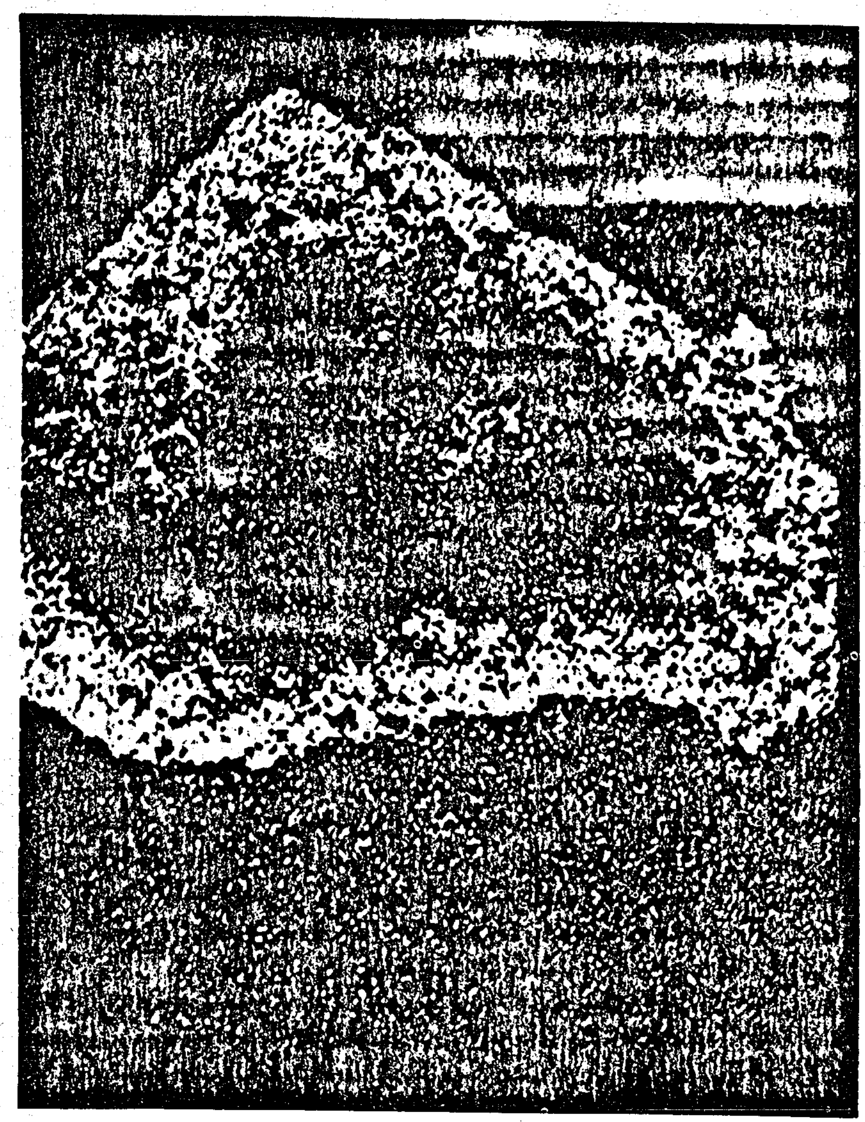
(Slide 8)

This slide shows results of research at Argonne, where people in the Chemical Engineering Division were looking at the use

SO_2 REMOVAL FROM FOSSIL FUEL



FRESH DOLOMITE
Ca, Mg (CO_3)



PARTIALLY SULFATED DOLOMITE

of dolomite to scrub SO_2. They got together with their colleagues in the Materials Science Division and applied materials science techniques to this chemical engineering problem. What they found from these studies are shown on these two micrographs. The one on the left is unreacted dolomite. After it has been partially reacted, one finds that the crystallite has a sulfated region around it, which impedes the flow of CO_2 out and impedes the flow of SO_2 in -- thus slowing down its reaction and reducing the efficiency of dolomite as an SO_2 scrubber. The study shows that it is as much a solid state problem as it is a chemical program. It has to do with diffusion. It has to do with impeding of diffusion and effusion.

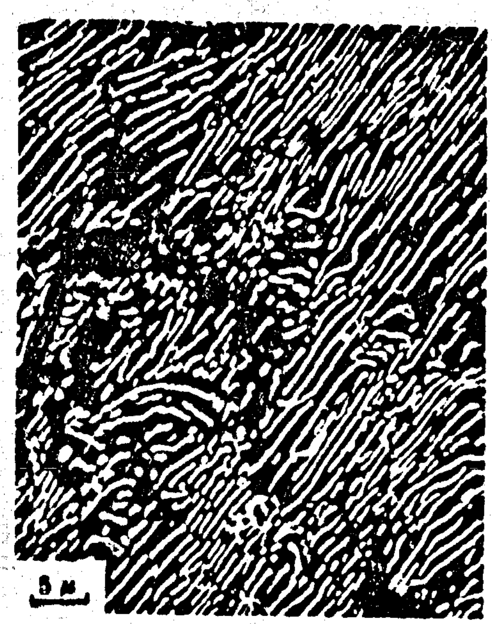
The next slide is an example of research that we're supporting in the area of erosion.

(Slide 9)

At the Berkeley Laboratory they have set up a very substantial program in erosion and have developed some extremely sensitive equipment costing in excess of $200,000.

In this series of vugraphs, we're looking at 1075-steel. One finds that on the left, in coarse pearlite, the erosion rate is 3.06 times 10^{-4}. If you go over to the far right, and fine pearlite, one has an increase of something like 17 percent in the erosion rate simply as a result of a different microstructure of the material. We don't understand the reason for this but are trying to find the answer. It's a real effect -- the equipment is that good.

