# Panel Discussion—Summation and Future Projections

**Woodson** Let me welcome you to the afternoon session, *Summation and Future Projections.* I am Herbert Woodson, the chairman of the session this afternoon.

As I understand, a lot of people are itching to say a lot. I am going to be as brief as I can with introductions and such. We have a distinguished panel to discuss almost anything that needs discussing.

Each one of them will make some brief introductory remarks. After they have all made their introductory remarks, we will then proceed to take questions, comments, statements from the floor, and there ought to be ample opportunity for everyone to get his licks in.

Without further ado, let me introduce Dr. Joseph Barnea, who was formerly director of Resources and Transport for the United Nations. He retired in 1973 and is now an energy consultant to UNITAR, which is the United Nations Institute for Traning and Research. Here is Dr. Barnea.

**Barnea** Thank you, Mr. Chairman. I would like first of all to express my thanks for the invitation to participate in this first meeting on geopressured zones.

I am especially grateful to Professor Dorfman for his invitation. I believe that this meeting in which we all participate is not only important for Texas, though it is important in the long run for Texas, but it is also important for the United States as a whole and for the world because we are beginning to study a resource which is not unique to Texas, but is found in many parts of the world.

I appreciate the initial participation by Texas. I suppose as Texas has become the world's center for petroleum geology, some farsighted people here have seen the possibility that Texas might also become the technological center for geopressured zones all over the world.

Now, in this meeting which we have all attended, we have heard very many different opinions and very many problems, very many high-cost estimates, and, therefore, I would like to discuss some of these points.

First of all, we have to take into account our general experience in the various types of geothermal resources as they were discovered and developed.

We will find that in the history of geothermal-resource development, we find a very unique feature, namely that the pioneering stage was always taken by government or by individuals and not by companies.

I have the impression that we may witness the pioneering stage, which we are entering now in geopressure zones, that we may see the same picture.

The technology of the dry—steam fields was developed by the Italians. The technology of the wet-steam fields was developed by the New Zealanders. The technology of the low-salinity field was developed by the Hungarians. I can go on and describe some of the big developments such as the Reykjavik municipal heating system or governmental-municipal activities.

In this country, the pioneering work in the gaseous areas and others was done by real pioneers, people like McCabe and McNeil. I believe, if we will go back in history, we will also find the very important role of independents.

I believe, therefore, that some of the assessments we have heard by company representatives should not be taken too seriously. They have a different

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approach. They have to evaluate where to put their money among the many opportunities and from the point of view of the stockholders and everyone of us is also a stockholder.

Perhaps the approach is "Where do we get the highest return." That is important for companies, but that is not the pioneering attitude which we need in natural resources and which we need in geopressured zones.

Therefore, I believe that in this pioneering role, the federal government, the State of Texas and individuals will play the major role in the first stage until we have a much better assessment of the resource and of the appropriate technology.

One further remark on the very high equipment estimates that we heard yesterday—and here again I think the history of geothermal-resource development is interesting.

When I studied for the first time the geothermal system in operation in Italy in the 1950s, we found that the power-station equipment was produced by Misaldo and the plant investment per kilowatt of capacity was running around $300.

Then, The Geysers came in in the beginning of the 1960s. The Japanese entered the manufacture of geothermal power equipment, and by the middle of the 1960s, the cost per kilowatt of power equipment had dropped to less than half.

In other words, this confirms what we have found in other areas, too. As a resource becomes better known and we can begin to design the equipment and to manufacture the equipment knowing much better the resource characteristics, equipment costs can come down considerably. I have talked to some of the people here who are engaged in new types of generating equipment and I believe we will witness, because so many new approaches are being tested, a reduction in equipment costs over the next 10 years. This may be a benefit for geopressured systems.

Now, Mr. Chairman, I would like to say something on the general approach to geopressured zones and their application. I think the approach taken in this meeting, perhaps unavoidably, was a little narrow.

It was dealing practically only with the geopressured resources in Texas and, to some extent, in Louisiana. The main implication was the production of power and the utilization of natural gas.

I believe that, in the future—and certainly on a worldwide basis—our approach has to be broader and more flexible. In general, with a geothermal resource, as with many other resources, two groups of factors are decisive.

One is the resource characteristics and the other one is the economic environment in which the resource is located.

If we freely discuss some of the factors involved, resource condition means that we have to have data that we don't have today on all of the characteristics of geopressured resources and that, gentlemen, also includes mineral content, which hasn't been discussed at all in this conference. We have to know more about the size of the small fields, and the big fields. The approach in our discussion—the utilization of one size field—may not always be advisable.

The municipal water-supply system and heating system is based on a number of fields, small and big. The joint development of fields, big and small, is a technical and economical possibility, and it may, in some cases, be the only economical useful way to go about it.

Therefore, the one-field approach is something that we do not have to consider as the only possible solution to resource utilization. When we go to the

economic environment, we have to realize that geopressured zones in desert areas may have a totally different set of priorities than a geopressured zone in an area where water is not really required. In a desert area, water is the biggest and most important resource, and we at UNITAR are beginning a study on the role of geopressured zones in deserts, which may be of very great significance.

Now, let's assume that one finds a geopressured zone in cold climates. You have immediately the possibility of using the hot water for house heating, for mine heating, for agricultural processing, and for a variety of applications which may not exist in a country which is warm enough to avoid house heating.

We haven't discussed the exciting possibilities of geopressure offshore. Offshore will reduce certain costs, it may increase certain others. In a state like Texas where a very considerable part of the potential is offshore, I think the offshore possibilities should not be forgotten.

In particular, when we are approaching a period where, in the near future, artificial islands will be built, because American ports are not big enough to handle big tankers, those artificial ports will be centers of industrial activities. On those centers, there will be refineries and other processing industries. Now, if those artificial islands are to be built, why not look for the underlying geopressured zones and utilize them on the island.

Studies of this type have just come out, and I wanted to show you a summary report on such artificial islands offshore Texas as well as some other states, a study which, if no one minds my saying it, some people from the University of Texas participated in and in which geopressured zones as a potential were totally overlooked.

I believe, therefore, that geopressured zones and their potential contribution are not yet sufficiently widely known among other groups of professionals and policy makers and, therefore, this conference will have an additional function; namely, to spread the knowledge of the potential of geopressured zones.

Now, a third group of effects of geopressured zones, which has not been discussed at this meeting and may be of some significance, is the social and communal significance of geothermal resources in general and geopressured zones in particular.

That will also depend on the economics and the climate and other conditions in the area. Geopressured zones can provide swimming pools with warm water. In cold areas, it can provide road deicing and make roads safer.

There are many other social and communal functions which geopressured zones can provide. The most important, I believe, in many areas, is the contribution of geopressured waters to the water supply. Here, one point which didn't come up in the discussion is that, even if the water is salty, the water has a high enough temperature for self-desalination.

In other words, we can feed it into a desalination plant and can provide desalination without additional energy input, which means we can produce desalinated water in the range of 30¢ or 40¢ per 1,000 gallons.

Today, desalinated water, based on purchased energy is not available below $2. Therefore, this is an important asset. I don't know whether it's applicable in Texas, but this is an important feature which may make geopressured-zone water very attractive in a number of areas.

Mr. Chairman, I think I have spoken longer than you gave me. May I conclude with one request; namely, let's publish the data on geopressured zones. Everything we can get, I don't know where the data are. We have had very many good papers and opinions presented here, but the raw data were not published.

I think the University of Texas could perform a very important task if they would start to collect systematically all of the data, not only for Texas, and publish them and perhaps publish the data for all countries in the world for which data can be collected. Thank you very much.

**Woodson** Thank you, Dr. Barnea. The next panelist is the Honorable Clyde F. Bel, Jr., who is a member of the house of representatives of the State of Louisiana, representing District 90 and New Orleans.

