be more selective? Now obviously the ones that I listed, the catalytic gasification, on the one hand, flash hydropyrolysis, and some of the others, are ones we hope; but the research business, as you know, is that you hope you have ten good candidates and one winner.

DR. KANE: Thank you, Alex.

DR. KANE: I'm delighted to be able to introduce at this time Dr. Phillip White, who is the Assistant Administrator for Fossil Energy, and who is going to discuss the goals and other aspects, as he chooses, of the fossil-energy program.

DR. WHITE: Thank you, Jim.

Let me apologize for arriving at this hour for an 8:30 meeting, but after spending four hours in a hearing under the television lights, it's nice to get in here where it's cool and take off my jacket.

I also want to express my personal welcome, and thank you for your help in tackling this very difficult subject.

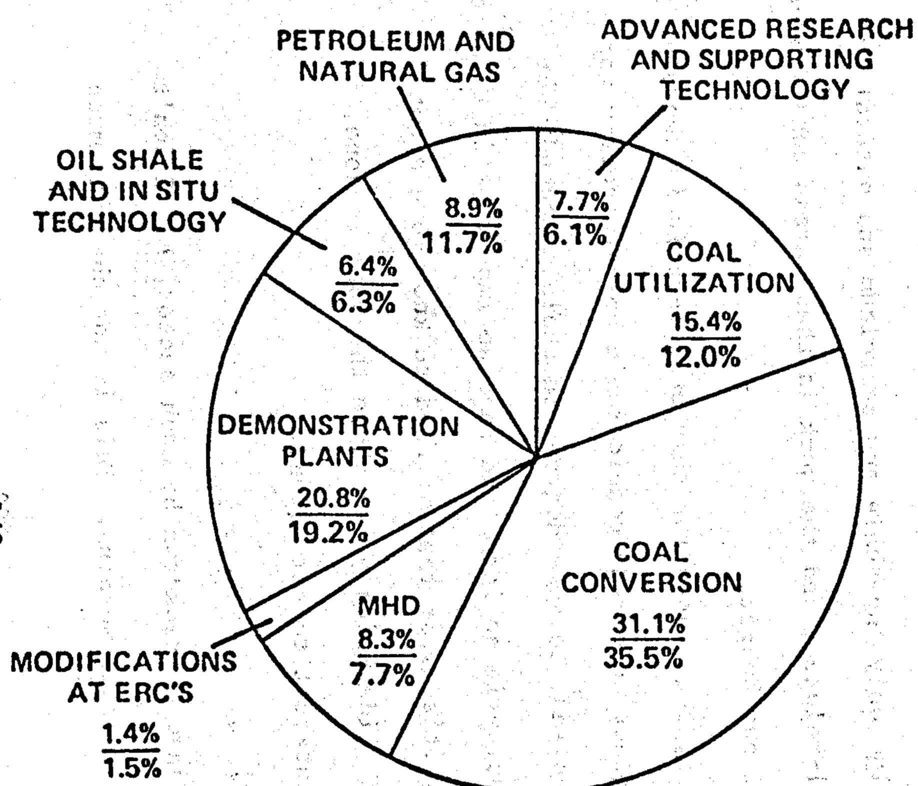
I'm going to run through the same sort of briefing that we've given our budget committees in Congress, which is as good a job as we can do of summarizing our total fossil energy program.

And if we could have the first slide--

(Slide 1)

Here is the distribution of our Fossil Energy pie, which in this Fiscal Year, totaled as you see in the first column on the

FOSSIL ENERGY BUDGET ESTIMATES
DISTRIBUTION OF FUNDS



PERCENTAGE DISTRIBUTION OF FOSSIL ENERGY BUDGET ESTIMATES IN FY 1977 AND FY 1978 SHOWN AS FOLLOWS:

FY 1977%
FY 1978%

BUDGET AUTHORITY
(DOLLARS IN MILLIONS)

	FY 77	FY 78	INCREASE DECREASE
COAL CONVERSION	$150.3	$233.3	$ +83.0
COAL UTILIZATION	74.4	79.1	+ 4.7
ADVANCED RESEARCH AND SUPPORTING TECHNOLOGY	37.1	40.3	+3.2
DEMONSTRATION PLANTS	100.3	125.9	+ 25.6
MAGNETOHYDRODYNAMICS (MHD)	40.0	50.5	+10.5
PETROLEUM AND NATURAL GAS	43.2	76.7	+33.5
OIL SHALE AND IN SITU TECHNOLOGY	31.0	41.5	+10.5
MODIFICATIONS AT ERC'S	6.9	9.6	+2.7
TOTAL	$483.2	$656.9	$+173.7

77-2656M/1-4

left, some 483 million dollars, approved for '78. This does not count some actions by Congress this last week, this 656 million dollars. I think what they did, netted out, we hope, positive, but I am not real sure of that 'till I see all the report language. But it is of that order of magnitude.

Most of those funds are for coal because, of course, the demonstration plants are all, at this point, on coal processing.

Since MHD is also a coal process, in reality well over three-quarters of the work of fossil is directed to coal. In addition much of the advanced research and supporting technology, as previously described by Alex, is coal-related.

So really, only the shale and petroleum and natural gas parts are not coal-related, and the work in these areas constitutes some 20 percent of our budget.

Of course, the reason for this budget-split is twofold. First, it is a reflection of the considerable private sector work done in oil and gas and, to some degree, in shale. Second, our domestic coal resource is so large and thus so important in terms of national interest, it's clear that we need to know more about it.

The next slide which shows where the work is done, is a matter of some interest to this group.

(Slide 2)

--We do have a breakdown by each sector, but I don't have that detail here this morning. This is not changing much.

FOSSIL ENERGY BUDGET ESTIMATES
BREAKDOWN OF FUNDS BY R&D AGENCY
BUDGET AUTHORITY (DOLLARS IN MILLIONS)

	FY 1977	(% OF TOTAL)	FY 1978	(% OF TOTAL)
ENERGY RESEARCH CENTERS	$ 47.0	(9.7)	$ 60.9	(9.3)
NATIONAL LABORATORIES	35.2	(7.3)	34.0	(5.2)
UNIVERSITIES	18.2	(3.8)	26.1	(4.0)
INDUSTRY	375.9	(77.8)	526.3	(80.1)
GENERAL PLANT AND EQUIPMENT, CONSTRUCTION, OSHA AND ENVIRONMENT AT ENERGY RESEARCH CENTERS	6.9	(1.4)	9.6	(1.4)
TOTAL	$483.2		$656.9	

Almost all of this work is done outside with industry, reflecting very large cost-shared contracts with the pilot plants and demonstration plants particularly. But the other, the in-house work, at the energy research centers, accounts for about 50 percent more, almost twice as much a year as the national laboratories. This was, I think, an early figure on national labs. That is likely to change.

The universities, account for about 4 percent in both years. This was our estimate at the time we put the budget together. One of the things we are doing in ERDA Fossil Energy is to try to increase the work done out in the field.

We expect to do a lot more in the field as we go through the rest of the year and FY '78. Therefore, I think these numbers on how much is done in the national labs and energy research centers are quite likely to grow. Now, let's look at some of the details. We'll talk about coal conversion first.

(Slide 3)

Here are three basic subprograms: liquefaction of coal, gasification to produce high Btu or pipeline quality gas, and the gasification to produce low Btu or fuel gas for use in industry, the sort of gas we got out of the old coal town gasifiers many, many years ago.

Funding for each type of gasification is about the same and the total for gasification exceeds that for liquefaction.

COAL CONVERSION
BUDGET AUTHORITY (DOLLARS IN MILLIONS)

	FY 1977	FY 1978	CHANGE (%)
LIQUEFACTION	$73.0	$107.4	+ 47.1
HIGH BTU GASIFICATION	$44.2	$ 51.5	+ 16.5
LOW BTU GASIFICATION	$33.1	$ 74.4	+124.8

1977 ACCOMPLISHMENTS

- H-COAL PILOT PLANT CONSTRUCTION UNDERWAY
- COMPLETE CONSTRUCTION 10 TON PER DAY SYNTHOIL PDU
- SUCCESSFULLY START UP BIGAS, SYNTHANE AND STEAM IRON PILOT PLANTS
- COMPLETE REFIT OF CRESAP TEST FACILITY FOR ADVANCED TECHNOLOGY TESTING

1978 CHANGES

- CONTINUOUS OPERATION OF PRESSURIZED FLUID-BED GASIFIER (Westinghouse)
- MAJOR CONSTRUCTION OF HYDROGEN FROM COAL FACILITY Start
- INITIATE DONOR SOLVENT PROCESS PILOT PLANT DESIGN AND LONG LEAD ITEM PROCUREMENT
- INITIATE PILOT PLANT PHASE OF CATALYZED GASIFICATION PROCESS
- MAJOR CONSTRUCTION OF LOW BTU GASIFICATION COMBINED CYCLE PILOT PLANT (POWERTON)

ISSUES/PROBLEMS

- CONTINUED UTILIZATION OF EXISTING PILOT PLANT FACILITIES
- EXTENT OF FUTURE DEVELOPMENT WORK IN HIGH BTU GASIFICATION

There are some pertinent accomplishments. For example, the H-coal pilot plant is under construction.

H-coal is a process developed by the Hydrocarbon Research Corporation, who teamed up with a number of companies to help support that contract, which is cost-shared with us.

The other pilot plants, which a year ago were in the construction stage, have all started up this last year, Bi-Gas at Homer City, Pennsylvania; Synthane also at Bruceton; and Steam Iron, a process which IGT is developing in Chicago.

We are still struggling to finish retrofitting the Cresap facility for advanced technology testing in liquids.

What do we see for '78? We see a continuation of some of these projects--and the operation of the fluidized bed gasifier, under development at Westinghouse. With respect to the hydrogen-from-coal facility, we will probably choose a contractor shortly. This plant will aim at the production of hydrogen for industrial use.

We expect to start the Donor Solvent process developed by Exxon Company. The pilot plant design and long lead item procurements will certainly take place in '78.

We also expect to build the low Btu gasification plant at Powerton, in Illinois, in which low Btu gas will be fed to a gas/steam combined cycle. This gives promise of an increased efficiency for electricity power generation.

What are our problems? The two listed here probably give us the most concern. One is the utilizing of our existing pilot facility. We've been criticized for having more facilities in parallel than we really need, and spending too much of the taxpayer's money this way. I think it's a somewhat valid criticism, although each of those pilot plants was justified for somewhat different purposes, and at the time seemed to be the correct thing to do.

But as we bring in new processes we want to use the old facilities, shut them down when appropriate and put in something new. It may be just a change of the gasifier, t much of the supporting system can be used and s.ve a great deal of money and a great deal of time.

Then, there is the whole question of how much more ERDA/FE work to do on high Btu gasification. At what point should we say, all right, we now have a process on-line, maybe a commercial plant, demonstrating it can be done? Second generation processes, there are pilot plants being piloted. There is laboratory work on third generation processes. Is it now time to end the Federal Government's role and say, private industry, you take it from here? If there are process improvements to be made by further research, that is your logical job, and you do that. This is a philosophical question which we haven't really resolved.

The other part of the coal program is utilization, as you see in the next slide.

(Slide 4)

Here is a much smaller program. There are two major parts: advanced power systems and direct combustion.

Coal utilization involves hooking up either a gasifier or a fluidized bed combustor to a turbine combination. In either case, the two major problems are (1) the control of the system, because it is a system that has to be very carefully integrated, and (2) the cleanup of the gas after it leaves the gasification or combustion zone, because turbine blades and vanes are very sensitive to corrosion and erosion.

The question then is how far do you clean up the gas and how much can you improve the blade technology in order to make them more resistent? And that is the thrust of the matter.

Now as far as the accomplishments, we did issue a coal-oil slurry PON. This is a sort of quick and dirty way to conserve petroleum by replacing part of it with coal in the form of a coal/oil slurry. The point now is to see if these slurries can be fired in industrial installations with minimal retrofitting and, if so, will they meet air pollution standards.

It is a way to use coal without much retrofitting.

We have awarded a number of contracts for small atmospheric fluidized bed combustors to burn high sulfur coal mixed with limestone so that the sulfur oxides are absorbed in the bed rather than by scrubbing stack gas. Some of these units are available in the

COAL UTILIZATION
BUDGET AUTHORITY (DOLLARS IN MILLIONS)

	FY 1977	FY 1978	CHANGE (%)
ADVANCED POWER SYSTEMS	$22.5	$25.7	+14.2
DIRECT COMBUSTION	$51.9	$53.4	+ 2.9

3×10^3 lbs/hr steam

1977 ACCOMPLISHMENTS

- COMPLETED 1000 HR COMBUSTION TEST OF COAL-OIL SLURRY IN A 100 HP BOILER (PERC)
- MULTIPLE CONTRACTS AWARDED ON INDUSTRIAL AND INSTITUTIONAL APPLICATIONS OF AFB COMBUSTION
- OPEN CYCLE GAS TURBINE EFFORTS UNDERWAY ON VANE AND BLADE COOLING, CERAMIC COMPONENT AND MATERIAL TESTING

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- BEGIN OPERATION OF 30 MWe FLUIDIZED-BED BOILER PROJECT IN RIVESVILLE, W. VA.
- MULTIPLE CONTRACTS AWARDED TO DEMONSTRATE COMBUSTION OF COAL-OIL MIXTURES IN EXISTING BOILERS

1978 CHANGES

deferred until FY 79 (ANL)

- BEGIN CONSTRUCTION OF ATMOSPHERIC ~~AND PRESSURIZED~~ FLUIDIZED-BED COMBUSTION CTIU
- ~~BEGIN CONSTRUCTION~~ OF THE 13 MWe PRESSURIZED, FLUIDIZED-BED COMBINED CYCLE PILOT PLANT
- FABRICATION OF PROTOTYPE AFB COMBUSTION SYSTEMS FOR INDUSTRIAL APPLICATIONS
- ~~LONG-LEAD PROCUREMENT FOR OPEN CYCLE GAS TURBINE TO PERMIT VERIFICATION TESTING~~

ISSUES/CHANGES

- FEASIBILITY OF COMBINED CYCLE
- FLUIDIZED BED COMBUSTION, STACK GAS SCRUBBING, COAL BENEFICATION TRADE-OFFS

country today, and we're trying to simply push them and demonstrate them because they can be applied to different industries. We have had a number of joint contracts to introduce these.

To get higher thermal efficiency, the temperature at the inlet to the turbine must be raised several hundred degrees. This necessitates developing techniques to cool those blades and vanes. The efficiency of a gas turbine combination is much better if you can raise the temperature. By raising it from 1600 to 2400, one can achieve more efficiency. So, there is a good deal of work going on, and much of that advanced power system budget for '78 is going to be devoted to that sort of work on turbines.

We have a big fluidized bed unit in Rivesville operating in an actual utility. We have not only that test we mentioned in the first line, but a number of awards on coal-oil mixtures in existing boilers.

We plan next year to build what we call a CTIU, a component test and integration unit, designed to be able to change things back and forth, to be the sort of workhouse for developing both pressurized and atmospheric fluidized bed work. One of these will be at the atmospheric one at Morgantown, and the other will be a pressurized one at Argonne.

Flexibility must be built into a study of atmospheric fluidized bed combustion. Flexibility was the main thrust behind creation of CTIU at Argonne. A similar kind of work for pressurized fluidized bed combustion is ongoing at combustion engineering in Windsor, Connecticut. And we're doing the same thing on taking data on the small fluidized bed as I mentioned for this year. Next year we hope to actually start some fabrication of a full, larger sized fluidized bed combustion system, and even the long lead procurements of a prototype turbine.