EROSION OF 1075 STEEL

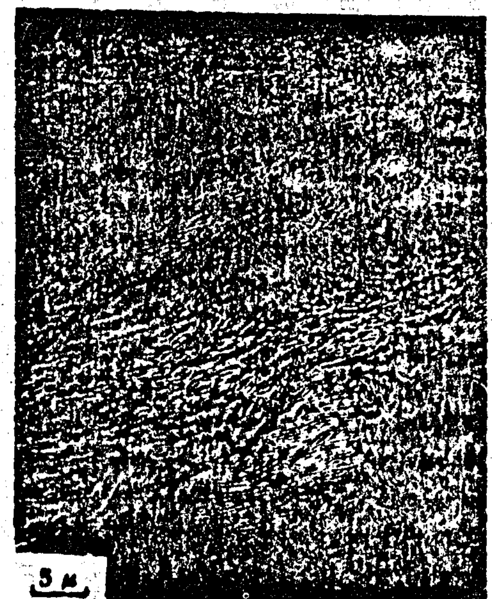


COARSE PEARLITE

Erosion Rate - 3.06×10^{-4} gm/gm

Hardness - R_B 90

Lamillar Spacing ~ 1 µm

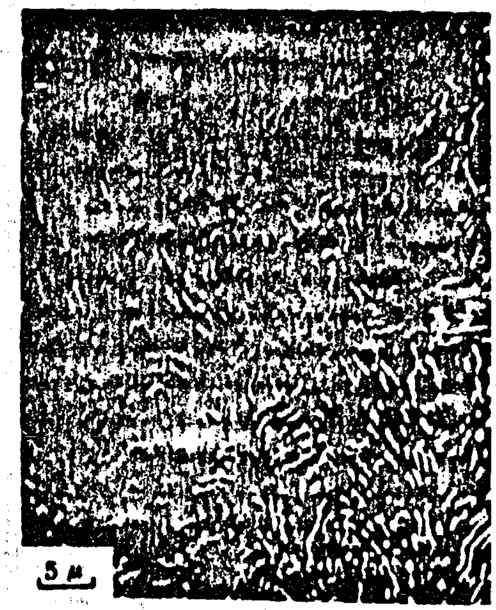


FINE PEARLITE

Erosion Rate - 3.18×10^{-4} gm/gm

Hardness - R_B 99 (R_C 20)

Lamillar Spacing ~ 0.25 µm



SPHEROIDIZED

Erosion Rate - 3.56×10^{-4} gm/gm

Hardness - R_B 88

Sphere Diameter ~ 1.25 µm

Impacting Particle: SiC
Impacting Particle Size: 88 µm
Angle of Impingement: 15°
Velocity of Impacting Particle: 386 ft/sec

Next slide, please.

(Slide 10)

Where is the Materials Sciences Program going? As I mentioned, we have a lot of input from technology workshops, our own workshops, topical workshops, from COMAT, from ERDA coordinating committee studies, etc.

We have just completed a series of overview workshops, wherein we have attempted to break out the entire field of materials science into nine tropical areas. The major objective has been to identify and assign priorities within the area of material science.

The two individuals that I mentioned who are with us for this past year from the universities were given the responsibility to manage this study, so that it wouldn't be a rubber stamp of what we're doing, but, hopefully, as an objective study as possible, to find out what we ought to be doing, where the scientific opportunities lie, and where the problems are.

Nine workshops were set up. There were 380 attendees. There were multiple attendees in certain cases. So there were 360 different individuals, whom we consider were the cream of the scientific crop in this country.

Thirty-seven percent of those attendees were from the national laboratories, thirty-three percent from universities, and fifteen percent from industry.

MATERIALS SCIENCES

WORKSHOP SERIES

- **MAJOR OBJECTIVE:** TO IDENTIFY AND ASSIGN PRIORITY TO AREAS IN MATERIALS SCIENCES WHICH WILL HAVE SCIENTIFIC AND TECHNOLOGICAL IMPORTANCE TO ERDA

- **NINE WORKSHOPS:**
  - ELECTRON PROPERTIES
  - SURFACE SCIENCE
  - LOW TEMPERATURE RESEARCH
  - NEUTRON SCATTERING
  - PHASE TRANSFORMATIONS
  - DEFECTS AND DIFFUSION
  - ENGINEERING MATERIALS SCIENCE
  - MECHANICAL PROPERTIES
  - THERMODYNAMICS AND ELECTROCHEMISTRY

- **MAKEUP:** 380 ATTENDEES
  - 37% NATIONAL LABORATORIES
  - 33% UNIVERSITIES
  - 15% INDUSTRY
  - 8% ERDA
  - 7% OTHER

- **RESULTS:**
  - MEETING—PRESENTATION OF WORKSHOP OVERVIEWS
  - COMPENDIUM OF WORKSHOP REPORTS
  - EXECUTIVE SUMMARY

At each of these workshops overviews were given by the technologies to lay out what their problems were and where they foresaw their problems. Then the workshops were broken up into subpanels to analyze those problems in the scientific field. We had a meeting in early June, wherein, technical people from the technologies, people from other agencies, and people from the community as a whole were invited to come to listen to summaries of each of these workshops.

We have a deadline for the complete report of July 15th. We expect to have these reports printed by August 15th or September 1st - a complete compendium of the full reports and an executive summary.

Now, again, like everything else, when you get a bunch of scientists together, they have difficulty in doing what the administrator has to do, that is, establish priorities. A scientist is more interested in what he is doing, and often he's unable to appreciate what somebody else is doing, as compared to his own work. So we're going to end up with a great compendium of recommendations, and it will be part of our job to boil these down into a reasonable set of priorities. But to give you an idea of some of the things which have emerged, may I have the next slide.

(Slide 11)

We have a new program in engineering materials science. This will hit areas of welding and joining, nondestructive evaluation, engineering corrosion, and advanced materials.