**Bel** Thank you, Dr. Woodson. You know, many people comment to me that they were very surprised to see a state legislator spend three days at this conference. Well, it's just necessary, in my opinion. I am sorry that I don't have other state officials with me, but we are in our legislative session at this point and they, to say the least, were otherwise occupied.

I was very happy to see the Texas officials participating in this program, and I was happy to see that on the 20th of May, the Texas legislature did pass the Geothermal Resource Act.

We are studying and doing the same thing in Louisiana now. As a matter of fact, last Saturday, the Geothermal Resources Act did pass the state house of representatives.

This particular act is very general. I don't believe that we could have done anything very specific at this time because even you don't have the specific information on geothermal at this point. The only thing we did is make enabling legislation that would vest one central source, our Department of Conservation, with the responsibility for guiding the development of this resource. We are also going to vest out Mineral Board with leasing state-owned lands for the development of geothermal resources.

In summation and future projections, as I see it, state officials, elected officials, should keep themselves informed. They should work with industry, with state institutions such as this, and with the state governments and the various agencies of the federal government.

We should also keep in mind our goal. You can't get to your point unless you establish a goal. Our goal, at this point, should be to produce energy and to maintain a high standard of living for all of our citizens.

I was elected, reelected, during a special election, and I had to run for office back this past February. I can tell you that the people are more concerned about energy or the lack of energy than any other single thing.

They just anticipate that their way of life is going to deteriorate and rather rapidly, too, because this is what the press is projecting. I think they are projecting it accurately.

This deterioration of our life-style, I find, to be demoralizing and contagious. I think we must offer leadership and make every effort not to let this happen.

To be a little more specific, state legislators should enact laws to provide for the orderly development of this resource. I know of no other resource where we have had the benefit of the scientific knowledge and the refinement of politics as we have had at the outset of the development of this resource, and I think we ought to take every advantage of it.

Legislators should reflect also, in this legislation, the will of the people as to the ownership of this potential energy source, and that doesn't mean that I'm dedicated to the people owning the resource, but they should be protected no matter who owns the resource.

They should receive benefits from that resource. Another thing, we are having our off-session in Louisiana now, and this is a nontax year—so it is sort of a quiet year for the lobbyists—but we will have to consider a method of taxation.

It must be fair to all parties involved. It must not discourage industry from the timely development of this resource. On the other hand, it is a depletable resource and should provide income to the state and to the people of the state. It should provide, perhaps, funds for development of other resources. The legislature has to be a jack of all trades and really, a master of none.

I'm also interested in the solar resource. I think we ought to develop that. Now, people say you are premature and that we shouldn't really look at it yet. I think we should have been looking at it in years prior to development. Now, this is a little different approach for a legislator. Instead of saying we ought to impose taxes, I'm saying that we ought to offer tax incentives to people who are willing to take the risk of developing this new resource.

For example, I think we should suspend the ad valorem tax on any new buildings, new equipment for this type of resource. I think in the long run, it would economically benefit the state to do this, and it would add incentive if you have a marginal project with the taxes; maybe the project won't be so marginal without that tax.

Basically, don't penalize the developers; urge them along and help them. The states involved should enter into agreements for exchange of information at all levels, whether it be technical, political, or social.

They should provide for frequent meetings, such as this meeting, especially in the early stages of development. I know I thoroughly enjoyed what I could understand. I'm not technically oriented, but just getting the top 10 percent meant a lot to me, and I will be able to explain better to my fellow legislators why we need to go further in this development.

Frequent meetings and an exchange of ideas are most important. I will make these recommendations when I get back to my state. In summary, the thing that has stood out in my mind, is that I have heard two types of geologists, land geologists and water geologists, say this is a very valuable resource. I have heard the petroleum geologists say if we get enough gas from it, it's valuable. I would like to see a merging of these thoughts because I do believe they can live together, and I believe it will be good for both of them.

What I would really like to see after seeing that the geology is different in Texas than it is in Louisiana—we seem to have a cooler, softer area to work with, but I think we have a lot of the resource, and we have more coast line than you have. In Texas, apparently there are some problems—that if your land subsides any more down in Baytown, you will have a new Venice.

We do have to be careful in the way we approach it. We have to approach it as a supplemental energy source. We have to, basically, let our people know that we, as leaders, are trying to do something, that there is an alternative, and use this as the interim supplemental alternative, at least, for our areas. Thank you very much.

**Woodson** Thank you, Representative Bel. Our next speaker on the panel is Dr. David Lombard, who is acting chief of the Advanced Systems Branch of the Division of Geothermal Energy Research and Technology, Energy Research and Development Administration in Washington. It's through David's good auspices that we were able to hold this conference.

**Lombard** I would like to speak briefly today about the Federal role in the development of geopressured geothermal resources or at least the part of the federal role with which I am familiar.

The federal energy responsibility includes many agencies in addition to ERDA, which is a new agency. ERDA was formed in January of this year, and it includes parts of the Atomic Energy Commission, the Department of the Interior, and a small part of the National Science Foundation.

ERDA has the lead-agency responsibility for geothermal research and development and will, indeed, be conducting and sponsoring a great deal of this work.

Other agencies involved are the National Science Foundation, which is primarily now concerned with the environmental, legal, and institutional problems, which are not insignificant, as we've learned, and the United States Geological Survey, which has a basic national responsibility for exploration and assessment of the national geothermal resource.

The objective of the national geothermal plan is to identify and surmount barriers to the economically and environmentally sound private development of our geothermal-energy resources. The geopressured resource appears to be one of those.

Before ERDA came into existence, the federal government role was even more divided than it is now. You have heard, at this session, papers by Palmer House from the Lawrence Livermore Laboratory, by Mr. Hornburg from DSS Engineers, and from Dr. Bebout on some reservoir-assessment work that has been done in the southern part of Texas. All of these projects were funded by the Lawrence Livermore Laboratory before ERDA was formed. There were some other efforts getting under way in the National Science Foundation at the time ERDA was formed that have been carried forward into the ERDA program. These include the sponsorship of this conference. I think considerable further developmental work on a, hopefully, accurate three-dimensional model of the onshore geopressured geothermal resource in Texas and Louisiana by the Center for Energy Studies and the Bureau of Economic Geology here and by a group headed up by Murray Hawkins at Louisiana State University who are going to be working quite closely together.

This is a big project. They are going to be looking at formations that haven't been looked at yet in areas of Texas and Louisiana and at the coastal plains that haven't been looked at yet. We are hoping that this is going to be a part of a reservoir assessment that ultimately will enable us to make a reliable determination of how much of a resource we really have here.

We are funding some additional work aimed at determining the quality of the resource as opposed to its quantity. One of these contracts is with Southwest Research Institute, which is going to analyze production history from gas fields that are adjacent to the geopressured aquifers to find out whether they can learn anything about the character of these aquifers from those data. A recent contract was awarded to McNeese State University at Lake Charles, Louisiana, to find and perform some tests in a well that penetrates geopressured aquifers.

I have been talking, during this conference, with a number of other companies and individuals who are interested in cooperating with the government in trying to find out what these aquifers are like. Many of the technical questions have been well discussed here—questions of salinity, gas content, temperature, porosity and permeability of the reservoir, and ultimately, whether silica deposition is going to be a problem, and so forth.

We have also begun a phase zero study here at the University of Texas at Austin, which is the first step in looking down the road at the question of whether there should be pilot plants and test facilities, perhaps, under federal sponsorship in order to provide shakedown experience and experience in

managing the reservoir and the place to test various systems and components that may be associated with the production of energy from geopressured geothermal resources.

In addition, ERDA is sponsoring other work not specifically related to the geopressured resource, but which could have a profound influence upon its development, ultimately.