An issue in this case is the feasibility of this combined cycle. The combined cycle is not being practiced on coal today anywhere in the world except London and Germany, and that one doesn't work very well.

There is a real problem of feasibility. There's also the question of where do you clean up sulphur? If you clean the coal, do you use a fluidized bed or do you put it on a scrubber? That's the last line there. And this problem is complicated by the fact that we are working on fluidized beds; EPA has stack gas scrubbing, and the Bureau of Mines has coal cleaning. Maybe if we got a Department of Energy starting next week, or the week after, we could quickly resolve that ambiguity.

Advanced research and supporting technology is the next slide--

(Slide 5)

ADVANCED RESEARCH AND SUPPORTING TECHNOLOGY
MATERIALS AND EXPLORATORY RESEARCH
BUDGET AUTHORITY (DOLLARS IN MILLIONS)

FY 1977	FY 1978	CHANGES (%)
$29.3	$31.9	+8.9

1977 ACCOMPLISHMENTS

- DEVELOPED SIGNIFICANTLY LOWER COST, ENVIRONMENTALLY ACCEPTABLE PROCESS TO MAKE GASOLINE FROM COAL
- COMPLETED PROCESS RESEARCH ON NOVEL, SIGNIFICANTLY CHEAPER CATALYTIC COAL GASIFICATION PROCESS
- CORROSION STUDY ON CONSTRUCTION ALLOYS UNDER COAL GASIFICATION CONDITIONS
- MADE SIGNIFICANT PROGRESS IN DETERMINING RELIABLE MATERIALS AND VALVES FOR COAL CONVERSION PLANTS
- INITIATED STARTER GRANT PROGRAM TO STIMULATE FOSSIL ENERGY RESEARCH AT UNIVERSITIES

1978 CHANGES

- NEW EMPHASIS ON EXPLORATORY RESEARCH TO REDUCE COST OF PRODUCING SYNTHETIC FUELS FROM COAL
- COMPLETE LAB DEVELOPMENT OF PROMISING PROCESSES FOR SCALE UP OF FOSSIL TECHNOLOGIES

ISSUES/PROBLEMS

- RELIABLE MATERIALS AND COMPONENTS FOR COAL CONVERSION
- ACHIEVEMENT OF MAJOR PROCESS IMPROVEMENTS

--The budget here is about $31 million for '78, not enough to keep pace with inflation. We are trying to get them a little more money, and I think we'll make it go. I think he's probably covered that pretty well because it is really a subject of this meeting. I don't think it is necessary for me to spend any more time on it other than to give a picture of where it is in the total size of the budget.

The next one--

(Slide 6)

--is quite the contrary, a much bigger one. We have demonstration plants. And here we've had a sort of a rough go in trying to get going on this whole area. We started with a clean boiler fuel plant. This year we took another look at it, and decided there were some pretty serious weaknesses in the basic data, and we essentially stopped work on that plant except for small-scale studies. But there is no work now other than paper studies on the building of a demonstration plant for the so-called Coalcon project.

We did, however, sign the contracts just the other day on the synthetic pipeline gas demonstration plants, two of them. One with Conoco and the other with the Illinois group. We have two others under negotiation for a fuel (low Btu) gas, and we're starting much smaller ones on an intermediate level. We're aiming to have a spectrum of plant sizes for fuel gas demonstrations and applications.

DEMONSTRATION PLANTS
BUDGET AUTHORITY (DOLLARS IN MILLIONS)

	FY 1977	FY 1978	CHANGE (%)
OPERATING EXPENSES	$53.0	$50.9	– 4.0
PLANT AND CAPITAL EQUIPMENT	47.3	75.0	+ 58.6
	$100.3	$125.9	+ 25.5

1977 ACCOMPLISHMENTS

- RE-EVALUATED CLEAN BOILER FUEL PROGRAM
- INITIATED CONCEPTUAL DESIGN OF HIGH-BTU SYNTHETIC PIPELINE GAS DEMONSTRATION PLANT
- INITIATED CONCEPTUAL DESIGN OF INDUSTRIAL LOW-BTU FUEL GAS DEMONSTRATION PLANT
- INITIATED CONCEPTUAL DESIGNS FOR SMALL INDUSTRIAL LOW-BTU FUEL GAS DEMONSTRATION PLANT

1978 CHANGES

- BEGIN CONSTRUCTION OF HIGH-BTU SYNTHETIC PIPELINE GAS DEMONSTRATION PLANT AND LOW-BTU FUEL GAS DEMONSTRATION PLANT
- START DESIGN FOR DIRECT COMBUSTION DEMONSTRATION PLANT
- START DESIGN FOR SOLVENT REFINED COAL DEMONSTRATION PLANT

ISSUES/PROBLEMS

- COST SHARING FOR MAXIMUM INDUSTRY PARTICIPATION
- OPTIMUM PROJECT MIX TO MAXIMIZE PROGRAM BENEFITS
- RELATIONSHIP TO ALTERNATIVE FUELS DEMONSTRATION PROGRAM

77-2656M/2-4

In '78 we'll certainly begin the first stages of construction on both these plants, and we will start design on a demonstration plant for the fluidized bed direct combustion and, we hope, on solvent refined coal.

I didn't mention, liquefaction. We have a major pilot plant on solvent refined coal at Takoma, Washington, which has run for several years. Last year we made 3000 tons of solvent refined coal. And just a couple of weeks ago, we started burning it in a utility in Albany, Georgia, which I am happy to say, provides the power for Plains. It is working beautifully. This is the first time we've taken a solvent refined coal, which is like coal except it is very firable. It melts at about 400°F--it gets very sticky. It has very little sulfur, very little ash, so, it is nice if it will burn right, but it is a problem of how you handle it, and we seem to be able to handle it.

Magnetohydrodynamics, the next slide--

(Slide 7)

We see three competing ways to burn coal for power generation with improved efficiency. I previously mentioned advanced power systems. MHD is another advanced power system. Here one takes coal, burns it at a very high temperature; passes it through a channel which has electrodes under a very high magnetic field; and uses potassium carbonate seed to raise the electrical conductivity. The high velocity conducting gas passing through the magnetic field

MAGNETOHYDRODYNAMICS (MHD)
BUDGET AUTHORITY (DOLLARS IN MILLIONS)

FY 1977	FY 1978	CHANGES (%)
\$40.0	\$50.5	+26.2

1977 ACCOMPLISHMENTS

- INITIATED CONSTRUCTION OF CDIF TEST BUILDING
- INITIATED DEVELOPMENT OF FIRST CDIF GENERATOR CHANNEL
- DELIVERED BY-PASS SUPERCONDUCTING MAGNET FOR SOVIET U-25 FACILITY
- INITIATED MHD SUPERCONDUCTING MAGNET FOR CDIF
- INITIATED ETF SYSTEMS ENGINEERING AND CONCEPTUAL DESIGN

1978 CHANGES

- INITIATE DEVELOPMENT OF 2ND CDIF POWER TRAIN
- INITIATE HIGH PERFORMANCE GENERATOR CHANNEL TESTING AT AEDC
- INCREASE SYSTEMS AND DESIGN ANALYSIS TO SUPPORT AND GUIDE COMPONENTS DEVELOPMENT AND INTEGRATION
- DELIVER MHD GENERATOR FOR TESTING IN SOVIET U-25 FACILITY

ISSUES/PROBLEMS

- COMBUSTOR AND CHANNEL PERFORMANCE
- SEED/SLAG MANAGEMENT

surrounding part of the channel produces a current in the electrodes. The overall efficiency will probably be somewhat over 50 percent with a possibility of attaining 60 percent.

The Russians are doing a lot of MHD work. You may have seen an announcement in the paper in the last few days about our shipping them a super-conducting magnet. That magnet was just flown to Moscow in the first C5A ever to go to Moscow. It refueled in the air twice on the way over. That made a great story, and we hope that our joint project produced some useful results.

We have started to build the buildings at Butte, Montana, on this and we're building a generator channel for it. We see all this coming along next year in a program which I believe Congress has now raised, and it's for '78, from 50 million up to about 65 or 70, if my advanced information is correct.

There is a lot of MHD work going on in a number of places, not only at Butte, but also at Avco Laboratories at Everett, Massachusetts, at the University of Tennessee, and Stanford, and elsewhere around the country. Eventually, we'll not only have that channel, that magnet over in Moscow but also a generator working on a slip stream of the U25 magnet.

The problems here are still very much technical ones. MHD is a very tough technology to develop, requiring very high temperatures. Materials problems are troublesome. Other difficulties include air preheating; seed recovery/regeneration developing optimum combustion to minimize nitrogen oxides, and components problems.

The Soviets were delighted when they got the channel to run for 250 hours; but in the case of a utility, that is not very long. One must recover the seed and recycle it out of the slag if there is going to be success.

Petroleum and natural gas--the next slide--

(Slide 8)

--is about a $75 million program, as we saw earlier. Here we work almost entirely in the oil side of what we refer to as enhanced oil recovery, getting at the oil which is left in the ground by conventional production and water flooding through one of three major techniques--warming it up, either with fire or with steam; lowering its viscosity with carbon dioxide, and finally, washing it out with a detergent just like you wash a dirty greasy spot out of clothes.

Managing this 5,000 or 10,000 feet underground though, is a little tricky, and we have a lot of pilot tests going on with industry. The number is steadily increasing; and just yesterday we talked about adding another one.

We have had some criticism from the Office of Management and Budget on this because of the large private sector activity in this area. Sometimes we've gotten into these programs, we just sort

PETROLEUM AND NATURAL GAS
BUDGET AUTHORITY (DOLLARS IN MILLIONS)

FY 1977	FY 1978	CHANGE (%)
$43.2	$76.7	+77.5

1977 ACCOMPLISHMENTS

- INITIATED THREE COST-SHARED FIELD TESTS FOR ENHANCED OIL RECOVERY
- DETERMINED CHEMICAL SUPPLY AND DEMAND FOR MICELLAR-POLYMER AND CO_2 PROCESSES
- COMPLETED PROJECT PLAN FOR CHARACTERIZATION AND STIMULATION OF EASTERN GAS SHALE (DEVONIAN SHALE PROJECT)
- INITIATED TWO PROJECTS TO INCREASE DRILLING SPEED AND REDUCE DOWN TIME
- IMPLEMENTED IMPROVED MANAGEMENT PLAN FOR ENHANCED OIL RECOVERY
- COMPLETED PROJECT PLAN FOR CHARACTERIZATION AND STIMULATION OF WESTERN TIGHT GAS SANDS

1978 CHANGES

- PILOT TESTING TO DETERMINE ECONOMICS OF MICELLAR-POLYMER PROCESS
- EMPHASIZE STEAM FLOODING EXPERIMENTS AT VARIOUS LOCATIONS
- NEW START, IN THERMAL RECOVERY OF OIL - TECHNOLOGY EMPHASIZED IN MANAGEMENT PLAN
- IMPLEMENT IMPROVED MANAGEMENT PLAN FOR ENHANCED GAS RECOVERY
- ACCELERATE EASTERN GAS (DEVONIAN) SHALE PROJECT

ISSUES/PROBLEMS

- KNOWLEDGE BASE VS IMPLEMENTATION FOR ENHANCED OIL RECOVERY
- DEVELOPING VIABLE TECHNOLOGY FOR ENHANCED GAS RECOVERY

of respond to targets of opportunity. Some company makes a proposal, and if we think it looks good, we go ahead.

OMB asked us if we had a systematic plan. For the first time, we sat down and tried to work out exactly what the total program should be, and just what types of formations should be tested, and how many tests should be involved. That is what we did last year. We found all of us more comfortable with a whole program and now we have that in-house, now we're doing the same thing for gas.

In the case of gas, we're looking at not what is left in the ground, but at some gas reserves that normally aren't considered gas reserves when one hears about 10 years or 20 years of natural gas. In that case they're talking about conventional gas that flows out by itself. But in the Devonian shale, the western tight sands of the Mesa Verde formation in Colorado, and in the coal seams in the East, there is a lot of natural gas. It has usually just been stripped out and wasted for a safety measure, and now we're going after it as a resource. Using those unconventional resources gives us about 50 years of gas, and if you believe Wall Street Journal headlines about 1000 years of gas. There's only one place that could be, and that is in that geopressured zone in the Gulf where there is a lot of salty water saturated with methane. Maybe it is there and maybe we can get it out. We don't know what it will cost, but it potentially could be a very large resource of great importance.

So we are working on that.

I think you probably had a chance to read what we did pretty much as far as nominal improvements. We are doing a little bit of drilling research here as well, trying to improve drilling speed, and reduce some of the instrumentation to reduce the so-called down-hole time. Some of this work is cooperative with industry and some is work leaning very heavily on Sandia and other national labs where there is this type of technology developed as an offshoot of the nuclear program and its need to drill for nuclear shots in Nevada. For that reason, they have developed a lot of drilling technology.

We expect to just continue much the same way for '78. We are particularly pointing at that last bullet under '78, the acceleration of Eastern gas, where we are trying to beef up testing of Devonian Shale. The wells are shallow, and not very productive, but there are a lot of them. We think if we can find a way to fracture them, and if we can improve their productivity, they can be valuable. They have the attraction of being close to the market in the East where we need the gas.

Our problems here are the knowledge base and implementation. We don't have good resource data for gas, and for oil, we need to increase our general knowledge of that field.

Another one in this same division is--on the slide--

(Slide 9)

--the oil shale and the underground coal gasification. These two may not seem to fit together, but in oil shale we're working exclusively on what is referred to as in situ retorting, where we retort underground rather than mining of shale, bringing it up and retorting it. And because they both involve the same sort of technology, we've handled them in the same organization. But it's a rather modest area. They are increasing significantly for next year, but are still, a minor part of the program.

We have had a number of contracts under negotiation now for in situ retorting of shale--shared contracts with industry. For the first time we completed a test at Rock Springs, Wyoming of what we call true in situ. We didn't do any mining. We just stuck a shaft down, set in some explosives, did some rubblizing that way and then set off a fire, and collected oil out of an adjacent well. It worked, but not very well.

The Antrim shale in Michigan is a different sort of project. Here's an odd type of shale, which doesn't produce oil, but which we can gasify. Dow Chemical has done a lot of work in this field. We have now joined them to try to improve that technology.

Moving to in situ coal gasification to the so-called linked-vertical well, in which several wells are first linked by combustion and then by gasification. We burn some of the coal with a lot of

OIL SHALE AND IN SITU TECHNOLOGY
BUDGET AUTHORITY (DOLLARS IN MILLIONS)

	FY 1977	FY 1978	CHANGES (%)
OIL SHALE	$22.8	$28.9	26.8
IN SITU COAL GASIFICATION	$ 8.2	$12.6	53.7

1977 ACCOMPLISHMENTS

- COMPLETED COST-SHARING CONTRACTS FOR SEVERAL IN SITU RETORTING EXPERIMENTS
- COMPLETED DIRECT-COMBUSTION SHALE-OIL PRODUCTION TEST AT ROCK SPRINGS, WYOMING
- INITIATED MICHIGAN ANTRIM SHALE GASIFICATION PROJECT
- COMPLETED LINKED VERTICAL-WELLS PROCESS (LVW) TEST
- INITIATED FIELD GASIFICATION TESTS ON PACKED-BED PROCESS
- STARTED FIELDING FIRST COMBUSTION TEST ON DIRECTIONAL WELLS
- DESIGNED STEEPLY-DIPPING-BED (SDB) PROJECT WITH INDUSTRY

1978 CHANGES

- COMPLETE DESIGN OF A MULTI-TON OIL SHALE GASIFICATION FACILITY
- BEGIN HANNA IV LVW FIELD TEST
- CONDUCT THE FIRST STEAM/OXYGEN IN SITU GASIFICATION TEST AT HOE CREEK 2
- START SDB FIELD TEST PROGRAM

ISSUES/PROBLEMS

- ENVIRONMENTAL IMPACTS AND ACCEPTABILITY
- FUTURE OF IN SITU VS ABOVE GROUND SHALE OIL PRODUCTION
- DEVELOPING ACCEPTABLE ECONOMIC INCENTIVES FOR OIL SHALE
- MARKETS FOR IN SITU COAL GASIFICATION PRODUCTS

steam present and have a typical water gasification reaction of that coal and can take a good 175 Btu gas out of the other wells. We did this in Wyoming very successfully last year producing a good quality gas, a very even composition, which is one of the tricks.