MATERIALS SCIENCES

FUTURE EMPHASIS

- **ENGINEERING MATERIALS SCIENCES**

  WELDING & JOINING
  NONDESTRUCTIVE EVALUATION
  ENGINEERING CORROSION
  ADVANCED MATERIALS (COMPOSITES, POLYMERS, AMORPHOUS ALLOYS, ETC.)
  SQUID DEVICES

- **HIGH TEMPERATURE MATERIALS**

  LABORATORY–INTERDISCIPLINARY
  CERAMICS, COATINGS, ALLOYS

- **SURFACE & INTERFACE PHENOMENA**

  CORROSION, EROSION
  CATALYSIS
  SYNCHROTRON LIGHT SOURCE
  ATOMIC RESOLUTION MICROSCOPY

- **THEORY–MODELLING**

  ELECTRICAL & ELECTRONIC PHENOMENA
  FRACTURE & DEFORMATION

One of the things which came out in the summary reports is the need for ERDA to develop the capability to produce and characterize advanced materials, which will be used within the scientific and technical community for materials research and development.

In the area of high temperature materials, while we have work going on in this area, additional research on the thermodynamics of high temperature materials and on the engineering properties of materials at high temperatures are required.

In this regard, we have under consideration a proposal from the Oak Ridge National Laboratory to set up an interdisciplinary laboratory, which will be a high temperature materials laboratory and which will be staffed by chemists, physicists, metallurgists, ceramists, working together to apply their combined talents. The facilities will be available to the entire research community, and there will be work supported by the applied programs. So, again, there will be an interchange between the basic and the applied -- where the problems are and where the new information is.

In the area of surface phenomena and interface phenomena, for example, we don't know anything about erosion. We all know you can sandblast a building, and you know erosion wears away the blades in a high temperature turbine, but actually what the mechanisms involved are, we don't know.

So, again, this is an area where it's been stressed that we expand our efforts.

Obviously, doing more work in catalysis is very important, because this is a high payoff area. Dr. Kane mentioned the synchrotron light source that is in our '78 budget before Congress. The $24 million facility will be available to the entire scientific community and will provide extensive opportunities for surface research.

And, further, in our workshops, it was pointed that we have to get down to the atomic level, electron microscopy. We have provided high voltage electron microscopes to Argonne, Oak Ridge, and the Lawrence Berkeley Laboratory for research on thick samples and high atomic weight elements. Now the technology has progressed to the point where we should be able to see individual atoms. We should actually be able to see atoms in a grain boundary, how they move around, and atoms on a surface. The technique will have a profound impact on the field of materials science. A major recommendation of the workshops was that we do something about that particular area.

And a major recommendation, also, was the need to increase the amount of theoretical support that goes on with the experimental work. If one has a theorist working closely with an experimentalist, to show him how, if he could change his experimental conditions slightly or change his sample a little bit, he could provide some additional information which would be crucial to the evolution of theory, it would be possible to make significant advances.

As I say, there were a large number of individual recommendations which we have to boil down and put in context, so it would be rather senseless for me to read you off a half an hour of recommendations. But, believe me, these workshops were a profound experience. For each, we named a host laboratory, and an individual at the host laboratory was named as cochairman. We then selected, with him, a person who had no connection with ERDA, to be cochairman of each of these workshops. These people, then, in conjunction with the staff managers in my office, worked out what the subpanel distribution should be, and who should be on them.

And there were a tremendous number of people, if you recall, from the university sector and from industry that didn't have a penny of our money, who came in and worked themselves into a lather to provide input to help us in our job to do what we have for the entire ERDA.

With that, I will close my remarks and be anxious to answer any questions that you might have.

(Applause.)

DR. KROPSCHOT: Questions or comments for Professor Stevens?

DR. RAMSEY: If I understand your bar chart correctly it looks as if the materials research stimulated by the fusion project is rather a larger expenditure than the materials research stimulated by fossil fuels.

But in view of the fact that the fossil fuel deficiencies are largely materials limited, as far as I can imagine, and in view of the more immediacy of those and the inevitable long-term problem of the fusion one and even uncertainties on it, I am a little surprised that this distribution is equal.

Now, maybe it is because the industrial research more than makes up for it. I don't know.

DR. STEVENS: Well, that comes about for two reasons, Dr. Ramsey.

Number one, as shown on that chart, we're just newly into the fossil area, and that area is growing rapidly.

DR. RAMSEY: So also is the fusion.

DR. STEVENS: Yes, but I think not quite as fast. Part of the problem is that the fusion materials problems are substantial when one looks at them in detail. We do not anticipate that the fusion portion of our program will grow in the future nearly to the extent that the research related to the fossil technologies, solar technologies, and so on.

MR. HILL: I am wearing my industry hat now, and I was a little alarmed that only 15 percent of people in these meetings were from industry. It sounds almost as if you have a closed fraternity doing some great and marvelous things, tying theoretical to experimental, but I didn't hear you say tying experimental to the real world. Where does that interface take place? Where do you get the input, where do you learn what kinds of things are really rate-determining in the growth of the industrial processes which you are trying to establish.

DR. STEVENS: Well, the participation by industry, industrial representatives, clearly was not as great as it perhaps would have been desirable to have.

The industrial input came primarily from people who were working in the technologies. This was a good share of the input from industry, but then there were, indeed, people from the General Electric Research, Bell Labs, IBM, Westinghouse, Atomics International, General Atomic and industries like that.

Again, one has to remember that we were trying to analyze the scientific opportunities, the basic research opportunities. We wanted input to tell us where the problems are, or foreseen. But the primary emphasis was to analyze those problems into where the scientific opportunities lie.

MR. HILL: Let me just carry it one more step.

DR. STEVENS: I might also say that EPRI was involved.