We are looking at virgin technology at Lawrence Livermore, where they are looking at various types of total-flow systems. They have a very nice, new test facility at which they can test machines up to 100-kilowatt size under laboratory conditions. We hope that in the not too distant future, that there will be opportunities for them to bring machines like this down to the Gulf Coast and test them on actual geopressured production.

We are also sponsoring work in drilling technology, hoping to cut the cost of drilling wells and to make it possible to drill them deeper, faster and cheaper and in the formations that are so warm that today's technology has problems with the temperature. We are also sponsoring some work on heat exchangers that might very well be related to conversion technology.

There are a couple other parts of the program that I want to tell you about, too. One of them is an information-dissemination portion that will be handled by the Division of Geothermal Energy in ERDA. We hope to utilize the resources of the Technical Information Center at Oak Ridge, and already Oak Ridge has compiled a first cut in the geothermal technical bibliography.

This is available for sale from the Technical Information Center in Oak Ridge. It's my understanding that they have some thoughts about updating this periodically, much in the manner of the Nuclear Science Abstracts with which some of you, at least, may be familiar.

We also, under Congressional mandate, are working with the concept of a loan-guaranteed program under which the Federal government would guarantee private loans involving the development of geothermal-energy resources.

Now, the rules haven't been written, and Congress hasn't given the final authorization, but the groundwork is being done right now, and I will be happy to talk with anyone about that after the meeting if he is interested in knowing more about it.

The overall national geothermal plan and what it says about geopressured geothermal resources has not quite been completed. It's undergoing the last of many analyses in the highest levels of the administration right now and will be presented as part of the National Energy Research and Development Program to the Congress by the President on June 30, 1975.

I think that is about the end of my remarks. During the question period, I will be happy to respond to any queries you may have.

**Woodson** Thank you. Our next panelist is Mr. Fred C. Repper, who is vice-president of the Central Power and Light Company in Corpus Christi, Texas, and I might add, one of our early industrial supporters in this activity.

**Repper**
**Central Power and Light Co.**

Thank you, Herb. You know, I feel very much like Mr. Bel, being a non-technical person. I have found it singularly invigorating to rub shoulders with so many Doctor's degrees.

Perhaps I didn't get quite as much rubbed off on me as you did. If I get 5 percent, I'll be happy. To me, it's been a tremendous conference, one that I have personally received a lot of.

I have been inspired by the degree of participation and interest by everyone in attendance as well as those who have presented papers. I have been particularly inspired by the brain trust that is being developed so well to go into this.

I think Mr. Bel, it's particularly interesting, from your viewpoint as well as mine, that we're doing something somewhat unique and somewhat original for the first time. We are seeing a wholehearted attempt and a very forward-looking effort by the federal government, ERDA, state governments, institutions like this, and all walks of industries to work together to try to develop a resource for the best interests of the people.

To me, this is one thing that I have gotten out of this conference, is this degree of dedication. To me, Herb, I compliment you and your staff on such a fine display.

I can't help but be somewhat reflective of a utility-company management viewpoint in looking at this, where everyone is talking about producing power—and this is my business and has been for a number of years. We do serve about 300 miles of Gulf Coast lines that will be in the geopressured geothermal area—all the way from Brownsville to Houston. We do have a very definite interest in power production.

I think, as Attorney General Hill stated to this group and as Commissioner Armstrong stated, there is a far more decided interest, and this is in the total energy that we might get out of the system and its meaning to society and what this will do, not only for South Texas, but for all of Texas.

I do feel it very much myself and as Dr. Barnea says, perhaps we are too limited in our scope here of just Texas and Louisiana, that it is really reflecting to the rest of the nation.

I have to equate a somewhat similar experience to you as we developed the nuclear industry in the United States. There were many meetings just like this. Trying to look back and reflect on these meetings, I was visiting with the head of our nuclear engineering department and he made the statement, "You know, the problems that we have been able to possibly foresee are not nearly the problems we had in the nuclear business." They seem very small in comparison and we ought to be able to overcome these problems with a high degree of success. I'm also encouraged to think that, if the people can find solutions as easily as you have found questions, then I am going to be very much impressed with your abilities.

I think I might add in closing, a somewhat personal note on my feeling about this conference and the interest and the personal enthusiasm we have displayed. We became involved—my company along with the other utility companies in Texas—in fusion research some 15 years ago. Well, as you know, no one knows how to accomplish fusion yet. Someone said, "Well, what has it done in that 15 years?" Well, I heard some wit made the comment that it's kept a lot of physicists off the street. Well, I certainly hope, Herb, that we're not laying out a scheme to keep the geologists off the street here, but I feel that we do have a resource that there is enough information on and that you do have the technology to go get.

You have it now, and you know how to do it. You have not only the geological information to know how to do it, you have the technological information to drill the wells, and I'm certain and confident that when we get that resource to the surface and you analyze it as you so well described, that we will be able to have the engineering talent, the biological talent, the conservation talent to make the best use of that resource, and it will be something that will be in the best public interest.

I would like to tell you personally of the utility industry and of our own particular interest, and I certainly want you to, perhaps, equate these interests with yours. I'll do this with a South Texas story.

Commissioner Armstrong was telling you some stories about mules. Mine is about a chicken and a pig. They were walking down the street one day, and the chicken said to the pig, "You know, I'm getting hungry. Why don't we stop and have breakfast?" So he said, "Well, that's a fine idea. Next time we see a cafe, let's stop." And they did, and they saw a sign that said, "Ham and eggs." The chicken said, "Say, here's a place that has some breakfast. Let's stop." And the pig said, "Nothing doing. For you, that's just a contribution. For me, that's a total committment."

Well, I feel we enter into this very much like the chicken, and we will just make a contribution to the development. All of us are going to lay our eggs.

I want to tell you that, from my point of view, I'm interested in total commitment so that we can see this job done.

(Applause.)

**Woodson** Thank you. Don't let him kid you. He is an outstanding engineer. Out next speaker on the panel is Dr. Hans Suter who is self-employed as an environmental consultant in Corpus Christi, Texas. He currently writes an environmental column for the Corpus Christi Caller Times.

**Suter** Thank you. I can't resist making the comment, "Dear persons." I am here totally unconnected. Whatever I say, I am the only one responsible for it and that feels great. I don't represent a company or an organization. I don't know how I got on here. The point I'm speaking from is as a person of the public with some thoughts that I had while listening.

I heard something about geothermal energy and I was very enthused. Early in the conversation and the presentations of the papers, the remark was made, I believe by Dr. Dorfman, that if you don't find methane, it isn't worth extracting the fluid.

Well, I have a little industrial background to know a little bit about economics. I made the remark to my wife, "If the hinge is on that, it doesn't fly." Because it is so low, it seems to me, that if it depends just on penny-pinching, you don't go. You have to have a little bit bigger goal.

I mention that for another reason. Also, the remark was made, "Is it worthwhile extracting the geothermal energy—or the water—just for getting the methane?" Dr. Wilson made the comment that he is not at liberty to quote where the break-even point is, but it was obvious that it is between $2 and $5 per 1,000 cubic feet of methane.

Hopefully, we have a little bit more foresight than was demonstrated by the oil industry some 30 years ago. It's nearly today that I came to the United States 28 years ago.

I came up the Mississippi at 2:00 a.m. and it was lit up; all the gas was flaring. Well, we have learned that the gas is just as valuable a resource as the oil—or more valuable today.

I think the same idea should apply to the energy—both mechanical and heat energy—which is contained in the geothermal resource. I don't believe we should waste the heat and the potential energy just to get the methane.

I believe that industry today cannot operate with the same rules as they operated with 20 years ago. We are much poorer today than we were then. Our resources have diminished although the total usage is still the same. I believe

that today we have to look at a resource quite differently than when we looked at the same resource 20 years ago.

I for one am very, very pleased that geothermal was not contemplated for production say 20 years ago. Now I'm going to clarify why. Several speakers took some cracks at the Feds.