We have some other approaches to drilling the wells and to fitting other formations a little better, and that is one of the things we hope to look at, including steeply dipping beds. We expect to keep on doing this same sort of thing next year.

Now both of these projects have tricky environmental problems, which we are trying to address. We know that they are potentially there, but in cases like this where you've got to do the work in the field, there's no way to know the extent of the problem, until you get out there and try it.

Groundwater is one problem. If there are underground aquifers, you retort the shale which is leachable, and that leaching can get into the aquifer.

If you do either of these, and a lot of it, you obviously have a subsidence problem, and the ground level begins to drop above your retorted formation, and that is not acceptable in most locations. How bad is it? What we can do to control it? These are the things we still have to learn. I'm sure in the discussions this afternoon and tomorrow, we'll have a chance to explore what some of those areas are.

This gives you a sort of general picture of the total program; where the emphases are; and some problems, as I see them. I'm not sure I could answer that question that Alex said he didn't get a high enough salary to answer and I guess I don't either, but I might offer -- toss in a few things as we get through.

Thank you very much.

(Applause).

DR. KANE: He has a car waiting, but he will answer a few questions.

MR. LODEL: In the demonstration plants program ERDA had been considering three categories for low Btu fuel gas. The industrial category, I believe, is going ahead. I wasn't able to sort out from your plans whether in fact you plan to go ahead with the utility category?

DR. WHITE: I'm waiting until I get the language of the conference report on the appropriations to be able to answer that question. I asked it myself yesterday, and I couldn't get an answer. I think we have -- I know we have authorization, maybe we've got money, but maybe we've got language that says, don't do it, or maybe we've got language that says, do it. I don't know. It is just hanging in that balance right now. And if we are told not to do it, we will have to drop that project. It is too early to answer, I'm sorry. Within a few days, we should know. I just haven't been informed.

DR. KANE: Thank you very much, Bill.

DR. WHITE: Okay. I'll be back right after lunch.

DR. KANE: Very good. He's been on the grill since 7:00 this morning, enjoy your lunch.

DR. KANE: I've decided to, with your forbearance, juggle the program one more time. And we have another gentleman here who is going to talk to you about synthetic fuel pricing. He, too, has been on the grill for a long time this morning, and he'd like to get out of here so, I think I'll impose on you, and we'll have a talk now by Chris Knudsen.

DR. KNUDSEN: Thank you very much.

I have been asked to talk about the cost of various processes that we are doing research and development on in ERDA. Copies of my slides are here on the table.

I'll try to make this a short talk so that you can get on with your luncheon plans.

My wife has been with me all morning, and I asked permission to go ahead and give it now because she has been sweating it out with me, and I promised to take her to lunch and that's the most important thing to me at this moment.

(Laughter.)

(Slide 1)

I want to begin with several slides about the methods used in cost estimating. The first slide illustrates different types of cost estimates of differing accuracies. Many people compare one estimate with another of differing quality, a back of the envelope estimate with one from a detailed study, and sometimes draw conclusions from this. We try not to, because an estimate is a function

CURRENT AFE ECONOMIC ESTIMATES

PROCESS COST ESTIMATES

HARDWARE DEVELOPMENT LEVEL

	ORDER OF MAGNITUDE ($\$2\text{-}5 \times 10^3$)	STUDY ($\$2\text{-}5 \times 10^4$)	PRELIMINARY ($\$2\text{-}5 \times 10^5$)	DEFINITIVE ($\$2\text{-}5 \times 10^6$)	DETAILED ($\$20\text{-}50 \times 10^6$)
LABORATORY (BENCH)	MORTGAGE MODEL	USBM PEG			
PDU	MORTGAGE MODEL	USBM PEG KELLOGG	ORNL FLUOR PARSONS BRAUN		COALCON
PILOT	MORTGAGE MODEL	USBM PEG	ORNL BRAUN PARSONS AMOCO	BADGER	CONOCO ICGG
DEMON-STRATION	MORTGAGE MODEL				
COMMER-CIAL			BRAUN	SASOL	

175-1

of both the engineering effort that is put into it, and the data available.

Hardware development level is indicated vertically on the slide. As shown, data quality ranges between laboratory and commercial. Horizontally, the cost levels of various types of estimates are indicated by order of magnitude. For example, a study design might cost $20,000 to $50,000 of engineering effort, a preliminary study $200,000 to $500,000, a definitive study $2 to $5 million, and a detailed study $20 to $50 million. The detailed study is the type of estimate needed for actual construction of a project where detailed mechanical drawings are needed.

The order of magnitude type of estimate or "Mortgage Model" has been developed within ERDA based on past information. We have made correlations of gasification, liquefaction, enhanced oil recovery and other processes based on R&D experience. These correlations allow us to make a crude estimate of the cost of a proposed process development unit (PDU) or pilot plant.

(Slide 2)

Let me define the differences between three types of cost estimates on the last slide: the preliminary, definitive, and detailed cost estimates. The first thing that is done in any cost estimate, of course, is the design basis. All three estimate types require the same type of design basis information, with the exception that the site specification for the three differs. For example, a

DESIGN BASIS

PRELIMINARY ($0.2-0.5 X 10^6)	DEFINITIVE ($2-5 X 10^6)	DETAILED ($20-50 X 10^6)
• PRODUCT SPECS	• DO	• DO
• FEED SPECS	• DO	• DO
• DESIGN ASSUMPTIONS	• DO	• DO
• PROCESS DESCRIPTION	• DO	• DO
• UTILITY SPECS	• DO	• DO
• GENERAL SITE	• HYPOTHETICAL SITE	• ACTUAL SITE

detailed design, including detailed mechanical drawings, requires specification of an actual site with core drillings to determine foundation design.

(Slide 3)

The next phase of a process estimate is the design itself. Differences in estimate accuracy are most obvious from consideration of the varying efforts expanded in this step.

In a preliminary design, the effort ends with an equipment list, but in a definitive design, piping and instrumentation specifications are prepared. This additional information requires a great deal more engineering effort to develop. A detailed estimate includes the latter plus detailed engineering drawings and plans which may require hundreds of thousands on man-hours. Process plants contain piping and instrumentation that may represent 40 percent of the capital investment, so that preparation of P&I diagrams, for example, significantly improves estimate accuracy.

(Slide 4)

The last step is the estimate itself, process economics. For preliminary estimates, cost curves, experience factors, and rules of thumb are used; whereas for a definitive estimate, a more detailed estimating procedure is required. Vendor quotes, specific cost indexes, and projected financial conditions are appropriate. For a detailed study, one seeks vendor bids, finances under actual conditions, and look into actual labor and productivity.

PROCESS DESIGN

PRELIMINARY ($0.2-0.5 $\times 10^6$)	DEFINITIVE ($2-5 $\times 10^6$)	DETAILED ($20-50 $\times 10^6$)
• FLOW DIAGRAM	• DO	• DO
• MATERIAL BALANCE	• DO	• DO
• ENERGY BALANCE	• DO	• DO
• OPERATING CONDITIONS	• DO	• DO
• PLOT PLAN	• DO	• DO
• ENVIRONMENTAL ASSESSMENT	• DO	• ENVIRONMENTAL IMPACT STATEMENT
• MAJOR EQUIPMENT SIZED	• ALL EQUIPMENT SIZED	• DO
• EQUIPMENT LIST	• EQUIPMENT LIST AND DETAILED SPECS	• DO
	• P AND I DIAGRAMS	• DO
	• PIPING SPECS	• DO
	• PROCESS RELATED STRUCTURAL SPECS	• COMPLETE STRUCTURAL DRAWINGS
		• DETAILED ENGINEERING DRAWINGS
		• PLANT ELEVATION DRAWINGS
		• PROCUREMENT AND CONSTRUCTION PLAN

PROCESS ECONOMICS

PRELIMINARY ($0.2-0.5 $\times 10^6$)	DEFINITIVE ($2-5 $\times 10^6$)	DETAILED ($20-50 $\times 10^6$)
• COST CURVES	• DO	• VENDOR BIDS
• EXPERIENCE FACTORS	• VENDOR QUOTES ON MAJOR ITEMS	• ACTUAL LABOR COSTS AND PRODUCTIVITY
• RULES OF THUMB	• EXPERIENCE FACTORS BASED ON MORE DETAILED DRAWINGS	• DETAILED ENGINEERING EVALUATION
• GENERAL COST INDEXES	• SPECIFIC COST INDEXES	• FINANCING UNDER ACTUAL CONDITIONS
• ASSUMED FINANCIAL CONDITIONS	• PROJECTED FINANCIAL CONDITIONS	

A vendor bid is usually much more accurate than a quote and may require payment for the engineering time required to make it.

Actual labor costs and productivity are extremely important factors which are generally overlooked. The availability of skilled craftsmen and union rules vary in different parts of the country and have a large effect on the final cost of a plant.

Project contingencies and process contingencies can be assigned to account for the inaccuracies brought about by the estimating process and the uncertainty of the available data, respectively - the horizontal and vertical categories of the first slide. These contingencies require analysis of past estimating experience to determine and we have visited companies like Exxon, Gulf, and Mobil to begin developing them. Our figures are therefore a reflection of what we have learned because we are not a large construction or operating company. We are a small branch in the government, and we are relying on available industrial information.

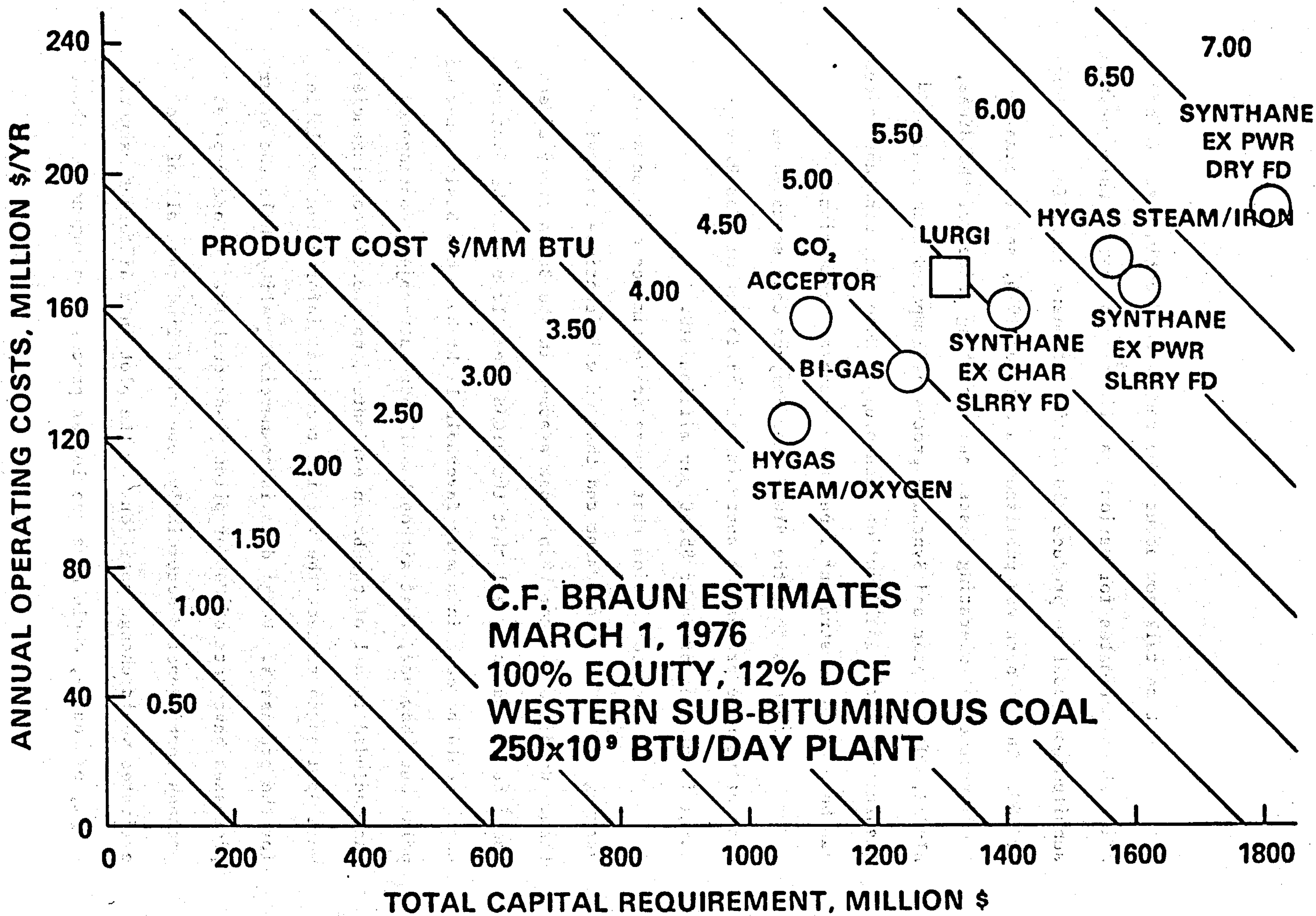
The project contingency one might assign to a study estimate would be typically greater than 20 percent. At the preliminary estimate level, a 15 to 20 percent. At the preliminary estimate level, a 15 to 20 percent project contingency might be appropriate. For the definitive estimate level, a 10 to 15 percent project contingency is indicated. Finally, for the detailed type of estimate, a 10 percent contingency would be appropriate.

Note that the project contingency reflects only the uncertainty of constructing a given design for a given cost and in effect assumes known technology. Therefore, even for a detailed estimate late in the actual construction period the project contingency is still typically about five percent to account for the bills yet to arrive, labor and material problems in completing construction, and possible start-up problems.

Turning to the process contingency, some experience indicates that an estimate based on laboratory data requires a contingency of approximately 100 percent to account for additional equipment later found to be necessary during the PDU, pilot plant and demonstration development stages leading to commercialization. Perhaps a 25 to 50 percent contingency is appropriate for the PDU stage, only a 15 to 25 percent contingency at the pilot plant stage, about 10 to 15 percent at the demonstration stage, and as little as 5 percent at the commercial state.

Application of the contingencies is made as follows. The process contingency is added as a percentage on the on-site process equipment, whereas the project contingency is applied to total investment, including off-sites and the process contingency. I would caution that these types of add-on contingencies should be used with care, as they are meant for guidance.

(Slide 5)



ANNUAL OPERATING COSTS, MILLION $/YR
TOTAL CAPITAL REQUIREMENT, MILLION $
PRODUCT COST $/MM BTU
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
SYNTHANE EX PWR DRY FD
HYGAS STEAM/IRON
LURGI
CO_2 ACCEPTOR
BI-GAS
SYNTHANE EX CHAR SLRRY FD
SYNTHANE EX PWR SLRRY FD
HYGAS STEAM/OXYGEN
C.F. BRAUN ESTIMATES
MARCH 1, 1976
100% EQUITY, 12% DCF
WESTERN SUB-BITUMINOUS COAL
250x10⁹ BTU/DAY PLANT

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Let me talk now about some recent cost estimates. This slide shows estimates for various gasification processes using western subbituminous coal to produce 250 million standard cubic feet per day of SNG. This report was published in October 1976, and it examines the investments, operating costs, and resulting prices of the HYGAS, BI-GAS, CO_2 Acceptor and Synthane processes compared with similar figures for Lurgi gasification technology. Note that constant prices can be plotted as straight lines to a close approximation.