MR. HILL: I know we were involved there, but the point I want to make is, we had an overview of how much materials work we should do at the Electric Power Research Institute, and the feeling was expressed by the top management, who were relating closely to the utilities, that you can almost spend an infinite amount of money, if you please, on materials research.

Of course, this is a concept, to this extent. This is why I bring it up. You can spend an infinite amount of money on materials research. And great restraints were put on our materials work to be sure that it really was attacking problems that need answers. This is the image abroad. I am merely suggesting it might pay to pay some heed to the impression in industry of what materials work is doing and what it's not doing, and perhaps some lack of support is evident on the industry side.

DR. STEVENS: One area again that showed up -- I alluded to it in my comments. It was shown that a very large impediment to progress in the materials area, was the lack of really well-evaluated engineering and thermodynamic data. This whole area, for instance, Hansen's work on phase diagrams, and thermodynamic analysis of that sort, is no longer in existence in this country. So researchers, who, for example, are trying to investigate the strengthening mechanisms in materials, which often involve the relative stability of one phase versus another, need essential thermodynamic data. There is a major insufficiency of work going on to either generate the data or to critically evaluate it.

There is the National Standard Reference Data Program at the National Bureau of Standards but, unfortunately, it has not gotten the backing that it should have. Materials science and engineering is deeply dependent upon the NBS activities in this important area. And I think -- I may let the cat out of the bag -- this is one of the areas that Drs. Kropschot and Phillips have identified that this agency must look into.

DR. KROPSCHOT: Comments or questions?

(No response)

Thank you very much. We appreciate your participation.

I would like now for a summary session, to introduce my colleague, Dr. Gerry Phillips. We've tried to develop thoughts on how to bring the meeting into perspective and set the tone for the next series of inputs from you.

DR. PHILLIPS: As we told you at the outset of this meeting, the purpose of the meeting is to present to you the status of research in the fossil energy area, as we are doing research within the ERDA agency. And after having presented this to you, then to seek your response to a set of questions.

Now, you will recall that in your meeting the first morning (with competition from various people over on the Hill), we nevertheless got through, I think, a very interesting summary of what the whole agency, ERDA, is all about. And, in particular, what the Division of Fossil Energy has as its mission, its goals and its programs.

And then yesterday afternoon, and here this morning, you've heard a succession of talks on research topics in the fossil energy research areas. These were not all given, please understand, by people in the Fossil Energy Division, but were also given as papers from the Conservation Division, from the Environment and Safety

Division, and from the Division of Physical Research or the Basic Energy Sciences.

So, now, you've had your crash course in what fossil energy research is all about within our agency, and we come to the conclusion, then, by trying to summarize the sort of information that we'd like to have from you and, in particular, what we'd like for you to focus your attention upon this afternoon when you meet in four working group sessions.

We have for those of you that asked us to, put you on one of four lists, each one of which is roughly 10 to 13 people.

They should be small enough groups so that you can talk things over and address yourself to the questions that we now want to present to you.

To aid you in running each of these groups, there will be two cochairmen, one of them will be an ERDA person, and one of them will be a person from our contractor, The MITRE Corporation, and they will introduce themselves to you and try to lead you in your discussions.

Now, the main thing that we're concerned with here is the quality of the research or the adequacy of the research that's going on within ERDA.

(Slide 1)

This is the charge that the administrator gave to Dr. Kane; and Dr. Kropschot and I walked in the door at the wrong time and said we wanted to help out, so we got the job.

QUANTITY OPTIONS

PRESENT ERDA FOSSIL ENERGY PROGRAM

INCREASE → **TOO LITTLE RESEARCH**

- O TECHNOLOGY NOT COST EFFECTIVE
- O & NEED EVOLUTIONARY RESEARCH
- O & NOVEL, REVOLUTIONARY ADVANCES POSSIBLE
- O & RESOURCES AVAILABLE TO EXPAND RESEARCH
- O & RESOURCES EXPANSION NEEDED

STEADY → **PROPER BALANCE OF RESEARCH**

- O TECHNOLOGY NEARLY COST EFFECTIVE
- O & EVOLUTIONARY, UNDERWAY, RESEARCH OK
- O & NO REVOLUTIONARY RESEARCH NEEDED
- O & PRESENT RESOURCES ADEQUATE

DECREASE → **TOO MUCH RESEARCH**

- O TECHNOLOGY IS COST EFFECTIVE
- O OR NO NOVEL ADVANCES POSSIBLE
- O OR NO RESOURCES AVAILABLE

SCOPE - $ ↑

TIME →

So, let me now talk about our study of this subject in the following context.

If we say that we have a present ERDA fossil energy research program, that you had described to you, and we asked the question: What should we do with that program? Should we increase its scope (which is a quality concept) or should we increase its quantity (which, in fact, is a dollar -- a budgetary concept)?

We really have three overall possibilities. We can say we should decrease it, leave it more or less steady, or increase it.

Now, going from the bottom to the top of this logic diagram (Slide 1), we might argue that there is too much research, and there are people within the ERDA agency that believe that; sincerely believe it.

Their arguments, perhaps, would be something like this: The technology that we have today; The technology of coal liquefaction; The technology of coal gasification; The underground in situ technology; All of the various things that we've been talking about as the supporting technologies, the crosscutting technologies, such as materials sciences, such as instrumentation, et cetera; That all of these are adequate and they are, in fact, cost - and environmentally-effective.

On the other hand, one could also argue that you don't need any research, if there are no new novel advances possible.

If no one has any possibly good new idea, then why bother to have research?

Or there are no resources available, there are not people, there are not institutions that want to propose to do new research.

It is very intersting that the logic in that bottom box is or-logic. Any one or the other of those three reasons is sufficient reason to not do research.