You the know the Feds are fair game. I believe that in the federal government, the federal bureaucracy, one act—the National Environmental Protection Act—the greatest thing that was done was this environmental impact statement because that, for the first time, gave the little man in the street, such as me, an equal standing with a big fellow from industry.

Argue that if you can. Read the statute and read the report, and argue with the people because economics doesn't play a role. What you protect is the environment.

We are still in the state of confrontation, which I regret because it is silly to meet in confrontation. We are protecting the same thing; we are protecting one environment.

I think one thing the space program has shown is that there is no other place for the human race to go, and as long as we have to live together, why not make the place as livable as possible.

Also, another thought is, with today's preoccupation of the public with the energy shortage, we don't have an energy shortage, really; we have a shortage of cheap energy. We have had unbelievably cheap energy. As is quite obvious from my accent, I'm not a native American. I was born in Brazil and raised in Switzerland, so I have two backgrounds. Both these peoples have a life-style which is totally different from ours. Yes, for the last 20 years, we have been on an energy binge and it's hard to readjust.

As I look through the room, I believe the average age here is about 45. The majority are males. Statistics say that at least 25 percent of the male population past the age of 40 have had some cardiac trouble. Why now, do I mention this? I like to equate the energy crisis with cardiac trouble. We have had a little warning. My physician friends also tell me those who have had this cardiac warning live longer than those who haven't had it; we have had a little bit of lead time.

I think that's good because we cannot afford to waste resources as we have done in the past. I think this is the key to living together.

There is another comment I would like to make. The English language has a very great peculiarity. It spells *I* with a capital. I would like to abolish that, and I would like to spell *We* with a capital. Thank you.

(Applause)

**Woodson** Thank you, Dr. Suter. I am going to start out the discussion part of this by asking the panelists if any of them have any further comments they would like to make before I open up to questions and comments from the floor. Do any of the panelists feel compelled to say anything else?

**Barnea** This is the report I wanted to show you.

**Woodson** Dr. Barnea's report that he wanted to show is entitled *Multipurpose Offshore Industrial Port Islands: Process Description and Adaptation Study.* This is available how?

**Barnea** This is a study published by the National Science Foundation.

**Woodson** If anyone was interested, how would they get a copy?

**Barnea** I don't know.
(Laughter)

**Woodson** That's very useful.
(Laughter)
This is a report prepared for NSF-RAND by Gilbert Associates, Inc., and it also has on the bottom of it, College of Marine Studies, University of Delaware. But it is prepared by Gilbert and Associates, Inc., P.O. Box 1498, Reading, Pennsylvania, 19603. I would imagine you can get it from there.

**Barnea** May I add one point. The study was done by the Industry Economics Research Division, Texas Engineering Experiment Station, Texas University.

**Woodson** Oh, no. That's Texas A&M.
(Laughter)
I'm going to have to get Dr. Barnea aside and explain that to him.
(Laughter)
All right. Why don't I open the floor for discussion. If you have any questions to ask the panelists, fine. Several people, I believe, are prepared to make statements of their own. I would like to save those for a little while unitl people have had a chance to question the panel. Also, when you do it, I would like to put some time constraints on it.
Let me open the floor to any questions or discussions based on what the panelists have said. Are there any questions?

**Hartman**
**Shell Oil Company** Dr. Lombard, you mentioned you were sponsoring some research on drilling technology. Would you care to amplify that a little bit, please?

**Lombard** Yes, there are some groups under contract to ERDA that are looking at the possibility of bit changes downhole to avoid long trips. There are some groups that are working on temperature-resistant bits. There are some groups that are working on drilling-control systems, perhaps along a similar line to the one that we heard about the other day, and I have forgotten, for the moment, who talked about it.
We also are sponsoring some research into some innovative ideas for approaches to drilling, including the Los Alamos rock-melting bit approach, and there is a project that (I think it is the University of Missouri) is looking at jet drilling, recavitation. Does this answer your question?

**Hartman** Who is doing some of this research, if there is some?

**Lombard** If you will call our office, I will put you in touch with the person who is in charge of this kind of research, and I'm sure he will be happy to check with.

**Trinko**
**Middle South Services** Just thinking back over the papers, I recall that there has been mention of 9-inch diameter wells going down, maybe, 16,000 feet. I just wanted to ask the expert if that is proven technology.

**Wolke**
**Dresser Industries, Inc.** We have drilled six in Freeport, holes down to 31,000 feet. As far as getting down there, once you know what your abnormal pressure controls are, there is no particular problem.

**Woodson** Does the 9-inch give you any particular problem?

**Wolke** No, 8¾ inches was the size at that depth.

**Dorfman** I would just add, it's possible. Whether it is optimum, that's something else again. As this gentleman just said, most of the holes that are drilled are smaller than this. The greater reduction in the hole size means a greater reduction in cost.

I think as we get into this investigation, this is one of the things we are going to be looking at. Whether we should go, perhaps, with more than one hole of a small size. This could have several potential benefits; in keeping a full stream of fluid on line all the time because tubines have to run all the time.

It may be advantageous to directionally drill slim holes and set small-size casings in them rather than drill one large hole. These are things for the future, things we are just getting into right now.

**Woodson** Any other questions?

**Wolf**
**John H. Wolf Associates, Inc.** I notice in the papers you had a thermal efficiency for electrical generation from 4.7 percent to some figure upward of 10 percent. Am I wrong in assuming that it is this range that is roughly looked for from geothermal power?

**Woodson** Would any one of the panelists like to have a try at that?

**Lombard** I'll make a comment on it without answering it. When you ask a question about efficiency, you kind of have to first identify which efficiency you are talking about.

There is an efficiency that is calculated from basic thermodynamic considerations that has a very low value when you are talking about making energy from low-temperature sources where you have a fairly narrow temperature range between your input temperature and your output temperature.

That, under the circumstances, represents the maximum amount of heat that you could extract from the fluid under these thermodynamic conditions. There isn't any way around it, and some of the number associated with that, as I say, are low when the temperature range is small.

Some people talk about high efficiencies. They are very often speaking of what fraction of that maximum, theoretical power extraction a particular machine or system will give them because no machine or system is perfect.

If you're worried about these low efficiency numbers, these 4 to 10 percent numbers, I think you may find that there is a basic thermodynamic limitation which makes the numbers so small.

**Wolf** Well, what's the total loss from the bottom-hole Btu content to kilowatt hours output?

**Woodson** If I can just make a comment here, If you simply look at the Carnot efficiency of a cycle operating from a 300°F source and exhausting heat at, let's say, a 100°F source, which is a good number to look at, this gives you a Carnot efficiency of something less than 12 percent.

Then you add the inefficiency of the conversion equipment on top of that, and it's back to a little bit less than 10 percent, and that's it for each Btu you pull out of the ground. You have to dump nine-tenths of that out into your cooling

water or however else you reject the heat, and that's a simple law of thermodynamics that even Congress cannot repeal.

**Barnea** Mr. Chairman, you are quite right. We can generalize it and say that the most inefficient usage of geothermal resources is for electricity generation.

I have therefore been pushing for many years for the nonelectric use of geothermal resources from refrigeration to air conditioning to agricultural and industrial processing to desalination, and so on. We had a very good paper on the use of geothermal hot water in sugar and paper processing. In all those applications, compared to the 16 percent in the Geysers field, we can reach 60 to 80 percent. Therefore, I think, when we study geothermal resources, including geopressured resources, we should not forget the great attractiveness of the nonelectric applications of our heat resources.

**Woodson** I just realized that I made a mistake in my calculation. The Carnot efficiency is more like 20 percent rather than 10.

**House**
**Lawrence Livermore Laboratory**

While the laws of thermodynamics put a rather severe limitation on the utilization of energy from the thermal source, there is quite a bit more flexibility in the mechanical or hydraulic energy aspect.