One sees that the HYGAS steam-oxygen case seems to be the most attractive process at approximately $4.25 per million BTU. Lurgi is plotted at about $5.50 per million BTU.

I want to caution that these are estimates of process at varying levels of development and that we will continue to review them. Conditions other than those assumed in the Braun study affect the results and some feel that the HYGAS Steam/Iron and the Synthane cases could be cast in a more favorable light by a new basis. Let me point out, however, that although a 15 percent project contingency was included in all of the Braun estimates, no process contingencies were applied to reflect the varying technical information available for the processes. Lurgi data is commercial quality while the other processes have data of PDU or pilot plant quality. If one applies process contingencies accordingly, one would find that all of the estimates would change positions on the plot in a different manner. Lurgi, of course, would have the lowest process contingency of about five percent. As a result of this, new plot would show much less price advantage for the newer processes compared with Lurgi.

We do not have a comparable plot for coal liquefaction at this time, although we have made comparisons between the H-Coal, Exxon Donor Solvent and Solvent Refined Coal processes. A common accounting basis was used - the same discounted cash flow rate, depreciation rate, and so forth - but large differences still remain that are a function of the investment. We realize that this is the result of having different firms produce the basic designs. We are now planning to visit Sterns Roger, Fluor, and Exxon, to attempt to resolve differences in design methods and to put the investments on a more consistent basis.

Until we have confidence that the engineering procedures are on a consistent basis, we can't make a comparison of the processes.

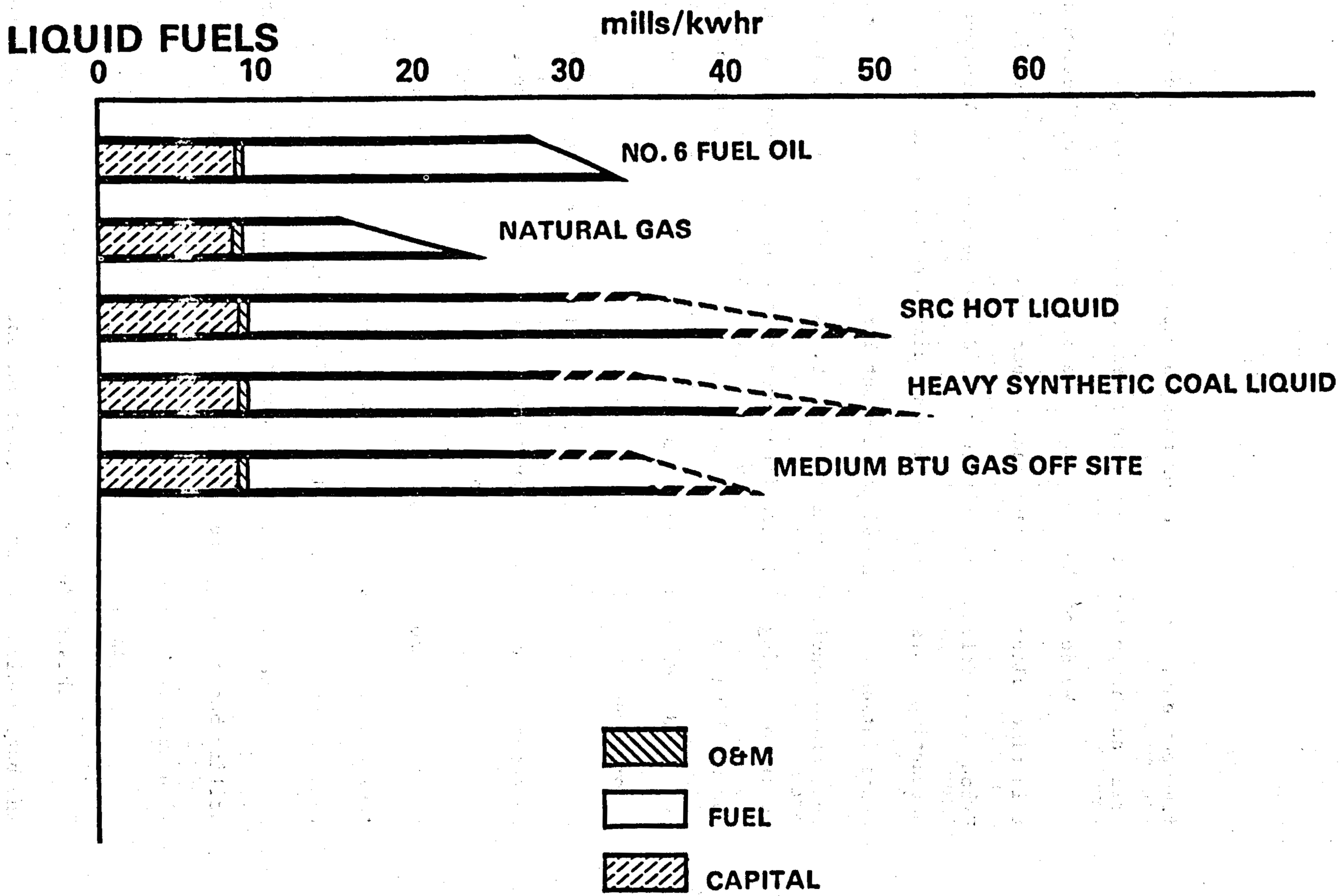
However, on a preliminary basis, liquefaction processes are indicated to produce synthetic crude at $30 per barrel or higher; a fuel oil product may be $5 per barrel less. This assures a 15 percent rate of return on a discounted cash flow, 100 percent equity basis.

The next three slides show come comparisons on an electric utility basis. They are derived from a recent report done by Gilbert with fuel costs added.

(Slide 6)

This slide shows new plants using various liquid fuels. The bars indicate capital, operation, and maintenance, and fuel costs

NEW ELECTRIC UTILITIES



components, respectively. The fuel cost component is slanted to show a range of fuel cost, giving an indication of sensitivity.

Using a cost for No. 6 fuel oil of $2.12 to $2.86, the cost of electricity ranges from 28 to 33 mills per kilowatt hour. For natural gas which costs $.52 to $2 per million Btu, the range is 16 to 24 mills per kilowatt.

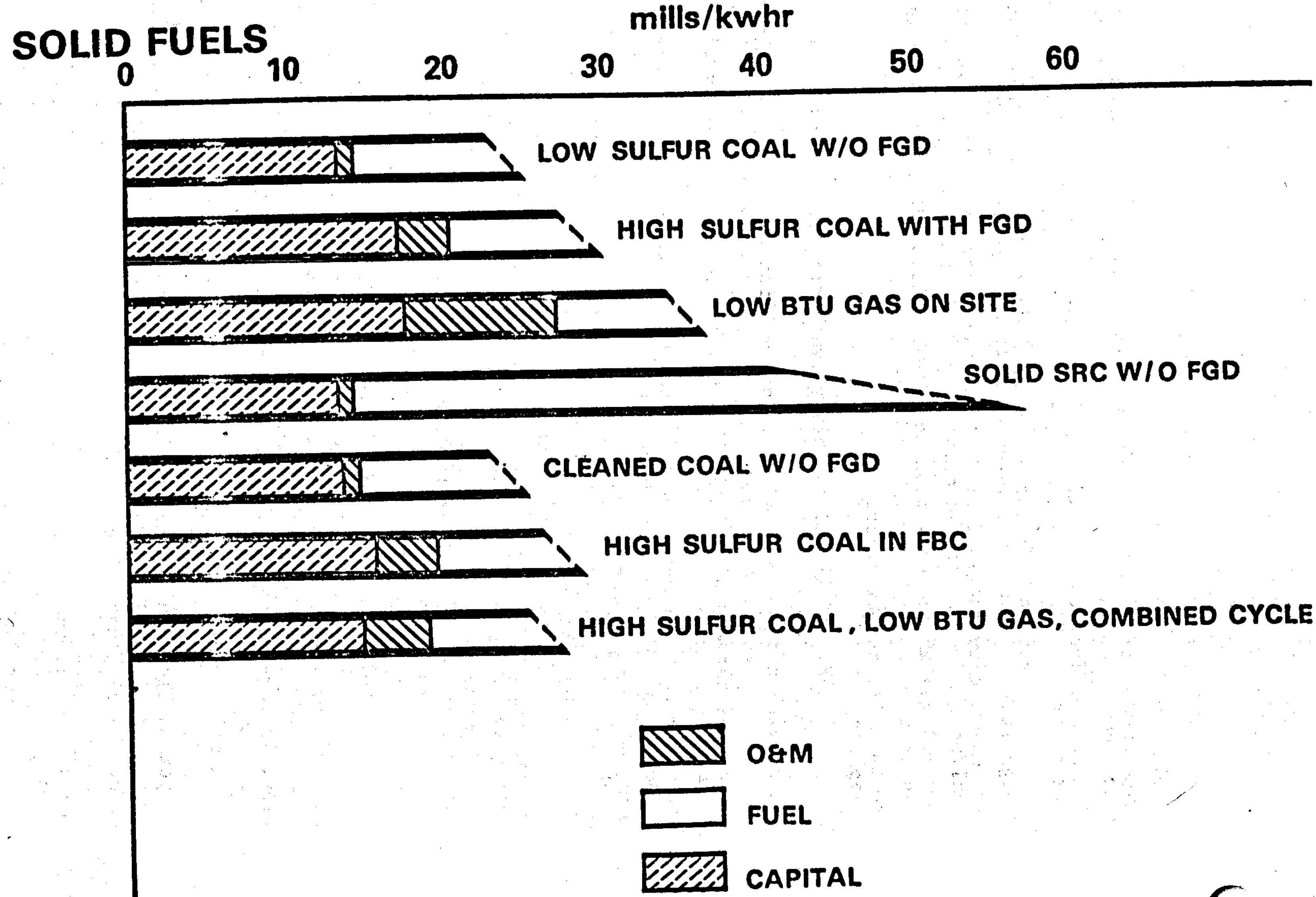
SRC hot liquid and heavy synthetic coal liquid, both estimated within a range of $3 to $5 per million Btu, produce electricity at a cost between 35 and 50 mills per kilowatt hour. The medium Btu off-site case assumes a cost for the gas between $3 and $4 per million Btu and produces electricity between 35 and 42 mills per kilowatt hour. These last three cases are more expensive than using fuel oil or natural gas, but they are based on coal which is much more secure as a commodity.

(Slide 7)

Solid fuel comparisons are shown on the next slide for new electric utilities. Low sulfur coal, without flue gas desulfurization, is very attractive. The fuel cost range assumed is $1 to $1.25 for a million Btu. High sulfur coal is assumed to cost 75 cents to $1 per million Btu at the utility and requires flue gas desulfurization. This results in greater capital and operation and maintenance costs, but the fuel cost is less.

Low Btu gas on site, requires additional capital and operating and maintenance costs, but again the fuel is the cheaper high

NEW ELECTRIC UTILITIES



sulfur coal. Solid SRC, without flue gas desulfurization, is assumed to cost \$3 to \$5 per million Btu and produces by far the highest cost of electricity. Cleaned coal, without flue gas desulfurization, uses high sulfur coal and is very competitive with low sulfur coal. High sulfur coal in fluid bed combustion is also an attractive alternative as is the case of high sulfur coal in a low Btu gas combined cycle application.

(Slide 8)

The effect of retrofit on the delta cost of electricity in mills per kilowatt hour is shown in this slide. For solid fuel plants, flue gas desulfurization adds about 10 mills per kilowatt hour. Solid SRC adds quite a bit. Clean coal adds the least of the three.

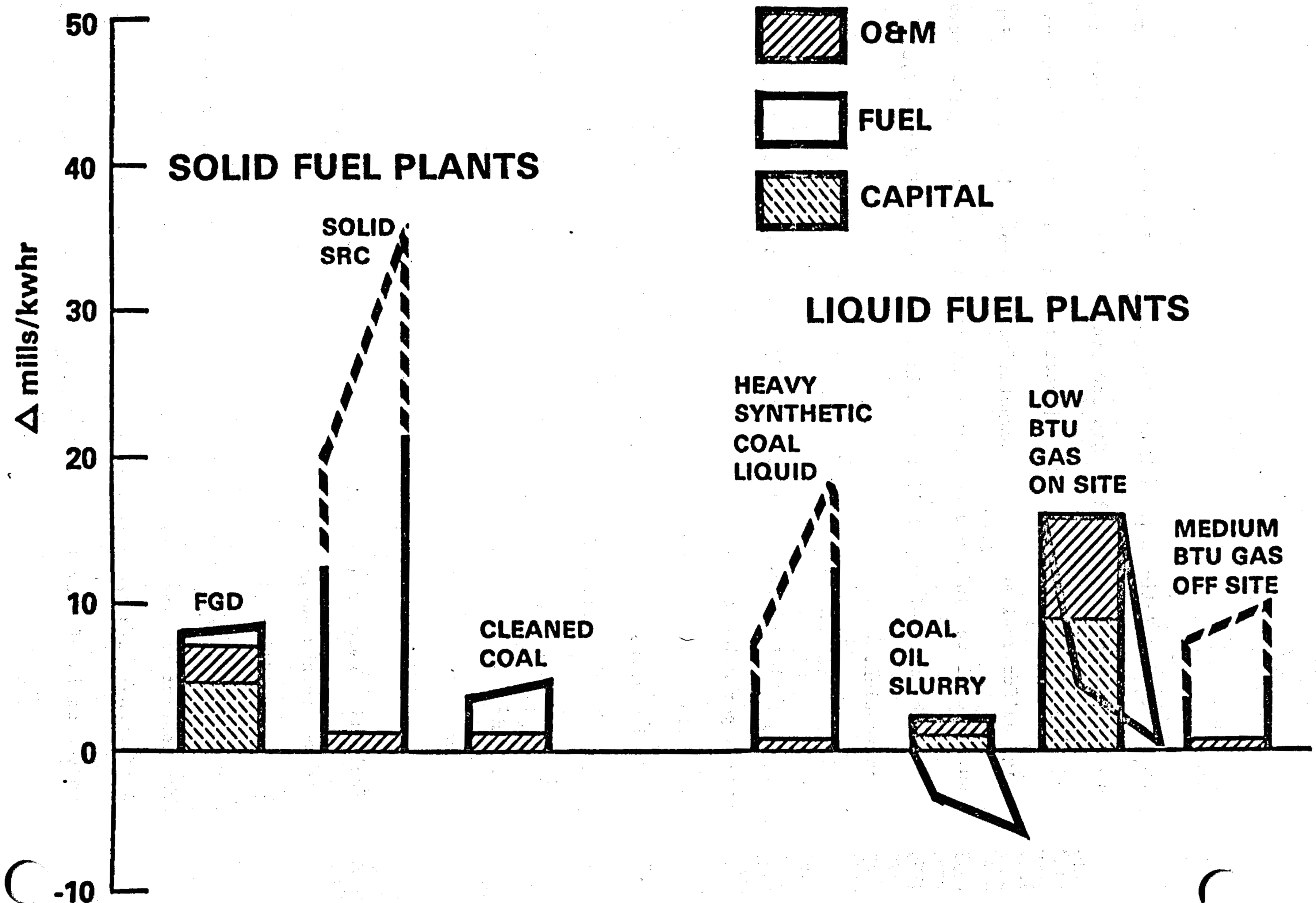
For liquid fuel plants, the retrofit of \$3 to \$5 per million Btu heavy synthetic coal liquid adds about 20 mills. And in the coal-oil slurry retrofit, substituting coal for part of the No. 6 fuel oil, a small saving results.