Now, as you go up in the diagram to the next box, we might argue that we have a good program right now, we should leave it steady, we should improve it where we can, add on here, take away there. But more or less leave it on its present course.

There we would argue to justify that viewpoint: That our technology that we have now is directed toward ERDA's mission of obtaining fossil energy, in a useful cost-effective and environmentally-attractive form; that we have that nearly available to us now, and that all we need is evolutionary sort of research to improve it. That type of research is perhaps already under way or could be brought under way. And that we don't really need any revolutionary improvements in our technology.

And, furthermore, the present resources that we have for carrying out the present sort of research are totally adequate to our needs.

And, finally, coming up to the top box, where one would have to argue for an increase, both in scope and quantity of research, we could argue that the technology is perhaps not cost-effective, and not environmentally-effective, and that you need evolutionary research to drive it in the direction of being cost- and environmentally-effective, and that you need, if you can possibly find them, novel and revolutionary advances to cut the cost and to solve the environmental control problems. You have resources available to start this program at the present time, and you probably have to expand those resources of personnel and institutions of the future.

DR. RAMSEY: Gerry, can I ask a question?

DR. PHILLIPS: Yes, Norman.

DR. RAMSEY: I don't quite understand why if the technology is cost-effective, do you have to have less research, and if it's not cost-effective, then you need more research. I can imagine the technology is cost-effective.

The technology is useful, but obviously it can be made better.

DR. PHILLIPS: Right.

DR. RAMSEY: So I don't understand that.

DR. PHILLIPS: Well, okay, I will accept your quibble. You can always certainly argue.

(Laughter)

DR. PHILLIPS: And I think it is a quibble, really, because you could -- if right now, just to be concrete about it -- if right now, we had a technology that would liquify coal, to provide good liquid fuel, gasoline, fuel oils and what not, and we could do this at, let's take a number, let's say $10 a barrel, while our friends in Arabia want more like $13 to $15, if we had that, then it would be very hard to justify a large research program.

You might, if you had some really good idea that would knock the price down to $2, that would really be very convincing.

DR. RAMSEY: But I mean, we do have a technology for burning coal which does produce power.

DR. PHILLIPS: Yes, but we don't have --

DR. RAMSEY: I think we could have a lot of other things, such as liquified --

DR. PHILLIPS: Well, let me come along. That's my next topic, as a matter of fact.

Okay, now this is a logic for us, perhaps, to consider the scope of our research efforts in fossil energy and the quantity of our research and, therefore, the budget.

Let me have the next slide, please, Dick.

(Slide 2)

All right. Now, then, let's turn to the present synfuel technologies. We heard a paper by Chris Knudsen, and we have other inputs during the course of the meeting here, I guess, from Alex Mills, as well, about whether or not the present technologies are cost-effective on the one hand and we've heard discussion also about, whether they are environmentally-effective, on the other hand.

ARE PRESENT SYNFUEL TECHNOLOGIES

o COST EFFECTIVE ?

- SYNLIQUIDS ~ 30^+ $/BBL
- SYNGAS ~ 5^+ $\$/10^6$ BTU
- DIRECT UTILIZATION WITH CLEAN UP.

AND o ENVIRONMENTALLY EFFECTIVE ?

- STRIP MINING
- WASTE DISPOSAL
- WATER RESOURCES/POLLUTION
- SULPHUR
- NO_x
- CO_2
- CARCENOGENIC

From now on, all of my slides and all of my comments are going to be addressed to you as questions in the logic of that first slide.

So we are asking the question now: are our technologies, as they stand at the moment, cost-effective and environmentally-effective?

Well, the numbers that Chris Knudsen quoted, for example, were numbers like 30-plus dollars per barrel and 5-plus dollars per million Btu for gas.

I think that Dr. Mills has quoted similar sorts of numbers.

It was interesting in Knudsen's talk that he said all of the engineering experiences they had in terms of the two parameters that he discussed, namely, the sophistication of experimental knowledge of the processes, on the one hand, and the detail to which engineering studies of costs have been worked out. Those things, in general, historically drive estimated prices upwards, as one goes to more complexity and to more sophistication.

On that basis, these numbers of 30 and 5 conceivably might be lower limits, rather than upper limits.

On the other hand, we believe that evolutionary research in materials science, for example, might very well bring those numbers down.

On the other hand, I guess the engineering experience that's been discussed with me, is that those numbers would never be expected to come down from that sort of research, evolutionary research, more than perhaps 10 to 25 percent.

Therefore, there may be something like a factor of three to five of the synthetic fuel cost prices in excess of what we're experiencing right now.

That's the discussion so far at the meeting.

Now, in regard to the environmental effectiveness of our technologies, we have not had a lot of discussion of that. I simply list here some of the topics that have come up in various of the research papers.

Some of them, it seems to me, are topics that we know very little about. We've heard a lot of interesting possibilities, for example, about the removal of sulfur from fossil fuel, but not a great deal seems to be known, although there seem to be interesting opportunities.

The concerns about the oxides of nitrogen and, perhaps, a rather terrifying concern about the carbon dioxide burdens in the atmosphere; both of those are in many ways unknown.

And, finally, the very worrisome thing about carcinogenic agents that might come from the use of any of these fossil fuels, certainly has to be in our thinking.

(Slide 3)

The next slide, then, asks the question, do we need evolutionary research. Well, a large number of the talks at this

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IS EVOLUTIONARY RESEARCH NEEDED ?