It's possible to have turbine efficiencies perhaps as high as 90 percent in the utilization of that energy available at the wellhead. In addition, in my calculations at the high flow rates, a lot of energy is lost due to high friction in the well bore on the way from the reservoir to the wellhead, and this is a case where the larger diameter of pipes will be very helpful for reducing that pipe friction because the pressure drop is a very strong function of the casing diameter.

We also have the option of operating at, perhaps, lower flow rates, and since the pressure drop is a function of the square of the flow rate, that also is an option that allows you to get a higher utilization of the mechanical energy per pound of reservoir fluid.

**Woodson** May I ask a question? In your paper, you have pretty much ignored the hydraulic energy that you could get out of this because it appeared to be small compared to the other forms.

**House** No, I think that was the case with the Dow report. I plotted the hydraulic power as well and tried to maximize the power output.

**Woodson** And it was a significant fraction of the total energy output?

**House** If you operate at maximum power, it turned out to be nearly 50 percent of the available energy.

**Woodson** I'm sorry. Thank you. Are there any other comments?

**Krutein**
**Global Marine Development, Inc.**

I think this conference was a marvelous cross-pollination between different groups of contributing members from industry or agencies and people which came from a different field.

And not only during the meeting hours but also outside, I have the feeling of getting ignited on several areas, where I see development in the future.

Could I ask the panelists if we would have such a meeting again periodically, in a year or half a year, or are there some areas which have been neglected and should be emphasized a little bit more in the next meeting?

**Lombard** There most likely will be another geopressured geothermal workshop in connection with the completion of the phase zero study approximatley 6 months from now.

This has been such a valuable meeting that I would hope that this kind of meeting could be held at some suitable intervals in future years. I would hope that the intervals would be long enough so that people would have an opportunity to get some work done between meetings.

**Repper** I would certainly hope that we not only have the opportunity, but we make sure that we have the opportunity to come back and reflect upon where we have been and what we have found out.

I can visualize that resource assessment will certainly have maps and have a more concrete and descriptive analysis of all the geopressured zones, all the way from Louisiana through Texas. I can visualize that the technology of the drilling and this type of thing, the questions of the 9-inch or the 6¾-inch and so forth, will be better defined.

I can visualize that in the institutional and environmental areas, we will not be in the embryo stage. I really sort of visualize this whole thing, where we are now, very much as being in what you might call the gleam in the mother's eye stage. We haven't yet even had the development of the embryo. Perhaps we are nothing more than the sperm that is beginning the fertilization and here, very shortly, we will begin to have the growth of the embryo.

The birth is still a long way off and it's when we have the birth that we will be able to come back and really talk again and in more definitive terms.

You know, we are only limited by the limits of our imagination. Certainly, I hope we have not imagined what could be to the full limits yet. I have to tell you how I visualize the questions on efficiencies that were being asked a while ago.

We talked about efficiencies in our business, the efficiency of generation, the efficiency of transportation, the efficiency of all things.

Of cource, as a manager of a utility looking at the overall viewpoint and trying to bring the legal, institutional, environmental and the whole works together, I am interested in the total output of what we have.

I certainly agree with Dr. Suter when he says, "Let's think of the total thing, let's don't waste anything in the process." I don't think we have to. I think this is one of the great opportunities not to waste anything in the process. Then, if you do that, you will be surprised at what your efficiency will come up to. You will be talking about extremely high efficiencies where you are not only using just the heat resource, but you are using the water resource, the methane resource, the total resources that are there.

I certainly hope, Dr. Lombard, that we do come back. We do have to get the work done, right, but I certainly do feel that we need to get back and have the best input of all of us.

**Woodson** Thank you. Is there anybody else on the panel that would like to comment?

**Bel** Only some mention was made about—talking again about using the whole resource—about seafood production. I know I have talked to Wildlife and Fisheries in Louisiana and they are very enthused about getting the effluent to control salinity.

We have the Mississippi River at flood stage frequently and then they open the spillway just north of New Orleans, which empties into Lake Pontchartrain and Lake Borgne. Lake Borgne is a breeding ground for oysters, the famous Louisiana oyster. At first, we thought it was a bad thing to open the spillway.

Then we found that it kills the oyster drill, which had very low tolerance to fresh water. Then they left it open a little too long and the oysters started to die. If we had use of the effluent in that general area, we could introduce some salt content and maintain the oysters.

Now, the oysters are bigger and better and more productive then ever. One other comment for the oil and gas people: If nothing else happens, if we don't achieve anything else, I just hope that we learn better drilling methods and come up with improved blowout preventers and more substantial equipment, because I think that one reason we haven't been drilling off the East Coast is because of the few accidents that we've had off the Gulf Coast and the West Coast that have been blown completely out of proportion compared to the benefits we've received.

If we can, by taking a new look, a second look, at our production equipment, maybe we will sort of get out of this energy crisis sort of indirectly and prove to the people on the East Coast that we can do it and do it totally effectively.

**Woodson** Are there any other comments from any other panelists?

**Repper** I do have one other comment. Mr. Bel, I agree with you on the possibility of the effluent. In water-short areas, although we have different problems, this can be, perhaps, even a central use of the resource. It can free up other waters that are more fresh for municipal use and this type of thing.

The seafood is a tremendous economy in the Gulf area, so by increasing production, we could be doing some double duty there.

All of us are a part of the energy business, as you well know. We do not have a national direction in energy. We are all searching for the direction in energy. One of the things that is disturbing to me right now is, as we are going from a resource that we have been using for power generation in Texas and Louisiana, natural gas, and we are looking to other resources, the only other really viable resource is not oil, but it is coal or nuclear. Coal, and you are talking about transporting that coal some 1,600 to 2,000 miles into Texas, and the net energetics really comes into question. This could very well be true, and one of the things we need to study in geothermal is the net energetic. By using the whole resource, we are certainly going to develop a greater net energetic.

**Bel** We may find that this water also is easier to separate from the salt than our surface water from the cost-of-energy standpoint.

**Trinko** Mr. Bel's comments just sparked this question. I recall that last year at this conference, the oil companies were particularly conspicuous by their absence.

I recall John Wilson of Dow Chemical indicated that at that time, if we went flat out in developing geothermal resources, that in about 5 years, we could know as much about geothermal resources in this area as the oil companies knew about it 5 years earlier.

Well, I see that it is not on this schedule here, and I would just be awfully interested to know what the oil companies are doing, what their attitudes are and why they are not carrying the ball in this area.

**Woodson** Well, that's certainly an unloaded little question (Laughter) Does anybody from an oil company want to tell us when you quit beating your wife?

**Stefanides**
**Union Oil Company of California** I will use this as an excuse to have access to the microphone. What really has been on my mind here, and, in part, answers the question, was the statement made earlier by Dr. Barnea that I would like to correct.

I think, perhaps, it's necessary for some of the audience to correct that statement which was, in effect, that all the pioneering work is done by the government.

I would like to point out that the only geothermal field in this country and the largest in the world is The Geysers geothermal field, north of San Francisco.

This was developed entirely by private capital, and you might say, in spite of the government.

(Applause)

Secondly, if my information is correct, I believe the Shell Oil Company has, in fact, some patents for the use of geopressured energy in some manner or other, which undoubtedly have resulted from research work that they have done.

The Union Oil Company, in the late 1960s, seriously considered a small oil-shale project in Colorado, but unlike the Canadian government, who provided a market and a price on a project in the Tar Sands, the lack of policy by our federal government and the Department of the Interior obviated our going into such a project at that time.

Now, we are a little sensitive—we admit this—to such accusations because in the recent Arab oil embargo, there were some people who criticized the industry for not having looked at other energy sources.

I might say when The Geysers field was developed, it, in fact, was not even economically competitive with alternate sources of energy, primarily gas.