Low Btu gas on site, using high sulfur coal, replacing No. 6 fuel oil, produces a saving that results in no added cost. Finally, medium Btu gas bought off site adds about 10 mills.

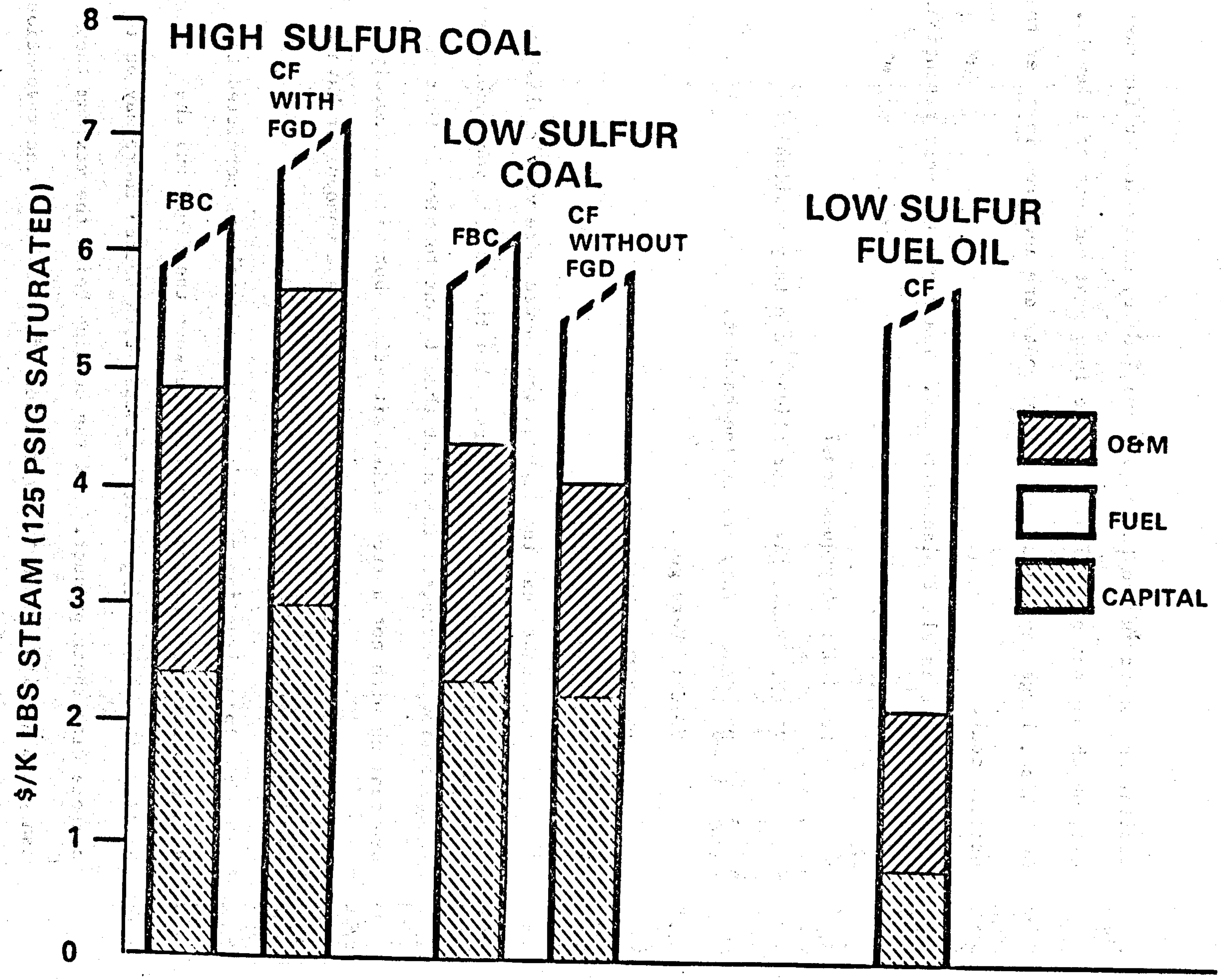
(Slide 9)

The last slide was a study done a year ago that indicates the cost of new industrial boilers. As you see for high and low sulfur coal, and low sulfur fuel oil, there is not a lot to choose from on the basis of overall cost. The plot makes the point, however, that

RETROFIT OF ELECTRIC UTILITY



NEW INDUSTRIAL BOILERS



capital and operating costs can be minimized by using low sulfur fuel oil, which may not be available in the future at current cost levels. Otherwise, large capital and operating costs are incurred in order to utilize coal.

That is all I planned to say. Thank you for your attention.

(Applause.)

DR. KANE: Any questions?

VOICE: Those last four slides, are they available?

DR. KANE: They are in the handout.

VOICE: Very good.

DR. KANE: Yes.

DR. BARON (Shell):

I thought that the figures you showed were very realistic and so were your contingency factors. And the numbers you showed are in the believable range. The point that I want to make is that we are dealing with not a free market situation, but with a monopoly situation in which the OPEC countries acting as a monopolist have a problem of setting their prices.

In a situation normally, when a monopoly is permitted to act, they set their prices somewhere between the floor and the ceiling, the floor being whatever competitive source there may be to compete with their product. And the ceiling being the maximum they can get away with, without a revolution of some kind. The revolution may be due to economic causes, disruption of society, or other.

The major point I want to make here is that in our case, the floor will be set by the prices you have shown. Say, minimum $20, as much as $30 a barrel, on the order of $5 per million Btus, something like that.

But interestingly enough, the ceiling which normally would be the ceiling, which the OPEC countries have chosen, even after you allow for importation and everything, is more like about $14, $15 a barrel. So we have a fantastic situation, in which the ceiling is below the floor. I'm using this poetic way of expressing myself to make the point of terrible danger, and that any government action that would arbitrarily and unnecessarily widen the gap between the ceiling and the floor, will contribute to increased instability.

Thank you.

DR. KANE: Further questions or comments?

If not, Dr. Phillips has an announcement, then we will let you go.

DR. PHILLIPS: Well, the first announcement is that I think we can all be back in an hour and seven minutes, namely, at 1:45, please, for the afternoon session.

I point out to all of you that there are restaurant facilities available, both in this Quality Inn and across the street at the Hyatt Regency.

Would you please fill in the forms if you wish to participate in tomorrow afternoon's smaller discussion groups.

(Whereup, at 12:38, the meeting was recessed, to reconvene at 1:45 p.m., this same day.)

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AFTERNOON SESSION

DR. KANE: I have a couple of announcements to make before we commence.

Let me remind all of you that wish to participate in our smaller discussion groups tomorrow afternoon, we do request that you indicate that; and it would be helpful if you would fill out one of those checklists that The MITRE Corporation has supplied.

Because of the uncertainties in fossil energy research meetings, we got somewhat out of order in our program this morning, but I believe we now have the opportunity to get back into the agenda as it was written up. So we will have first a talk by Dr. Kropschot, the talk on Overview of ERDA Research, agency-wide. That will be followed by the talk by Watkins; the talk by Holzer and Zucker; we have already done the talk by Dr. Alex Mills, and then we will proceed on through the program as it is printed.

So I now call on Dr. Richard Kropschot--Overview: ERDA Research.

DR. KROPSCHOT: I would just like to spend a few minutes putting the program, for the rest of the next day and a half, in perspective and to call your attention to the fact that what we were doing this morning was an attempt at giving you an overview of the broad based program going on in ERDA; and now I would like to deal with the research, the program that Dr. Phillips and I have been working on, and the reason for this meeting; and address what we are trying to do in soliciting your help in getting feedback to provide input into the planning session and the planning activities for the research in ERDA.

The Energy Reorganization Act of 1974 assigned to the Administrator of ERDA the central responsibility for policy planning, coordination suport and management of research, development, and demonstration for all the energy sources. (Slide 1) In addition, there are other elements of the Act but it is this legislative issue that we are trying to respond to today. For the remainder of our meeting, we would like to discuss the energy-related research in the near, mid, and long-term program.

We must recognize that the definition of "research" means different things to different people and we have great difficulty in obtaining a consistent definition. (Slide 2) However, research (Basic, Applied, Technology Base) as defined in ERDA IAD 0800-5 can and must be one of the Agency missions and should be justified as such.

In our definition, we include the basic research developed from the fundamental sciences and the broadly-applicable technologies.

What we do not include are the programs which respond to the pilot and demonstration plants. And, again, part of those programs can and do overlap into the research. The boundary is fuzzy, but the definition is many times only a problem in semantics.

Energy Reorganization of 1974

Central Responsibility for
Policy Planning
Coordination
Support
Management
of Research (and Development)
for all Energy Sources

Near - Mid - Long term:

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What is Research?

Basic
Applied
Broadly Appicable Technology

— Different things/different people
— What it is not

Using this definition, the ERDA-side program in research (Fossil only being a part of it) is $400 million annually. We have excluded the High Energy and Nuclear Physics program and the Environment and Safety Research from our inventory. The fossil research component is about $40 million annually and managed by four different Assistant Administrators (AFE, ASGA, AC and AES).

About a year ago, as Mr. Fri and Dr. Kane mentioned this morning, the Administrator of ERDA and the Assistant Administrators developed a group of management goals. One of these goals was to strengthen the Basic Energy Sciences (Slide 3) Program within the Agency and they assigned to Dr. Kane the responsibility for the quality of that Program. Dr. Phillips and I have been assisting Dr. Kane in his quest for an answer to this difficult task. The Federal role that we see emerging is outlined in Slide 3 responding to the Reorganization Act as well as other key elements which justify Federal involvement.

Slide 4 shows the key elements for a strong research program. Where are the <u>needs</u> for research; what are the <u>opportunities</u>; do we have the <u>resources</u> and can we provide the <u>leadership</u>? We have asked each of the speakers not only to address what they are doing, but to point out new opportunities. Do we have an infrastructure in place to take advantage of opportunity in an adequate way and can we provide the leadership to complete the job.

- Strengthen the Basic Energy Sciences Program
- Quality and Adequacy
- Federal Role
    - Reorganization Act
    - Broad Public Benefit
    - Sheer Size
    - Difuse Benefits
    - Risk
    - Balance of Trade
    - Scientific and Technical Leadership

OPPORTUNITY:
NEED:

RESOURCES
LEADERSHIP

Slide 5 is our schedule for the meeting. We have completed the Introductory Session. For the rest of the time through tomorrow noon, we will present to you the Fossil Energy Research Program and the research opportunities. We must recognize that in order to respond to these opportunities, we must provide adequate resources (Industry, Multidisciplinary laboratories and Universities).

In our handout, we addressed several issues and questions (Slide 6) that we have developed in concert with groups of people within the Agency. They are the key issues and are asked when determining the nature of the research program; the quality and adequacy of the new research, the balance, etc. Is the balance between research and the demonstration program correct? How can we use your input to make these decisions?

As Dr. Kane mentioned, the issue of crosscutting technologies needs serious consideration. Dr. Phillips and I felt that there were several areas (Slide 7) that deal with the broad-based disciplines: materials, combustion, instrumentation, nondestructive testing and so on, that have impact on more than one technology and are falling through the cracks.

The feedback seminars that we planned tomorrow afternoon are (hopefully) designed to get your input. We will divide up into smaller groups of 10 to 15 each and, with the aid of the staff from The MITRE Corporation, provide a mechanism for obtaining your input.

Schedule

- Introductory Session
- Research Program
- Research Opportunities
- Resources
  - Industry
  - ERC's
  - National Labs
  - Universities

Quality and Adequacy
New Research needs/opportunities
Balance research/demonstration
Industrial/University/Government Research
Technology Transfer
Management of Research
Cross-cutting Technologies

Feedback Seminars

CROSS-CUTTING TECHNOLOGIES

DISIPLINES

MATERIALS
COMBUSTION
INSTRUMENTATION
NON DESTR TESTING
MATHEMATICAL MODEL
SUPERCONDUCTIVITY
DATA BASE
CATALYSIS
CORROSION
ABRASION - WEAR

FACILITIES

PULSED NEWTON SOURCE
SYNCHROTRON RADIATION
LASER DIAGNOSTICS

To ask for input from you with this limited information is perhaps unfair, difficult or maybe impossible. But many of you (most of you) are working in the field of fossil energy and know a lot about the ERDA program. So we're starting at a pretty high level of knowledge. Also, I would like to call your attention to the fact that the decision making process of Fossil Research is being done during each budget cycle. We're asking for your help in providing input to that decision process.

(No response.)

DR. PHILLIPS: We will then proceed with our program.

The next speech will be a topic in fossil energy division research, oil, gas and shale technology presented by J. Wade Watkins.

MR. WATKINS: Thank you. Ladies and gentlemen, I had the same problem Dick Kropschot mentioned in trying to categorize research.

In 30-odd years, and some of them have been, indeed, especially recent ones. In 30-plus years of being involved in government R&D, it's never been clear in my mind, the line of demarcation between basic or fundamental research, applied research, engineering development, et cetera.

I think other people have the same difficulty.

In preparing this presentation --

(Laughter.)

-- I assumed that I was to focus primarily on basic research as compared with our entire program, which is what I had planned, and therefore, I am not going to go into detail about our cost-shared contracts with industry for field demonstrations or similar in-house programs and some of our other activities, but more the overall general program as compared with what we think may be basic research.

I'd like to point out that there's an attractive young lady in the back of the room who has a limited number of copies, hard copies, of the vugraphs I will present, which also includes vugraphs I will not use, because I'm not going to touch in detail on our applied programs.

In trying to rack up what we have in basic research, I took all of our headquarter's contracts and went through those categorically myself and said, well, this either is or is not basic research, which ignored such activities as cost-shared industry contracts, support research, computer modeling, environmental compliance, like EIA's, EIS's, EDP's, and a host of other things that just by no stretch of the imagination could I consider to be basic research.

And I went to the Energy Research Centers and National Laboratories and said, "Look, please tell me what you think you're doing for us that is basic research."

And that reinforced my confusion no end, because I had some of the National Lab directors come back and say, well, look, we're not doing anything for you that's basic research. It's all applied research. Conversely, I had one ERC director say, everything we're doing is basic research.

I knew this couldn't be right, so I rather categorically excised some of the things that had been in there, and then finally came up with a total, which I am not prepared to defend when I show it to you later. I can assure you it's not off by an order of magnitude, but it could be 25 percent more or less or something like that.

Okay. May I have the first slide, please.

(Slide 1)

You probably have seen this already. It identifies where we are, the Division of Oil, Gas and Shale Technology, one of seven divisions under Phil White.

Next one.