(LOW RISK / SMALL IMPROVEMENTS)

- o TO PROVIDE COST EFFECTIVENESS TO PILOT DEMOS ?
- o TO SOLVE ENVIRONMENTAL PROBLEMS ?
- o IS SUCH RESEARCH SUFFICIENT ?
- o RESEARCH PRIORITIES FOR :
  - -- MINING
  - -- SYN FUELS PROCESSES
  - -- MATERIALS
  - -- COMBUSTORS
  - -- ENERGY CONVERTERS
  - -- CATALYSIS
  - -- SCRUBBERS
  - -- COMPONENTS
  - -- INSTRUMENTATION / PROCESS CONTROL, ETC.

meeting were concerned with that type of research, where one is basically interested in trying to improve some extant process, some extant device, some extant concept aid, thereby, to improve its cost and environmental effectiveness.

The demonstration plants that we heard discussed yesterday morning, certainly could be improved, no doubt, by this sort of research.

Perhaps the environmental problems could be helped.

And then one has to wonder, is this sort of thing sufficient. In other words, if the price is still too high, there's not real cost-effectiveness, then perhaps that sort of improvement that might perhaps only be 15, 25 percent, perhaps that's not enough. Perhaps the fixes that one has for improving the environmental effectiveness might not be sufficient.

So what is needed for evolutionary research, is to discuss and, within ERDA, arrive at, a set of priorities for those sort of topics, some of which I list right there.

For example, all though the meeting we've talked about combustors and the totality of the ERDA-wide budget for combustion research is under \$6 million; I believe each of the speakers involved pointed to these numbers. For example, Kane pointed to -- about \$1.5 million. Bastress pointed to something like \$1.5, and so forth.

The whole program is, if you will, rather miniscule. And, yet, certainly this must be of some importance to ERDA in its planning of its research program.

The next slide, please.

(Slide 4)

Now, the next question that we want to ask of you is: Should we judge that there are innovative or, if you will, revolutionary possibilities in the way of research? Are there concepts, either spoken to here at this meeting, or that you're familiar with, or you in your own thinking can conceive of, that would provide us with innovations that would help us significantly in our efforts to develop fossil energy in a cost-effective way and in an environmentally-acceptable way?

For example, are new facilities, such as the use of synchrotron radiation to study the detailed properties of surfaces, and how molecules actually are oriented on surfaces; is this of sufficient potential that we should be investing in things of that sort, in the hopes of having, for example, really new basic fundamental understanding of how catalysis works, so that we might then more intelligently design certain types of catalysts?

After all, you know, in modern technology we've made remarkable progress in the lifetimes of all of us here in this room.

It seems to me, one of the things I like to think about is how astounding it is in color photography, which didn't exist when I was a young guy, and now-a-days these people design molecules -- you know, they really design a molecule just like you design a car.

ARE THERE INNOVATIVE RESEARCH OPPORTUNITIES ?

(HIGH RISK / HIGH POTENTIAL PAYOFF)

- NEW FACILITIES: (E.G., SYNCHROTRON RADIATION, SURFACES) ?
- FUNDAMENTALS: (E.G., COAL CHEMISTRY) ?
- APPLIED AREAS: (E.G.)
  - -- MATERIAL: (CORROSION, ERROSION, CRACKING)
  - -- COMBUSTION: (MIXING, MATHEMATICAL MODELING, LASER)
  - -- INSTRUMENTATION: (TRANSDUCERS, ON LINE N.T.D.)

Well, can we come to that stage, perhaps, someday in the design of catalysts?

At the fundamental level, are there real break-throughs that we might expect to have? I believe Dr. Mills mentioned the idea; here is this big coal molecule, and that one can go to it with some sort of scissors and snip it here and there, in a very clever sort of way, which, in principle, takes almost no energy to do, since the bonds are very, very low-energy bonds.

Then you might end up with something where you don't have to add a lot of hydrogen to, and it doesn't take a lot of energy to perform this, and it doesn't jack the entropy way up and then pump the entropy way back down again.

So are there new fundamental approaches to what we might do, for example, with coal?

In applied areas, I've listed materials, combustion and instrumentation, as areas where it's possible that there could be really new breakthroughs that could enable us to improve the cost and environmental effectiveness in a very significant sort of way, not by 15 or 20 percent, but perhaps by factors of two or five or something of that sort.

The next one, please.

(Slide 5)

Here I tried to make a matrix in which I discuss this old hobgloblin that we have of the different kinds of research; basic, applied, and technology development.

IF ERDA NEEDS RESEARCH, WHAT ARE THE PRIORITIES FOR:

CROSS-CUTTING	INNOVATIVE (HIGH RISK AND LEVERAGE)			EVOLUTIONARY (LOW RISK & IMPROVEMENT)
SCIENCE/TECH	BASIC	APPLIED	TECHNOLOGICAL DEV	TECHNOLOGICAL IMPROVEMENT
MATERIALS	SOLID STATE PHYS/CHEM	CORROSION, EROSION, CRACK.	ALLOYS, CERAMICS	COMPONENTS LIFE TESTS
SYNFUELS	COAL CHEM	EARLY H_2 OF COALS	NEW PROCESSES	BETTER PROCESS DESIGN
COMBUSTION	CHEMICAL KINETICS	LASER DIAGNOSTICS	NEW BURNERS	OPTIMIZE FLUIDIZED BEDS
EMISSION CONTROL	COAL SULPHUR NO_x	OXY-DESULPHURI-ZATION	NEW DEVICES	SCRUBBERS
INSTRUMENTATION	NEW TRANSDUCER	IN-SITU	ON-LINE D. N. T.	ON-LINE PROCESS CONTROL
CATALYSIS	SURFACES: SYNC. RAD.	ROLE OF TRACE METALS	NEW CATALYSISTS	OPTIMIZE REJUVENATION
GEOSCIENCES				

Over on the right-hand side I have a column that I call technology improvement, or it could be called engineering. I don't know exactly how to call this. Let's not be too confused by the names, but one has a continuity, in principle, from the most basic and fundamental on the left, towards real useful technologies on the right.