Yet, it was done. If you have noticed the ads on television lately, you should be aware that there are other oil companies who are very actively engaged in development of other energy sources, such as nuclear, solar, and so on.

Now, besides correcting the record, I want to emphasize to you that the industry is economically and technically prepared to make a great contribution to mitigate this energy problem.

It is a very serious problem. During the year 1975, the U.S. will spend approximately $25 billion for imported oil, and that's at $11 per barrel. Now, the Arabs are talking about possibly $15 per barrel as a price which will increase the drawdown on our dollar supply substantially, which is a burden that our economy cannot well tolerate.

Recently, there was a meeting by some of the representatives of industry and it was in regard to the present state of our economy. Generally, the industry leaders thought that the recession (or whatever you care to call it) had bottomed out and that it was on the way to recovery, but there was one very foreboding warning from a member of the eastern utilities.

He said that in the late seventies, 1979–1985, there is going to be a power shortage that will stagger us. A lot of this is due to environmental delays.

Nevertheless, about the time we would hope our economy would really be recovering and on the way to a good, healthy situation, I think that we might be very adversely affected by that.

Well, in spite of all this—and it should be perfectly clear to all the legislators—there are efforts today in some of the states (thank God not all, but in some of the states) and in Washington to divorce the oil industry from other forms of energy.

Now, it seems to me that people ought to recognize this problem, they ought to recognize the potential that the industry can offer. But we cannot help it if we are not allowed to operate in those fields.

So because of the type of representation we have here today, which is a good cross section, the fact that there are liberated legislators or representatives of these offices here, I should like to make that appeal to you—that the oil industry is, in fact, an energy industry.

We are denied the right to enter other energy fields. We are, in fact, going out of business. In the last 5 years, our company's production in California has declined by roughly a third.

Obviously, this is going to continue to go down. Ultimately, we would therefore in California be out of business. Now, what are we supposed to do, start making sewing machines?

Well, again, I think that you can probably appreciate my point by now. All I'm saying is that the industry has the potential. We think the problem is of such magnitude that it needs to be challenged from all fronts, and certainly the industry is ready to do their part if you'll just let us.

(Applause)

**Woodson** Thank you very much. In case I left the impression, through my impertinence, that we haven't had the cooperation of the oil companies (I assume Myron will say something about this later), we have had very good cooperation from the oil companies in providing data that form the basis for some of our work, and they have been extremely cooperative with us, and we appreciate it.

Without their help, we really would be way back. I assume Myron will say something about that in a few minutes. The oil companies have been very helpful, and I bet they won't let you make sewing machines, either.

(Laughter)

**Barnea** Mr. Chairman, if I might make a correction to a correction. I didn't say that all pioneering in the various types of geothermal resources and technology was done only by governments.

I said by governments and by individuals. I mentioned the name of McCabe and one or two others, and those were the pioneers. Union Oil bought into The Geysers field in 1967 and 1968 because the pioneers did not have the necessary capital resources to develop what ultimately turned out to be a giant field, the biggest geothermal field we have ever discovered.

The pioneering role in The Geysers field belongs to individuals. They started in the 1950s. Union Oil joined in 1967 or 1968.

**Stefanides** If I may correct a correction, the Union Oil Company, of course, entered the geothermal field by way of Pure Oil Company, who went into the geothermal field about 1960.

The Union Oil Company—rather Pure Oil Company—got started very early in the leasing of The Geysers areas. We, in fact, merged—or made a joint operating agreement in 1967 with Magma and Thermal in order to continue development.

We were in there substantially ahead of that time. We would be the very first to credit Mr. McCabe with the very great step forward in geothermal development in this country.

**Woodson** Thank you. Let me turn the microphone over to Professor Dorfman, who would like to make a comment.

**Dorfman** As program chairman, I stayed away from some of the most controversial things. I figured I would let them get it out of their system before I came up here. I would also like to comment on the role of the oil companies. We first got into the geothermal business, really, because of Union Oil in California.

I was invited to go out there and was asked to write something about 3 years ago. Union provided me the access to all of the geothermal areas, both in the

Salton Sea and The Geysers. This had to do with drilling technology. We went on from there. Since we have been involved in the Gulf Coast research, we have received a great deal of heretofore proprietary information from many oil companies.

We have representatives of management of several companies serving on our geothermal board of advisors, who are monitoring our overall project. I am an oil man myself, and I can appreciate the problems of the oil industry.

One thing that I want to address myself to is a comment I made the other day that may have been inadvertantly taken amiss. I intended to say that it appeared that geopressured geothermal might not be economically feasible without the inclusion of methane gas. After listening to Palmer House, I am gratified to hear that it may be viable even without the methane. I think the point is, that before the embargo there was no way you could consider geopressured geothermal as a viable source of energy. The cost figures simply just wouldn't make it. Today, it looks like we're at a point where we can, and this, I think, is why some of the oil companies who originally did some of this work (and this is simply my own opinion) probably kept a low profile in this field. We are now in a position to work with them and with our colleagues at Louisiana State University and other research groups. We look forward to working with them.

I was also gratified to hear the comment about the macroscopic nature of this conference. I like to mix disciplines up. I happen to be a geologist and a petroleum engineer. The geologists think I'm an engineer, and vice versa. We have gotten a great deal, I think, out of the cross-pollination that has resulted from this conference.

One thing that comes to my mind that we should do is this. After hearing the legal problems today, I think it might be a very good idea for the States of Texas and Louisiana and their elected representatives and their governmental agencies that are in charge of these matters, to get together and form a compact and work out the definition of the resource and the manner in which it can be handled by at least these two states so that we may proceed rapidly with exploration and development. I can't think of anything that would help to get this off the ground quicker than some sort of joint legal work between the States of Texas and Louisiana.

We have heard a lot of problems discussed; probably more problems than any of us knew existed. I happen to think some of these things are overdone. I have heard a lot of comments on methane content. I have heard nothing that would indicate that there is no methane content. Most of the comments that have been made have indicated that we would probably have a saturation of methane in most of our sands; certainly some of the early work that has been done would indicate so.

So far as the productivity of the reservoir rocks are concerned, I am very skeptical of any comments that might be made that would indicate that over 800 miles of shoreline and the zones lying beneath them, covering some eight different formations, laid down by a variety of depositional processes, might have uniformly poor porosity and permeability. All I can say is that I have been in oil and gas exploration for a long time. I heard those same comments and I went in behind a lot of people (who didn't think the reservoirs were any good) and found a lot of good production. I like to have a pessimistic type like that as my opposite number in an exploration program. I think we've seen enough already to indicate that there are some sizable reservoirs that are going to be of good quality, and we hope to identify more.

The ranges of temperature that we're talking about, I think, are there. The figures we've been using are very conservative, uncorrected temperatures, so I'll let it go at that for the time being, and we'll talk about it more a little later.

**Woodson** It seems that we are going to soon be picking a site and drilling a test well, and we're going to be looking at geothermal, and, if we happen to strike oil, do we declare it a failure and plug it?

(Laughter)

**Barnea** I would declare it a by-product.

**Repper** I would like to respond to the question about the oil companies from the electric-industry point of view. As I visualize geothermal, the electric-utility industry (or at least my company, which I'm speaking for) is ill-equipped to drill wells.

One thing we know how to do is to make electricity, so I would anticipate that, if this is a proven resource, an oil company or someone who is knowledgeable in that area would do the drilling of the wells, the development of the resource, and would sell the resource to us, or that portion of the resource that we would use in making electricity. They, in turn, would probably want to have their own other outlets for the utilization of the other resources that were present.

I just wanted to make it clear that I feel it's essential that the oil companies be a part of the team because they are going to be the ones that I need to buy the product from.