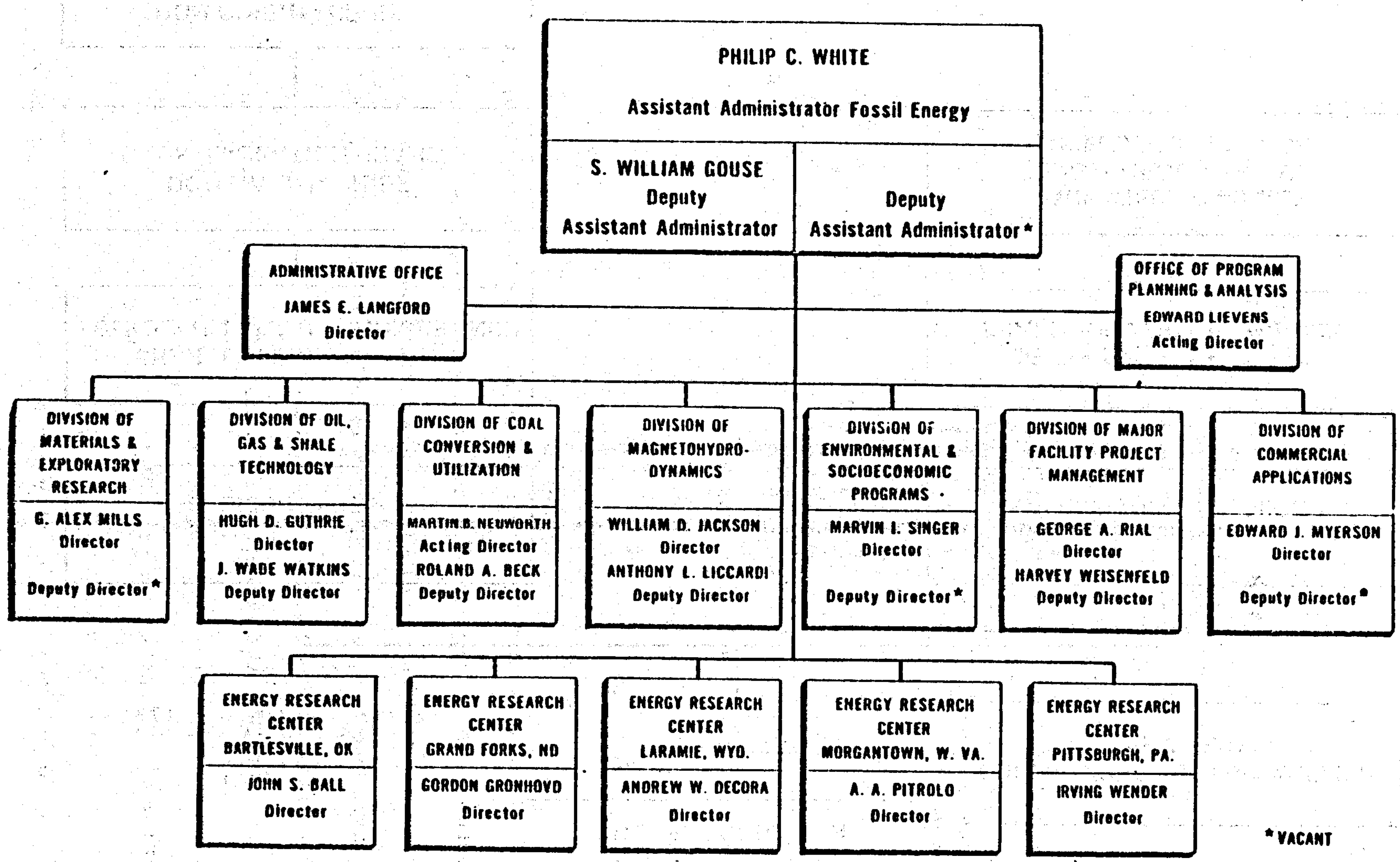
(Slide 2)

This is our division organization. We have two assistant directors, Jerry Hamm, for oil and gas, with 3 branches, Charles Perry, in petroleum stimulation or, better known as enhanced oil recovery, Don Ward, gas stimulation or enhanced gas recovery and Don Guier, drilling and offshore technology.

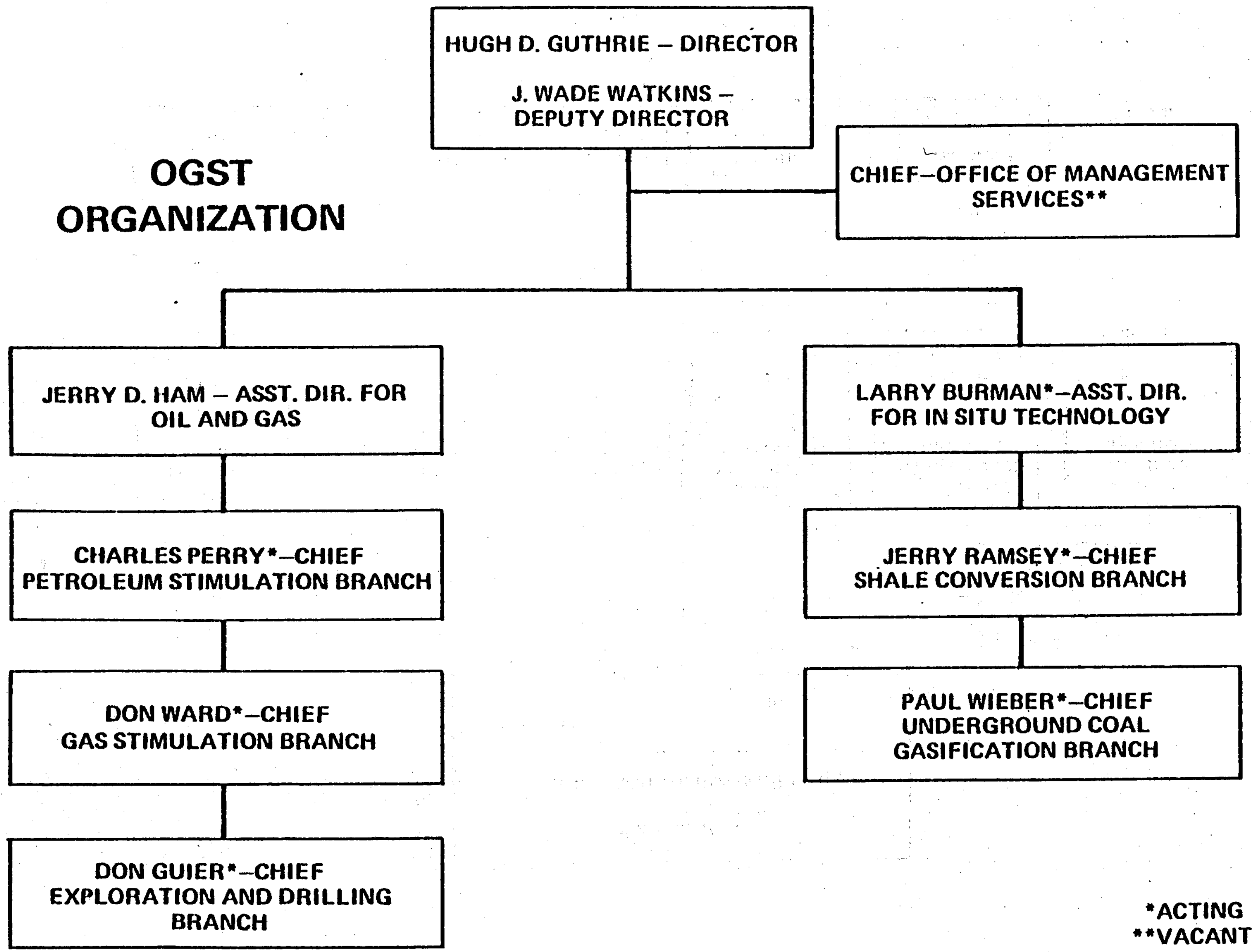
On the other side, Larry Burman, for in situ technology, with two branches. Jerry Ramsay, shale conversion, and Paul Wieber, underground coal gasification. Okay.

(Slide 3)

Objectives. I'll let you read the objectives, and point out that under implementation we do put a very heavy emphasis on


PHILIP C. WHITE
Assistant Administrator Fossil Energy
S. WILLIAM GOUSE
Deputy
Assistant Administrator
Deputy
Assistant Administrator*
ADMINISTRATIVE OFFICE
JAMES E. LANGFORD
Director
OFFICE OF PROGRAM PLANNING & ANALYSIS
EDWARD LIEVENS
Acting Director
DIVISION OF MATERIALS & EXPLORATORY RESEARCH
G. ALEX MILLS
Director
Deputy Director*
DIVISION OF OIL, GAS & SHALE TECHNOLOGY
HUGH D. GUTHRIE
Director
J. WADE WATKINS
Deputy Director
DIVISION OF COAL CONVERSION & UTILIZATION
MARTIN B. NEUWORTH
Acting Director
ROLAND A. BECK
Deputy Director
DIVISION OF MAGNETOHYDRO-DYNAMICS
WILLIAM D. JACKSON
Director
ANTHONY L. LICCARDI
Deputy Director
DIVISION OF ENVIRONMENTAL & SOCIOECONOMIC PROGRAMS
MARVIN I. SINGER
Director
Deputy Director*
DIVISION OF MAJOR FACILITY PROJECT MANAGEMENT
GEORGE A. RIAL
Director
HARVEY WEISENFELD
Deputy Director
DIVISION OF COMMERCIAL APPLICATIONS
EDWARD J. MYERSON
Director
Deputy Director*
ENERGY RESEARCH CENTER BARTLESVILLE, OK
JOHN S. BALL
Director
ENERGY RESEARCH CENTER GRAND FORKS, ND
GORDON GRONHOVD
Director
ENERGY RESEARCH CENTER LARAMIE, WYO.
ANDREW W. DECORA
Director
ENERGY RESEARCH CENTER MORGANTOWN, W. VA.
A. A. PITROLO
Director
ENERGY RESEARCH CENTER PITTSBURGH, PA.
IRVING WENDER
Director
*VACANT

OGST ORGANIZATION



ERDA DIVISION OF OIL, GAS, AND SHALE TECHNOLOGY

R&D OBJECTIVES

- MAXIMIZE EFFICIENCY OF PRODUCTION OF DOMESTIC DEPOSITS OF NATURAL GAS, PETROLEUM, HEAVY OILS, OIL SHALE, TAR SANDS, AND UNDERGROUND COAL CONVERSION

IMPLEMENTATION

- PROVIDE FUELS AT LOWEST POSSIBLE COST AND MINIMUM ADVERSE EFFECT ON ENVIRONMENT AND ECOLOGY
- EFFECT RAPID TECHNOLOGY TRANSFER
  - SYMPOSIA
  - QUARTERLY PROGRESS REPORTS
  - PUBLICATIONS AND PRESENTATIONS

rapid technology transfer. We do this through symposia. We have an annual symposium on enhanced oil and gas recovery, and periodic ones on such subjects as underground coal gasification and oil-shale retorting.

It's also done through quarterly progress reports on all of our contracts which have a very wide distribution, and it is done through technical and scientific publications and presentations.

(Slide 4)

Our research targets are some 290 billion barrels of normal gravity oil, more than 100 billion barrels of heavy oil, at least 30 billion barrels of bitumen in tar-sand deposits, principally identified in the state of Utah; more than 600 trillion cubic feet of natural gas in low permeability formations in the Rocky Mountain basins, and an unquantified but sizable amount in similar deposits in eastern shales, coal seams and geopressured aquifers.

In our contracts we have been shooting for at least 50 percent funding from industry and actually have exceeded that.

Our goals are to add to proved reserves by 1985, 3 billion barrels of oil and 10 trillion feet of natural gas, as a result of our program, and to increase daily production by an increment of 800,000 barrels of oil and 3 billion cubic feet of natural gas.

(Slide 5)

In in situ technology the resources are tremendous, and please remember, I'm talking about resources and not reserves. 1.8

PETROLEUM AND NATURAL GAS

- RESOURCE TARGETS
  - 290 BILLION BARRELS OF NORMAL-GRAVITY OIL
  - 107 BILLION BARRELS OF HEAVY OIL
  - 30 BILLION BARRELS OF BITUMEN
  - 600 TRILLION CUBIC FEET OF NATURAL GAS
- EXPECTED INDUSTRY PARTICIPATION
  - ABOUT 50 PERCENT
- EXPECTED ADDITIONS TO RESERVES BY 1985
  - 3 BILLION BARRELS OF OIL
  - 10 TRILLION CUBIC FEET OF NATURAL GAS
- EXPECTED INCREASED PRODUCTION BY 1985
  - 800 THOUSAND BARRELS OF OIL PER DAY
  - 3 BILLION CUBIC FEET OF NATURAL GAS PER DAY
- PROVED DOMESTIC RESERVES AT END OF 1975
  - 32.7 BILLION BARRELS OF CRUDE OIL
  - 228.2 TRILLION CUBIC FEET OF NATURAL GAS

IN SITU TECHNOLOGY

- RESOURCE TARGETS

  1.8 TRILLION BARRELS OF OIL EQUIVALENT FROM OIL SHALE

  1.8 TRILLION TONS OF COAL AMENABLE TO UCG

- EXPECTED INDUSTRY PARTICIPATION

  UP TO 50 PERCENT

- EXPECTED PRODUCTION BY 1985

  150 THOUSAND BPD EQUIVALENT FROM OIL SHALE

  50 THOUSAND BPD EQUIVALENT FROM UCG

trillion barrels equivalent of shale oil, 1.8 billion barrels of oil equivalent from coal formations that we feel should be amenable to underground coal gasification and that at the present time are not considered to be economically minable.

Here, again, we are shooting for 50 percent, at least, from industry, and we would expect 150,000 barrels of oil per day from oil shale by 1985 and 50,000 barrels equivalent from underground coal gasification.

(Slide 6)

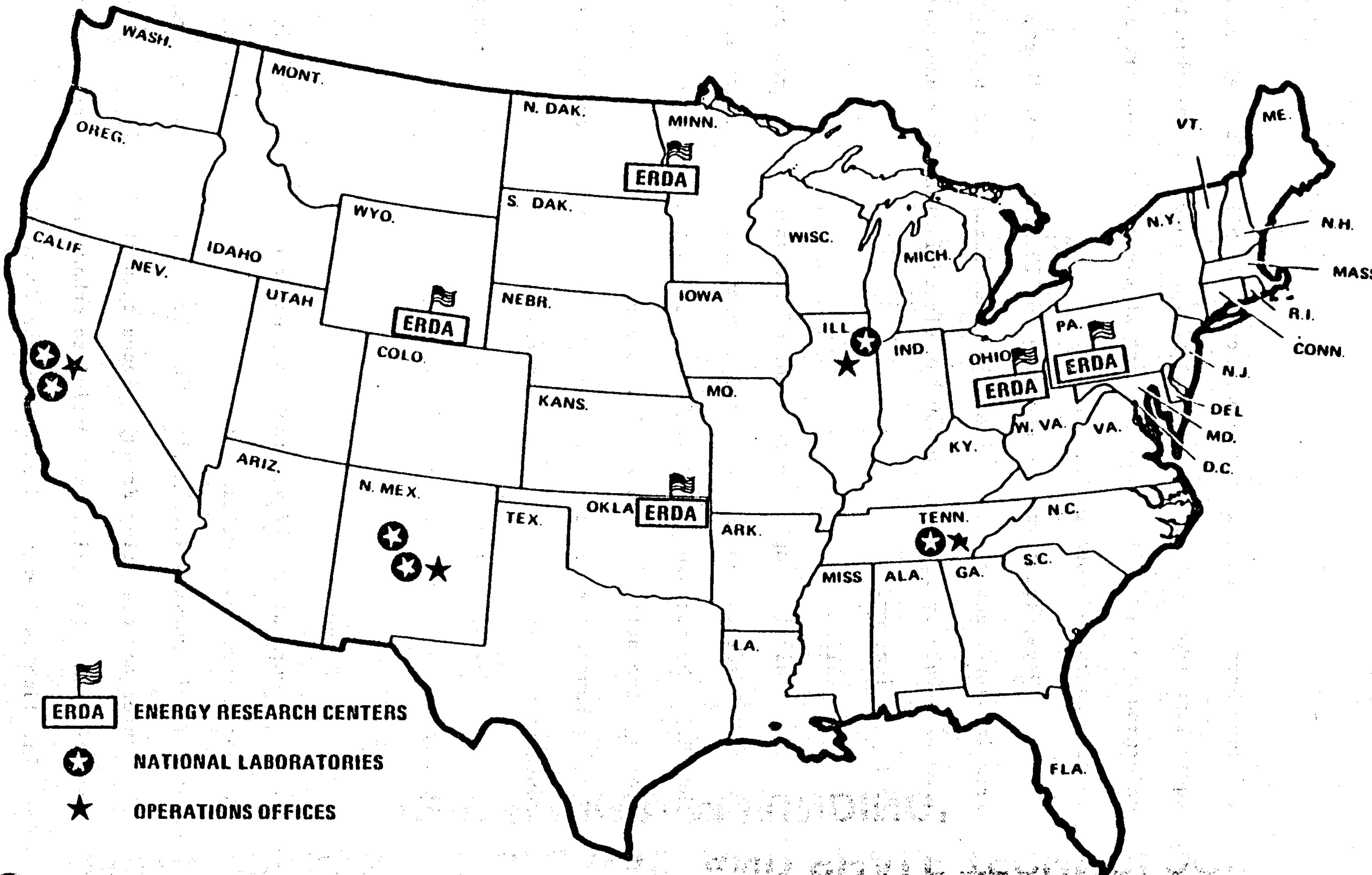
This is simply the location of the in-house programs at the National Laboratories and the Energy Research Centers, starting with the ERC's, Morgantown, West Virginia, Bartlesville, Oklahoma, Laramie, Wyoming, the national laboratories, Oak Ridge, Argonne, Los Alamos, Sandia, Lawrence Berkeley, Lawrence Livermore, and we do have a small contract with Mounds which is not on the map.