Over here as an ordinate in the vertical direction, I list what we might call crosscutting sciences or technologies. Such things as materials science, and synfuel development, combustion, emission control, instrumentation, et cetera.

One can come up with a list of perhaps 100 such topics, and so this is only an example.

Across this diagram I have tried to write down some of the new things that were discussed at this meeting, and I will not go through it in any detail wtih you; but, for example, in the basic column there, the synchrotron radiation facilities applied to catalysis, is a possible revolutionary new advance.

In the applied column under emission control, the oxide-sulfurization of coals, as was mentioned by Alex Mills, is potentially, to my mind, a revolutionary step ahead.

Over under technology development, under instrumentation, any number of speakers at this meeting talked about nondestructive testing. If one had really good on-line, that is real time, nondestructive testing, so that he knew exactly before a boiler is going to fail or before a high-pressure, high-temperature reactor is going to fail, if you had warning of it, then this might be a very, very important thing in these modern front line technologies.

Now, in the right-hand column, I have tried to put in that same context some technological improvements, and these are things that are going on right now, that ERDA had under way. So this tries to give us within this matrix a picture of the spectrum of our research in these two dimensions.

(Slide 6)

Now, I turn to another of the questions that we're also asking you: Are resources available?

Are there institutions available? Are there people that could carry out these efforts? Could they carry them out now, and can they carry them out in the future?

And what is the balance that ERDA should seek in the utilization, for example, of the energy research centers, the national labs, the universities, and industry?

This topic of balance amongst these different groups, of their various strengths and weaknesses, comes up time after time in nearly all of the talks that we've had.

Other places where ERDA must seek balance in and, in fact, is required by the federal statutes, if you will, that created this and its predecessor agencies, is that we're supposed to be concerned with the time span of your work and seek a balance there. Do we have

ARE RESOURCES AVAILABLE ?

- o NOW ?
  - -- ERC's / NATIONAL LABS / UNIVERSITIES / INDUSTRY ?
  - -- HOW TO BALANCE IN: TIMESPAN, GOALS, SCOPE, BUDGETS, SCIENCE & TECHNOLOGY TRANSFER

- o FOR THE FUTURE ?
  - -- WHAT SHOULD BE BALANCE ?
  - -- WHAT SHOULD BE ERDA's ROLE IN MANPOWER TRAINING ?
  - -- IF BALANCE CHANGES, HOW TO DISTRIBUTE ACROSS RESOURCES ?

a proper balance between our near-term goals, our crash goals that Congress is beating on our heads daily about?

Do we have that balanced with our more mid-term and long-term goals?

And do we have this balanced in terms, for example, of the scope of our program from basic to applied technology and development demonstration?

These sorts of balances: Do we have those available to us right now, within our resources?

And, for the future, one can ask those same questions, and additional ones, for example: What should be ERDA's role in manpower education and training? You heard a couple of university speakers address that problem. And this, it seems to me, is a very important thing that ERDA has to consider.

As Kobayashi mentioned, all the major high-technology agencies of the Federal Government more or less simultaneously dropped their support for graduate-student education and training in science and engineering in American universities; that is, the NDEA, the NSF fellowships, the AEC traineeships, and the NASA fellowships; all more or less simultaneously terminated. This created a very great step function in the abilities of the universities to educate and train future manpower. And does ERDA have a role in that? Should it accept some sort of responsibility for education in the same way that earlier high-technology departments of the government have accepted that role?

Next slide, please.

(Slide 7)

Here I talk about budgets. All through this meeting you've heard and seen a lot of budgets of various kinds, but this is the budget, as I see it, that is the present budget, 1977 agencywide, that is concerned with fossil-energy research.

The first entry there, Fossil Energy Division, about $20.4 million. You'll notice that is less than other numbers that you've seen, but this corresponds to the fact that in Dr. Kropschot and my judgment, part of the Fossil Energy Division research budget is in fact engineering for currently building pilot plants and demonstration plants, and that this is a realistic view of the research component.

The number 8.4 is our view of the Conservation Division's contribution to fossil energy research, and the two lower numbers for the Division of Physical Research, 5.6 and 5.8, are similar numbers for those two that you heard about in lectures this morning.

This totals, then, about $40 million -- for this current year.

Now, each of the speakers, as you'll recall, gave us at the end of their talk a set of research opportunities for the future -- the research speakers. And we have looked at those numbers and have

WHAT SHOULD ERDA's FOSSIL ENERGY RESEARCH BUDGETS BE?

($M / YEAR)

	o 1977	o FUTURE (?)
FOSSIL ENERGY	20.4	50
CONSERVATION	8.4	40
DIVISION OF PHYSICAL RESEARCH :		
CHEMICAL SCIENCES	5.8	13
MATERIALS	8.4	20
	$40.2M	$123M

- o IS THE PRESENT FOSSIL ENERGY RESEARCH BUDGET OKAY ?
- o WHAT SHOULD THE ERDA FOSSIL ENERGY RESEARCH BUDGET BE ? WHY ? WHAT ARE THE PRIORITIES ?

tried to extrapolate on the basis of taking ratios to comparable sort of research budgets. We've come up with the numbers over on the right. For example, Mills's program would grow from $20 million to $50 million, the conservation efforts would grow from 8 to 40 -- that's a very large jump -- approximate doubling in chemical sciences, and in material sciences about 2-1/2 times, totaling about $120 million.

Now, those are just our estimates, but they give you a feeling, within the context of the whole agency having just over $3 billion in the energy areas. The present budget corresponds to about 0.1 percent and the envisioned budgets would correspond, then, to an overall amount of about 1/3 percent in fossil energy research.

(Slide 8)

So now the next slide, then, shows you the questions that we asked you, about -- crosscutting technologies. We have talked a lot about crosscutting technologies, and how we have a basic dichotomy. The basic dichotomy is that we need to have a focus to carry out, for example, a materials research program or combustion program that is agencywide, within ERDA. We need that.