**Woodson** Thank you, Fred. I think it is also clear that if this resource really does prove to be economical, the level of activity necessary to develop it can only be provided by industry. You know, drilling one well is one thing but drilling thousands of wells is something that only industry can do.

**Keller**
**Keller Industries** I would like to say a few words if you've run out of questions.

**Woodson** You may say a few words.

**Keller** I won't use the word *I* any more than necessary after the very appropriate comment a while ago. That brought something home very clearly. I'm often criticized for using the word *we* when I am the only guy around. People say, "Who on earth is *we*?" I'll make that clear in the very beginning.

*We,* when I use the term, means myself and the 36 or 38 stockholders of our company, without whom I could accomplish absolutely nothing in any way whatsoever.

With all due respect to the oil companies, I would like to say that I don't think Dr. Barnea meant his comment to be super critical or perhaps even critical.

I think what he is trying to do is to point out that the answer is not always there in the major corporation or even in the federal governments.

If you will go look up some statistics, you will find that most of the useful technology in the world has been attributed to individuals. By a very wide margin, most of the technology in use today has come from individuals.

This is the reason we have kept our company small, because we are looking at this thing statistically. The larger we grow, the less apt we are to do something useful—speaking strictly from the standpoint of statistics. I'm not sure that guarantees success for a small company.

What I wanted to address is the exciting potential for everybody concerned—and certainly the oil industry is undoubtedly going to be the base industry for geothermal, both geopressurized and conventional steam, including of course, the hot water geothermal, which has not, perhaps, received appropriate attention up to this point. The thing I want to talk about is the potential

for new developments and technology. I'm talking about the kind of technology that gives you a new tool for the engineer and scientist to use, which they didn't have before and which frees his mind from convention so that he can create and do new things.

Geopressured fluid is a most excellent topic for this sort of discussion, I think, the reason being that here is a fluid that is a mixture of liquid and gas in solution or gas that is liquified by virtue of the high pressure. It presents a total, big, different set of mechanical and thermodynamic problems than those which we have worked with before. It is really exciting to contemplate what we can do with it in view of some of the recent technological advances in mechanical equipment.

Imagine, if you will, what you could do with geopressurized fluid if you had a machine that could, first of all, recover the bulk of the hydraulic energy in lowering the liquid pressure from 5,000 lb to atmospheric or below and during the process of doing this could also recover the expansion energy of the steam (which is going to also spontaneously generate during the lowering of pressure) and also the available enthalpy from the gas (which is going to begin to come out of solution and return to the gaseous form,) which, in essence, is boiling or generating vapor.

Now, if you sum all these together and you look at the data from wells, which we can thank an oil company for (we indirectly received data that was generated by Shell Oil Company), the data we were given indicates that a single well should be able to generate 10 megawatts of power.

Now, I said if you had a machine that could do this—and we can remove that *if* now. The machine has been developed. It's covered by three issued U.S. patents, and we think, whithin the next 6 months it will be on the market in, at least, limited production for those of you who want to experiment with it.

It is a new mechanical concept. We have found no prior art in any of the countries in the world where we have filed patents, and it's quite an unusual machine in that, based on displacement capacity per revolution, it has three to five times the horsepower capability and the volumetric-displacement capacity of any turbine that has ever been built.

It is a positive-displacement device. It can accept a superpressurized hot liquid and generate power and exhaust the steam if that liquid is water.

I wanted to appear here, I hope, as an optimist and to try to create some curiosity in the minds of you people who are scientists and engineers.

I'm sure, in view of the comments made by Union Oil Company, that now that this amazing news has been revealed that we will be literally swamped with petroleum companies who want to help develop geothermal energy.

If we are, I can assure you that it's going to get developed pretty quickly. Now, we will leave the resource evaluation and management to someone else.

We think it's in very capable hands. We are going to be standing there ready with the machinery to turn it into kilowatt hours once it's been established. Thank you very much.

**Woodson** Thank you, Mr. Keller. Are there any other comments or questions?

**Tenney**
**City Public Service** We have been speaking about geothermal energy being in the research-and-development phase, but I had a question concerning R&D funding. Particularly, what is the level of federal R&D efforts, and how does this federal effort compare with the effort we may expect will be required to develop geothermal resources?

**Lombard** Do any of you panel members want to comment on that?
(Laughter)

The administration, in its budget to the Congress, in January, requested initially about $28 million for fiscal 1976 for geothermal-energy research and development in ERDA.

The Congress and the administration have been having conversations with each other since then. The administration has been engaged, since the formation of ERDA, in the development of the national energy plan.

This includes a national geothermal research-and-development plan. There are going to be some dollar signs associated with that. I suspect—I can't prove it at the moment—but they may be a little bit higher than the original request, and the information as to what the administration's position is will become clear on June 30, when the President presents this plan to the Congress.

The plan has been very thoroughly generated. We have had a lot of industrial input including representatives from some oil companies, by the way, who participated with us, a great deal of consultant time and professional input from many disciplines in coming up with this plan.

We are convinced that it's going to be a good one and that it will do the job. It's undergoing final review at the highest levels of government right now, and in less than a month, you will know everything you want to know. I can't give you any better answer than that at the moment.

**Woodson** Now, may I ask a question, Dave? This is a program that is presented to the Congress by the administration, and it's up to the Congress to either accept that program, modify it, or whatever, but that simply is a proposal from the administration for what Congress ought to provide for ERDA for their long-range program?

**Lombard** Congress will certainly play a major role in the final determination of how much money is available for geothermal energy research and development in the next few years. I think that's quite clear.

**Power**
**University of Texas at Austin**

Just to go back a few years to get some idea of the growth of this present problem, I would like to refer to a paper by Dr. W. T. Tum of Princeton University dated 1945, a very enlightening paper, I would say, on this question.

The paper was concerned with national and regional work potentials, a paper that covered the energy situation of the "have" and "have-not" nations all over the world.

It was brought up today, and I think it is a good paper to emphasize again. Later, in 1948, Dr. Eugene Ayers of Gulf Research in Pittsburgh presented a paper, *Major Sources of Energy* before the American Petroleum Institute meeting in Chicago.

Now, I have a copy of this 48-page printed paper. At that time, it's surprising how early in our years these serious problems were considered. Then, going to another area, I have received from my very good and personal friend at Woods Hole Oceanographic Institute a paper entitled *The Slow and Steady Surprise.*

It's concerned mostly with continental drift, sea-floor spreading and plate tectonics. I'm prepared to spend a lot of time on this thing, having read the magazine that they put out. I have a copy of it.

I talked with several of you people about the significance of this study of the Woods Hole people in deep sea research, and I have gotten a favorable response from several of you, so I thought I would just briefly tell you what they

said. They discovered that, the earth is controlled by relatively simple laws. This is intellectually satisfying, but does it have any value to mankind in everyday life?

The answer is yes. It provides us with guidelines as to where certain earth processes will happen and where certain earth resources can be found.

The guidelines are still general, but they permit the broad domain of earth science to be narrowed for a beneficial result. Then, I have an article by the same enployee of Woods Hole, *Deep beneath the Sea*, and it's the main one I want to emphasize here. It's by Richard P. Van Aartsen, and its also published in the above-mentioned number of *Oceanus,* which may be of interest.

Just briefly, he goes into showing that the results of research on the ocean bottom may be tied in, as one of our friends here said, with what we have learned about the situation on the Gulf Coast.

Without going in to any detail there, I would just like to recommend this conference to a perusal of this magazine. Thank you.

**Woodson** Any other comments or questions?

**Sellars**
**Louisiana Land and Exploration**

I found out about geopressured potential about 2 weeks ago. My company sort of whirled into it, but anyway, I have noticed through the years that managements tend to think along certain lines.

Those guidelines usually guide them along the pathway to profit in their ventures. I believe that if we can sell coal or uranium or oil to a utility cheaper than we can sell geothermal power, whether it be a geopressured or not, that's what we are going to do first.