The operations offices with which we deal, are Oak Ridge, Chicago, Albuquerque, San Francisco, and Nevada, which also is not on the map.

(Slide 7)

Our budget, if you look at the bottom line, you see it increased from $64.3 million in '76 to $73.4 million in '77 and, whereas this shows $110.1 million in '78, the report that came out of the conference committee Friday, places this at $115 million, which results from a $4.9 million addition to enhanced gas recovery, which on this line is identified as nonnuclear fracturing.

LOCATION OF ERDA FOSSIL ENERGY RESEARCH CENTERS AND NATIONAL LABORATORIES



ERDA DIVISION OF OIL, GAS, AND SHALE TECHNOLOGY R&D PROGRAM FUNDING[1]

($ IN MILLIONS)

	FY 1976	TQ	FY 1977[2]	FY 1978[3]	
OIL & GAS TECHNOLOGY	(43.2)	(8.9)	(42.9)	(71.1)	76.0
FLUID INJECTION	25.7	4.6	23.8	46.1	
NON-NUCLEAR FRACTURING	13.5	3.1	14.9	22.0	26.9
EXPLORATION, DRILLING, OCS, RIO BLANCO TSTG	2.2	.7	2.4	1.6	
PROCESSING & UTILIZATION	1.8	.5	1.8	1.4	
IN SITU TECHNOLOGY	(21.1)	(4.0)	(30.5)	(39.0)	
OIL SHALE	13.7	2.0	21.0	28.0	
COAL (UCG)	6.1	1.7	8.2	11.0	
SUPPORTING RESEARCH	1.3	.3	1.3	—[4]	
TOTAL	64.3	12.9	73.4	110.1	115.0

[1]BUDGET AUTHORITY
[2]ACT PL 94 - 373
[3]REVISED PRESIDENTIAL BUDGET
[4]FY 78 SUPPORTING RESEARCH INCLUDED IN OIL SHALE

Okay.

(Slide 8)

In ERDA, fossil energy has 7.6 percent of the funding in FY '77, and 8.3 percent in FY '78, as the President's budget went to the Congress.

(Slide 9)

Our division's share in '77 was 15.4 percent and in '78, 17 percent, again based on the President's initial budget.

(Slide 10)

Personnel wise, Fossil Energy has four percent of the total. We have nine percent of the Fossil Energy share.

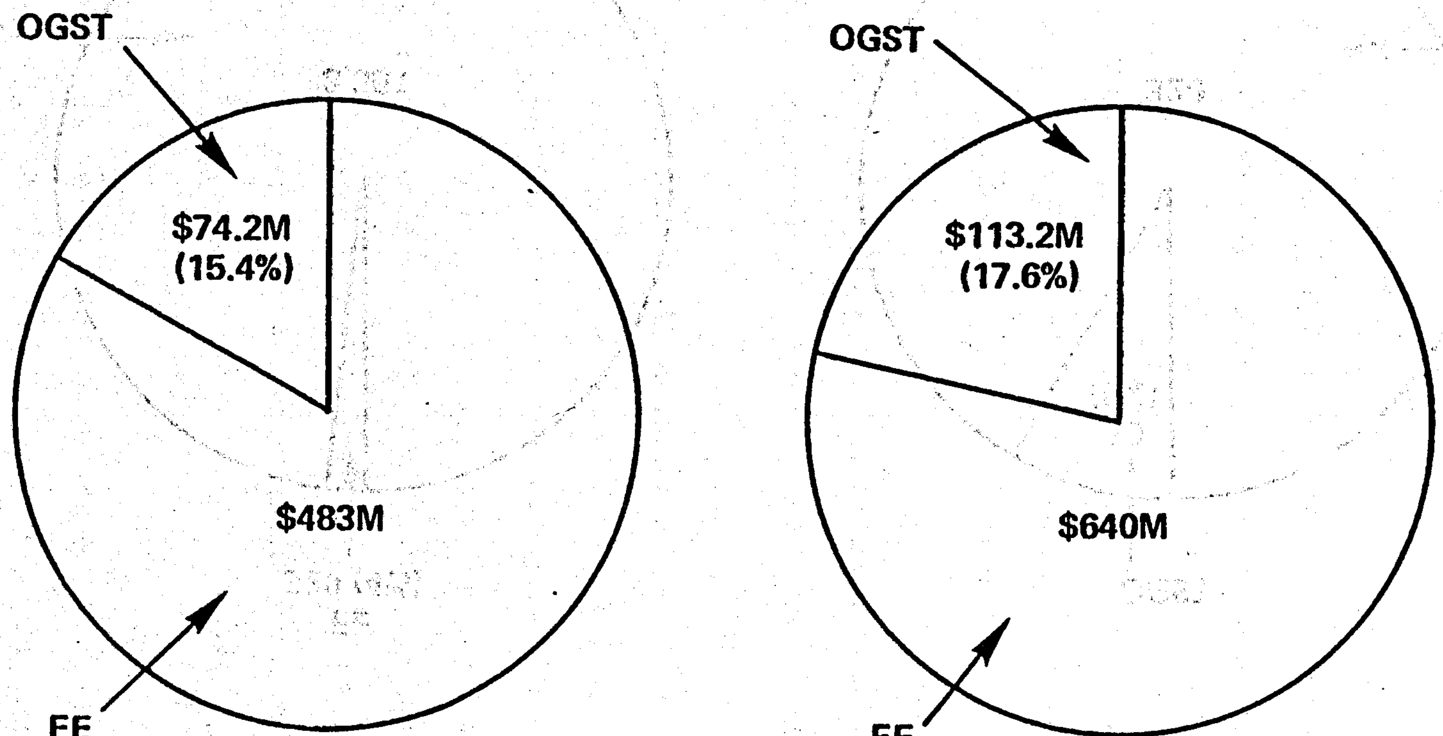
(Slide 11)

In FY '77, we were putting $24 million into enhanced oil recovery, $21 million into oil-shale technology, 8.2 million into underground coal gasification, $15 million into enhanced gas recovery, $3 million in supporting research, and $2.4 million into drilling and offshore technology. And this is going to industry-$35 million, National Labs $14 million, Energy Research Centers about $20 million, universities $1.6 million and supporting research, other government agencies, $3.5 million.

(Slide 12)

Now, this is my rackup on what we are doing in basic research which, as I said, may or may not be right and may be open to question.

OGST'S SHARE OF FOSSIL ENERGY'S FUNDING[1]

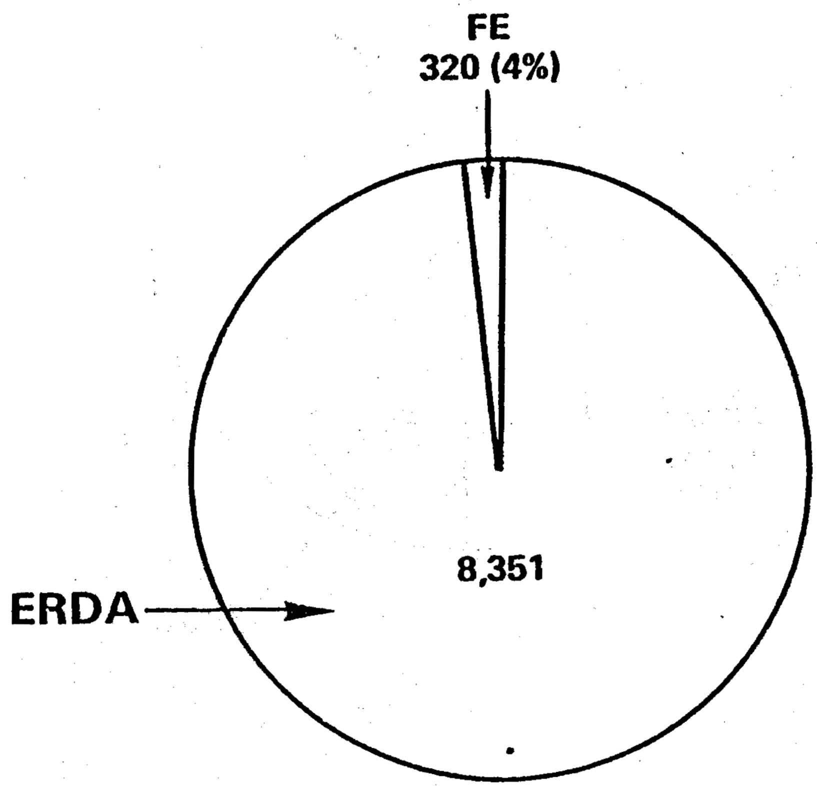


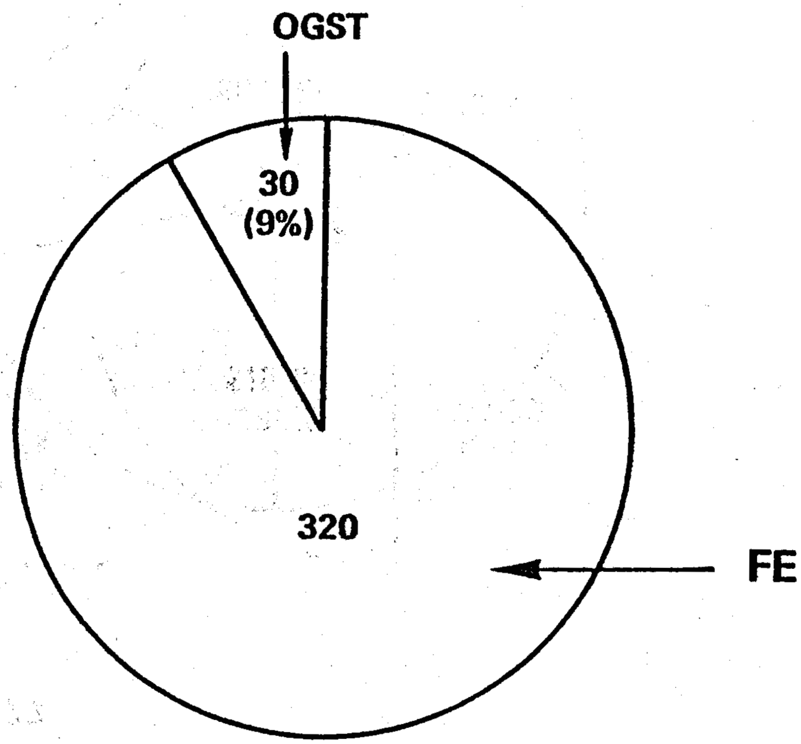
FY 77 FY 78

[1]BUDGET AUTHORITY INCLUDING OPERATING EXPENSES AND PLANT AND CAPITAL EQUIPMENT

PERSONNEL RESOURCES

FY 77





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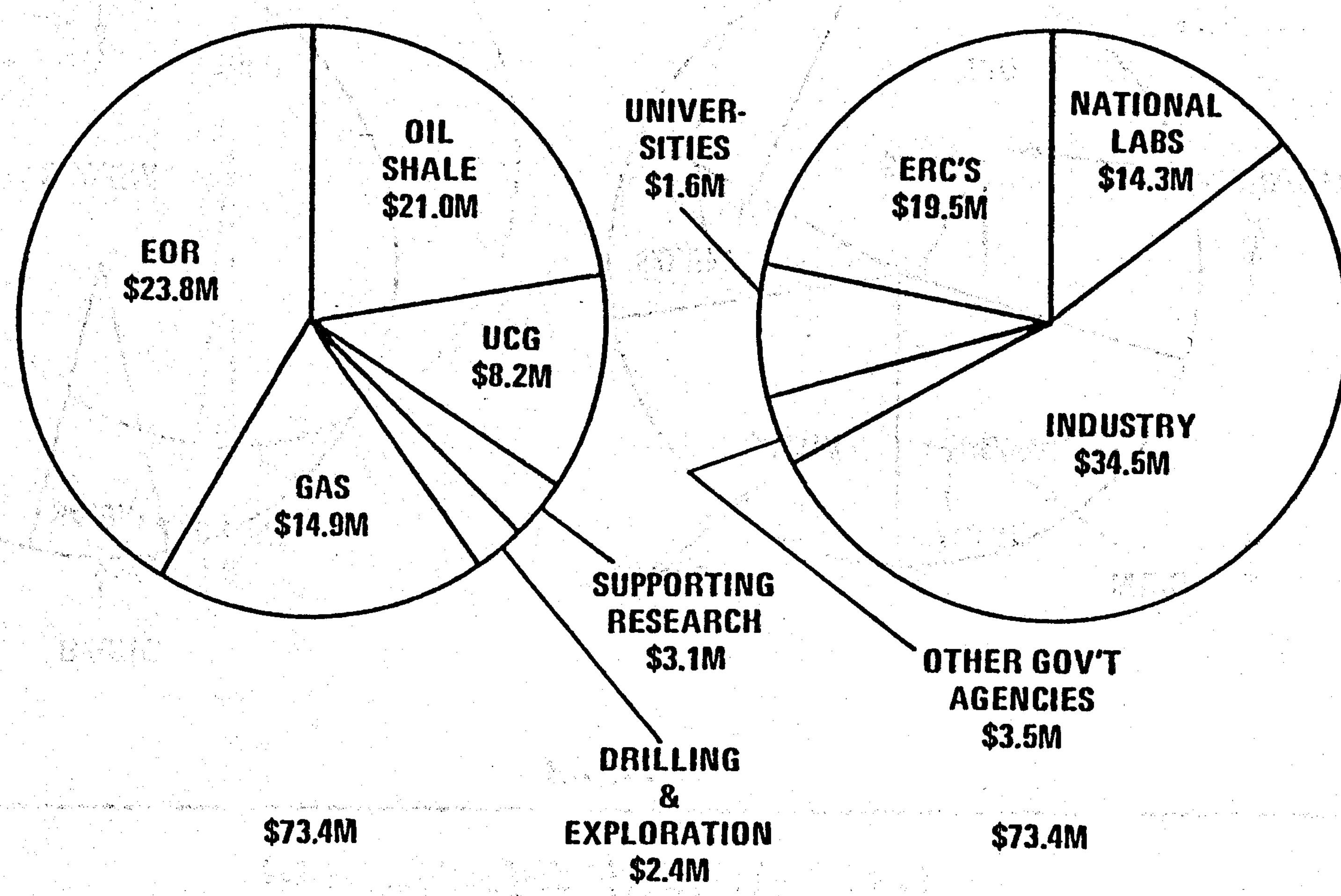
HOW AND WHERE OGST SPENDS ITS MONEY