And, yet, if we do that centralization we face the fact that we may lose the technology and science transfer from such a program to the other particular programs that need the results. So we don't have a simple solution. I think everybody that runs such

HOW SHOULD ERDA MANAGE CROSS-CUTTING TECHNOLOGIES ?

- o BASIC PROBLEM: FACED BY ALL HIGH-TECHNOLOGY ORGANIZATIONS: MATRIX MANAGEMENT.
  - -- NEED FOR FOCUS ;
    - - LEADER (S),
    - - BUDGETS.
  - -- AGENCY-WIDE PROGRAMS PRECLUDE:
    - - FALLING THROUGH CRACKS:
    - - USELESS DUPLICATION.
- o DICOTOMY
  - -- NEED FOR FOCUS
  - -- NEED TO TRANSFER SCIENCE / TECHNOLOGY.

programs has to face this dichotomy, and if you have brilliant advice for us, we'd like to have it.

(Slide 9)

So here, then, are the seven questions that we're asking you. You each have those attached to a piece of paper that's called "Purposes and Responses," and these are the questions for those of you that stay this afternoon. We want you to please give us your advice.

That's the end of my speech. Let me now thank all of the speakers that presented, I think, very interesting and informative material to all of us here at this meeting. I know that many of you, in fact most of you, went beyond the call of duty to prepare this material, and I want to thank each of you in the audience for attending. We appreciate it very much, and we look forward to your counsel in the future.

Thank you.

The meeting is adjourned.

(Applause)

DR. KROPSCHOT: Are there any questions for Dr. Phillips before we adjourn here.

MS. FOX: I have a comment I'd like to make.

On the first questions that you have up there, I think perhaps it's not appropriate to ask whether or not these technologies are environmentally acceptable. I think a more reasonable question

RESPONSES REQUESTED

- ARE PRESENT ENERGY TECHNOLOGIES COST AND ENVIRONMENTALLY EFFECTIVE?
- DOES ERDA HAVE RESEARCH NEEDS/OPPORTUNITIES?
- DOES ERDA HAVE RESOURCES NOW/IN FUTURE?
- ARE THE NATION'S NEEDS PROVIDED FOR IN:
  - GROWTH OF BASIC KNOWLEDGE
  - MANPOWER TRAINING
  - MANAGEMENT OF PROGRAMS ?
- IS THERE A SPECIAL ERDA ROLE IN FOSTERING CROSS-CUTTING TECHNOLOGIES? HOW SHOULD IT BE MANAGED?
- IS THE QUANTITY OF ERDA'S FOSSIL ENERGY RESEARCH BALANCED FOR:
  - BUDGETS
  - SCOPE: (BASIC/APPLIED/TECHNOLOGICAL DEVELOPMENT/DEMONSTRATION PLANTS)
  - TIME TERM: (NEAR/MID/FAR)
  - GOAL: (EVOLUTIONARY/REVOLUTIONARY)
  - SCIENCE/TECHNOLOGY TRANSFER
  - RESOURCE: (INDUSTRY, UNIVERSITY, NATIONAL LABS/ERC's)
- IS ERDA's QUALITY OF RESEARCH ADEQUATE TO ITS MISSION ?

would be whether or not the environmental problems can be solved with existing technology in a cost-effective manner.

I don't see why environmental problems are singled out any differently than, say, problems in materials research areas. I think the questions that we should be asking is whether or not they can be solved, and how can they be solved in a cost-effective manner. And then the environmental issue becomes, as we all know it is anyway, nothing more than the question of cost-effectiveness. It's not fair to ask whether or not they are environmentally acceptable.

DR. PHILLIPS: You're saying that the environmental problem is just another beautiful example of a crosscutting technology, and I certainly agree.

MS. FOX: Right.

DR. KROPSCHOT: We would like to have Dr. Haas introduce his staff. That, then, could be the focal point for our feedback sessions before we adjourn, and perhaps, Greg, maybe the thing to do is to let the groups meet together just for a short period of time or what time they want to, and set their own schedules, and Dr. Phillips and I will be available to the groups. We will, as Gerry mentioned, have our co-chairmen, and then Phillips and I will be available as resources.

DR. HAAS: Thank you, Dick. We have divided those who indicated an interest in participating in the groups up into four groups, with chairmen. We have two suites, and we will hold two of the groups up there and two of the groups down here. Unfortunately, we could not get any more suits than that for today.

The first group will meet up in Room 1030 with myself. The second group will meet in Room 1032 with Dr. Jim Ling. Jim, do you want to stand up?

The third group and the fourth group will meet down in here, at opposite ends of the room. We will have the chairs rearranged during the noon break, with a table, and chairs placed around them. One group will be under Roy Peterson. Do you want to stand up, Roy? And the other group under Chuck Bliss. You may want to get together at this point in time, in order to have a preliminary get-together, and then probably break for lunch, since it's a quarter of 12, and then return possibly to spend about two hours in these smaller groups, giving us the feedback that we would like to have to incorporate into a summary document, which we will produce within the next month.

So, the most important aspect of this meeting from our standpoint is the next two to three hours, really, to get your feedback and your responses.

One other point I would like to make. We recognize that this is a very short notice in which to give possibly detailed thought to some of these issues. Therefore, I would like to encourage you, after you leave, if you have further thoughts on these subjects, to please put them in writing and mail them in to us. Any written statements that we obtain will be included in the proceedings of this meeting, and we would very much like to have your comments in writing, possibly after you have had more time to think about this and to go back and even discuss it with your colleagues at your various institutions and organizations. So I would encourage you to please write us any thoughts that you have.

Thank you.

(Whereupon, at 11:45 a.m., the meeting was adjourned).

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