FY 77



BY TECHNOLOGY **BY RECIPIENT**

[1]OPERATING EXPENSES ONLY

OGST BASIC RESEARCH
FY 1977

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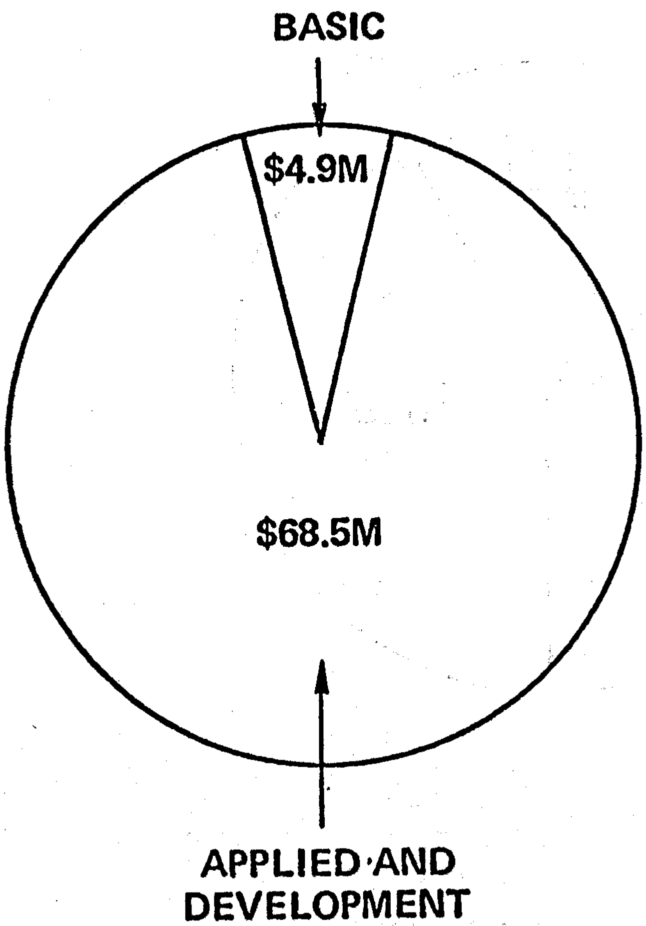
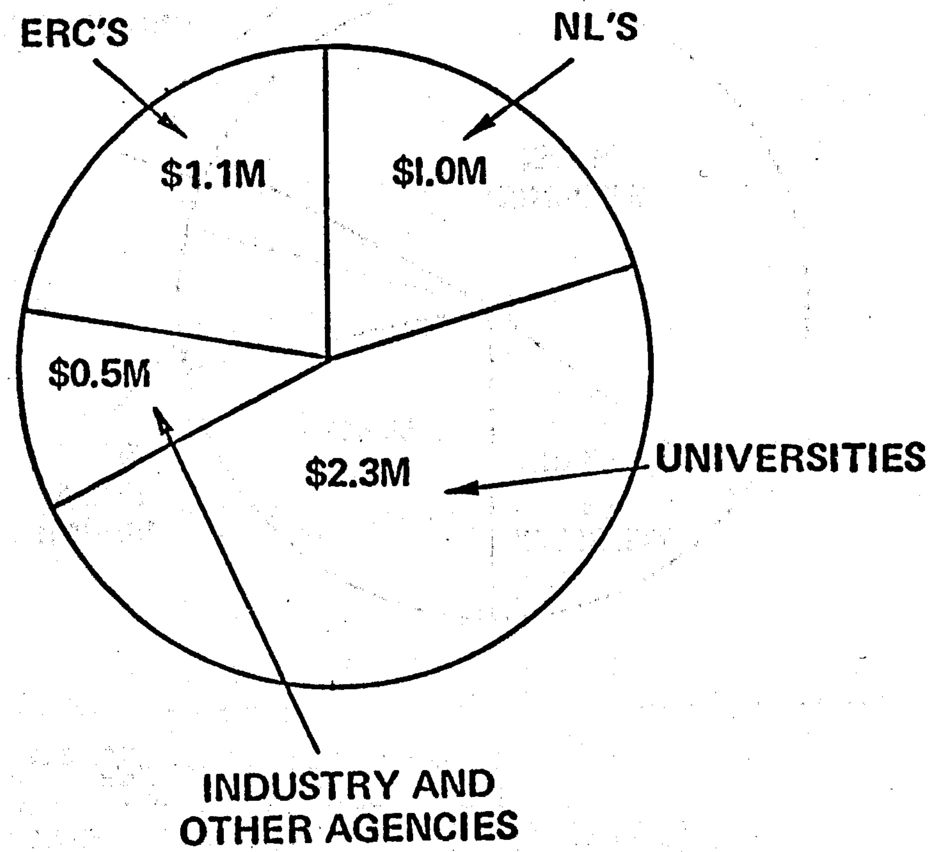


BY CLASSIFICATION



BY RECIPIENT

EXAMPLES OF PRESENT AND POTENTIAL OGST BASIC RESEARCH

- OIL SHALE CHARACTERIZATION AND BEHAVIOR
- OIL IDENTIFICATION
- PROPERTIES AND BEHAVIOR OF EOR CHEMICALS
- EOR TRACERS
- ROCK MECHANICS
- SURFACE CHEMISTRY
- THERMODYNAMIC PROPERTIES OF FLUIDS
- REACTION KINETICS
- ENVIRONMENTAL QUALITY AND REACTIONS

I totaled it up as 4.9, say $5 million, out of a total budget of $71 million, which leaves 68.5 in nonbasic research. Of this amount, the Energy Research Centers get $1.1 million, National Labs about $1 million, universities $2.3 million, and industry and other agencies a half-million dollars.

(Slides 13-23)

Now, I started to prepare two vugraphs here, showing what we are doing at present in basic research and what the needs might be in oil, gas, and shale technology for additional basic research. And as I tried to write this down, it occurred to me that I cannot differentiate the two. Possibly our immediate needs, if not our long-range needs, are simply more of what we are doing in some areas.

But let me run through these rather rapidly. One thing is oil-shale characterization and behavior. We have several projects going in this area. Oil identification, we have one at the Bartlesville Center. Properties and behavior of enhanced oil recovery chemicals. Here again, we have several projects at universities, National Laboratories and in-house at Energy Research Centers.

Enhanced oil recovery tracers, one project at Oak Ridge. This is to follow the subsurface flow of injected fluids.

Rock mechanics, applicable to virtually everything we're doing, because everything we're doing is in situ or underground, and

FOSSIL ENERGY RESEARCH PROGRAM

PETROLEUM AND NATURAL GAS

- STIMULATION OF PETROLEUM AND NATURAL GAS PRODUCTION
- EXTRACTION OF HEAVY OIL AND OIL FROM TAR SANDS
- CHARACTERIZATION OF PETROLEUM RESIDUES AND BITUMEN-LIKE MATERIAL
- QUALITY OF CRUDE OILS AND PRODUCTS
- IDENTIFICATION OF OIL SPILLS
- THERMODYNAMICS
- IMPROVED DRILLING TECHNOLOGY
- OFFSHORE TECHNOLOGY

FOSSIL ENERGY RESEARCH PROGRAM

IN SITU TECHNOLOGY

- IN SITU RETORTING
  - PROCESS DEVELOPMENT
  - SUPPORTING RESEARCH
- CHARACTERISTICS OF OIL SHALES
- OIL SHALE: NEW PROCESS TECHNOLOGY
- MAINTENANCE OF ANVIL POINTS FOR OBSERVATION OF RESEARCH BY DEVELOPMENT ENGINEERING, INC.
- ENVIRONMENTAL PROBLEMS ASSOCIATED WITH OIL SHALE PROCESSING AND UCG
- UNDERGROUND COAL GASIFICATION
  - PROCESS DEVELOPMENT
  - SUPPORTING RESEARCH
- IN SITU SHALE GASIFICATION (EASTERN AND WESTERN SHALES)

EOR FIELD TEST CONTRACTS SUMMARY

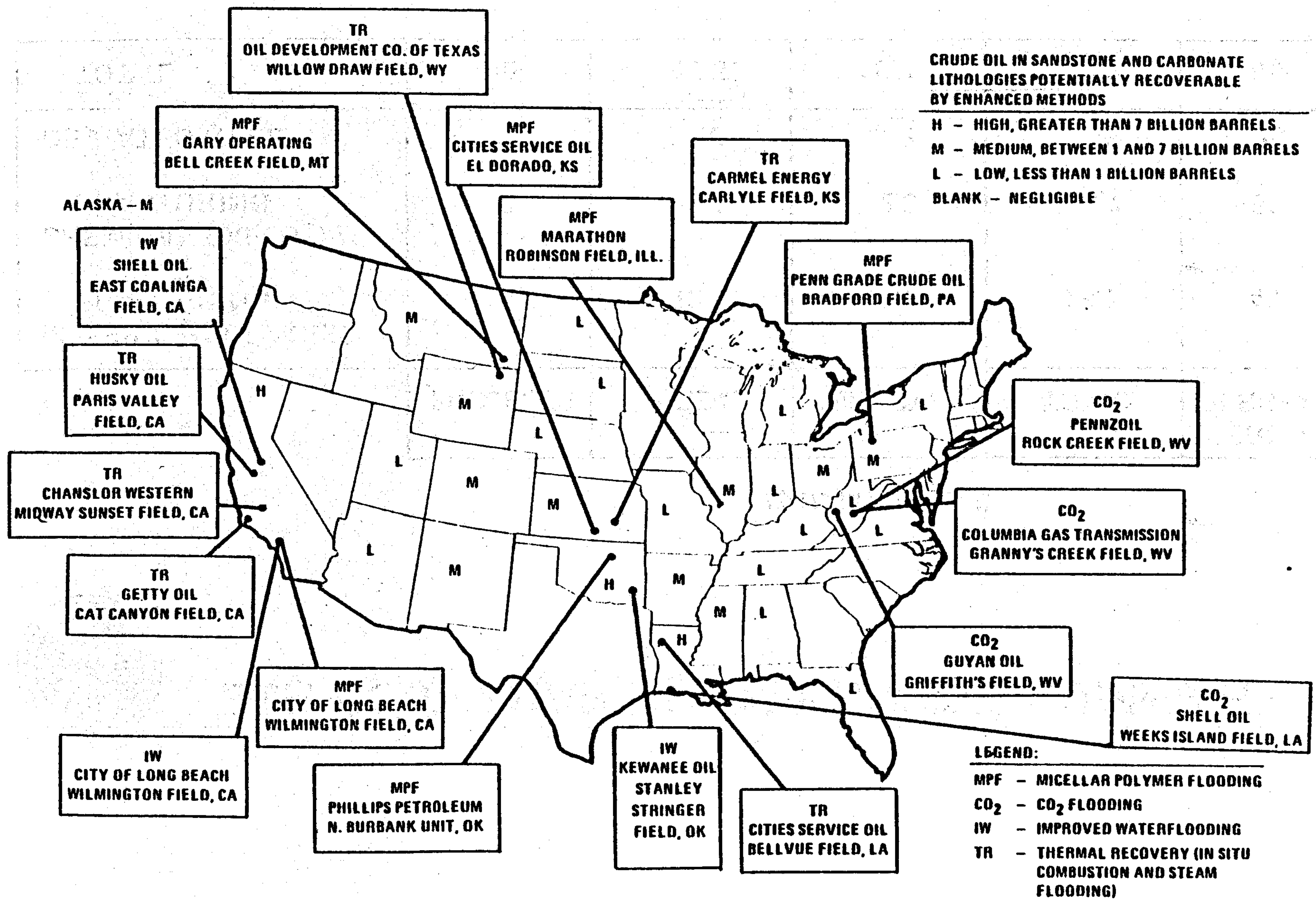
($ IN MILLIONS)

	PROJECTS	ERDA	INDUSTRY	TOTAL	ERDA PERCENT
MICELLAR-POLYMER	6	35.6	57.5	83.1	30
CO_2 FLOODING	4	1.5	5.7	7.2	20
IMPROVED WATERFLOOD	3	9.0	16.4	25.4	35
THERMAL RECOVERY	6	10.5	24.0	34.5	30
TOTAL	19	55.0	103.6	150.2	36

EOR FIELD TEST CONTRACTS

PROGRAM	TOTAL FUNDING (MILLIONS)	GOVERNMENT CONTRIBUTION	PERFORMER	LOCATION	STATUS
MICELLAR-POLYMER FLOODING	13.1	5.4	CITIES SERVICE, INC.	EL DORADO, KS	UNDER INJECTION
	9.8	3.4	PHILLIPS PETROLEUM CO.	BURBANK FIELD, OK	POLYMER INJECTION
	4.2	2.2	PENN GRADE CRUDE OIL CO.	BRADFORD FIELD, PA	DRILLING COMPLETE
	5.0	2.5	GARY OPERATING CO.	BELL CREEK FIELD, MT	PILOT DEMONSTRATION UNDERWAY
	7.0	3.5	CITY OF LONG BEACH	WILMINGTON FIELD, CA	INJECTION WELL TESTING
	44.0	14.0	MARATHON OIL CO.	ROBINSON FIELD, IL	SITE PREPARATION UNDERWAY
CO_2 FLOODING	3.2	1.2	GUYAN OIL CO.	GRIFFITHS FIELD, WV	BEGINNING INJECTION
	1.4	0.5	COLUMBIA GAS TRANSMISSION CORP.	GRANNY'S CREEK FIELD, WV	INJECTING CO_2
	2.6	1.0	PENNZOIL CO.	ROCK CREEK FIELD, WV	INJECTING WATER
			SHELL OIL COMPANY	WEEKS ISLAND FIELD, LA	INITIAL DEVELOPMENT
IMPROVED WATERFLOODING	3.9	1.2	KEWANEE OIL CO.	STANLEY STRINGER FIELD, OK	PRODUCING TERTIARY OIL
	7.6	2.2	SHELL OIL CO.	EAST COALINGA FIELD, CA	UNDER INJECTION
	14.0	5.6	CITY OF LONG BEACH	WILMINGTON FIELD, CA	DRILLING INJECTION WELLS
THERMAL RECOVERY	7.3	2.5	HUSKY OIL CO.	PARIS VALLEY FIELD, CA	INJECTING AIR
	0.8	0.7	CARMEL ENERGY CO.	CARLYLE FIELD, KS	INJECTING GAS AND STEAM
	8.7	2.0	GETTY OIL CO.	CAT CANYON FIELD, CA	CYCLIC STEAM STIMULATION
	8.2	3.1	CITIES SERVICE, INC.	BELLEVUE FIELD, LA	INJECTION TESTS
	8.2	1.7	CHANSLOR WESTERN CO.	MIDWAY SUNSET FIELD, CA	INJECTING STEAM
	1.3	0.5	OIL DEVELOPMENT CO. OF TEXAS	WILLOW DRAW FIELD, WY	UNDER INJECTION

POTENTIAL FOR ENHANCED OIL RECOVERY AND LOCATIONS OF SELECTED ERDA FIELD TEST CONTRACTS



EGR COST-SHARING CONTRACTS SUMMARY

($ IN MILLIONS)

	PROJECTS	ERDA	INDUSTRY	TOTAL	ERDA PERCENT
MASSIVE HYDRAULIC FRACTURING	6	12.5	16.2	28.7	43
CHEMICAL EXPLOSIVE FRACTURING	3	2.4	2.3	4.7	51
DEVIATED WELL	1	.6	.2	.8	75
TOTAL	10	15.5	18.7	34.2	45