I invite a summation from anyone, the panel or the audience, to give us an idea, in summary of where we stand today along that pathway toward profit in geopressured geothermal energy in the capacity of something like 1,000 megawatts, something that would do us substantial good in a metropolitan area.

**Lombard** Well, I'm really an old timer compared to you because I've known of geopressured geothermal energy for 9 months. (Laughter) The question of economics, how much it would cost to produce this kind of power, is dependent on a number of technical and institutional factors. We are just beginning to identify the questions that we have to ask and get answers to before we can put together a meaningful economic analysis.

We are beginning to move toward finding those answers. It may very well be that as a result of this effort that we will determine that geopressured geothermal energy will not be competitive with other energy forms.

At the time when we can make that determination, I think we may just quit and go try to develop other energy sources. On the other hand, it's also possible that we may find that, under some circumstances and with the application of certain technology, it will be possible to produce geopressured geothermal resources economically and competitively, and we would expect in such a situation that the resource indeed would be developed by private interests.

One unique thing about this, and there are a number of them, is that it appears from the work that's been done to date that individual sites will probably not support 1,000 megawatt plants, and that the electric utilities will be faced with a distributed-source problem.

They tell me they have already begun to consider the implications of this, but one thousand 10-megawatt plants makes 10,000 megawatts. If it is developed that way, an economically viable resource, then we have some confidence that it will be developed.

**Woodson** If I might just make a comment on that myself. I think the geopressured geothermal resource is enough of an unknown at the moment that there is not the basis for really evaluating its profitability.

As John Wilson said yesterday, Dow looked at geothermal and chose lignite. I think when a resource is that unknown, we have to collectively assess it.

How we sort of share the burden of assessing it is through government support, through collective support of the research program. I think once it proves itself—if it proves itself—there is no problem. Industry will jump in like crazy.

Since you brought up profits, I can't help but ask you if you know why the Roman Empire collapsed? Because the lions were eating all the prophets.

(Laughter)

**Barnea** I would also like to comment on the question of profitability of geothermal resources in general. I am using the word resources, as you probably noticed, and not geothermal energy.

In geothermal resources, we have a very much broader resource space, and that ultimately is very effective. You can develop geothermal resources not only for energy but for a number of other important commodities, and we can use the energy resources for other purposes and not only for electricity generation.

There is a lot of flexibility in this system, and the various types of geothermal resources have each their own characteristics. In dry- and wet-steam systems, we speak about a geothermal resource with a high longevity. We know today and we have the first experience in the recharge of wet-steam fields, and, therefore, we can introduce all kinds of new factors, which have an effect on the outward longevity and control, and also in certain cases, some environmental problems.

We can expect from geothermal resources water where water is needed, minerals, gases which might be valuable, and so on. There is a wide range of resource components, and, therefore, geothermal resources are very, very old in my opinion and very profitable.

The main problem for geothermal resources was the discovery. To discover geothermal fields is not easy because we have a very limited number of experienced explorationists.

Petroleum geology is not guaranteed to find geothermal fields, as some companies are experiencing. I don't think anyone could doubt the very effective profitability of The Geysers field, though it is only a dry-steam field.

As it appears for this area, to find the resource is no problem, from what I have learned; the existence and location of geopressured zones is known.

I doubt—I do not know—whether the precise constituents are well known. In the technology area, we are at the beginning. Therefore, I don't think we can today put a final judgement on the cost and utilization of geothermal geopressured resources. We simply have neither the experience nor the equipment.

In the paper by Dow Chemical, we heard equipment estimates that were the most conservative and we heard the most expensive and the most costly estimate based largely on the lack of experience.

I believe, at this stage, that it is the role of government, and those individuals who have the courage and resources will be the leaders.

Once the resource technology is known, I believe in the historical context in which we live, that there is no reason to assume that the resources will be uneconomical.

We are living in an area where, over time, we have to assume that both energy costs and water costs will increase in price, and these, as we know so far, are the two most important constituents in geopressured zones.

Therefore, on a long-term basis, it promises to be economically feasible. It might even be very profitable. Until we have much better resource knowledge and a specifically developed and tested technology, it is too early to make any economic judgement.

**Repper** Your comment, from the management of a utility standpoint, is 100 percent correct. You very obviously are going to make the economic decision.

Fortunately, during the past 5 years, and particularly during the past 2 years, we have seen a change where our economic decisions are a function of time.

If we had been attending this conference at this time last year and had predicted that the cost of geothermal energy was going to be around 89 cents per million Btu, we probably, from a utility standpoint, said, "Well, that's too high. There is no way that we could ever use it."

Today, we are paying $1.85 per million Btu, and we know it's going to go higher than that. These are the parameters—the name of the game today. Also, during the past 5 years, management has found that it has less discretion in making a solely economic decision.

More and more of the decisions are reflected in institutional events that are not necessarily based on economics. A case in point, the Railroad Commission of Texas is holding hearings now for the phasing out of natural gas under utility boilers, an institutional decision.

The cost of alternate fuels is obviously going to be higher, so management then will be forced to make a decision that is not based on economics alone.

A social and institutional problem that centers in managements' decisions today is the dependability of supply of the fuel. Sixty percent of oil available for boiler fuel is now coming from imports, and this makes you dependent upon the foreign markets, embargoes, pricing, et cetera, and this makes your dependability of supply a serious question.

In electric production, of course, one of the prime prerequisites is the continuous, steady source of fuel supply that's unhampered by social or political events.

It is extremely difficult to make preliminary economic analysis of geopressure. We are equating it to that that we know now with very little imagination of what might be just 1 year from now. If I visualize the future in anywhere near the direction I think it's going to go—I think the gentlemen from Union Oil Company made the observation that we have serious questions about energy supplies—we are going to need every available fuel source which, then, will tend to make it mandatory, so to speak, that we look at every available option. I think this is the importance that we see in geothermal.

**Wolf** In our study, I discovered one thing that hasn't been mentioned here that could possibly eliminate one of the large cost features in geothermal production.

Being a poor boy, I looked around to try to find out if I had to drill a well. I contacted one of the major oil companies, and a man said, "Well, give me the parameters within which you wish to work."

I gave him parameters of 340° bottom-hole temperature with the geopressure of 8,000 pounds. Putting those parameters into the computer, he ran every nonproducing well that the company had through the computer.

He came up with six wells that fell within those parameters. Some of them were very good. I think that we should look into the leasing of existing wells which are no longer producing or maybe never produced oil or gas.

**Woodson** I hope everybody heard that because I don't want to repeat it all. Who wants to respond to that?

**Keller** If there is no response, I would like to ask a question.

**Woodson** Well, there is going to be a response to it. Myron will respond to it if no one else will.

**Dorfman** Yes, I have several things I want to say about it. First of all, let me say we know there are such wells, too. However, finding an isolated well in a zone like this does not in and of itself ensure that there is sufficient reservoir to make it worthwhile to go back into that well.

We feel that we have to go back and do a great deal of geological work and well-log work to try to define the thickness of the sand, the aerial extent of the sand, as well as these physical parameters, to make a judgement on where we should go in.

I think that the fact that these wells exist is extremely useful. It points up the fact that there are geopressured zones within the right pressure and temperature regions, so that we should look further.

In addition, there are projects underway right now, that Dr. Lombard mentioned, where some research groups, who will be working mostly with us and with the group at LSU, will be going back in some of these wells in an attempt to make a determination of the fluid content, the amount of gas in the waters. Yes, that information is extremely useful, but in and of itself, it is not the total answer.

**Lombard** I did mention before our contract with McNeese State University, and that is just the type of thing that they expect to be doing. We hope that the experience that they obtain in this project will be useful in determining whether existing wells ultimately might present a good opportunity for exploiting the geopressured geothermal resource.

**Dunlap**
**Atlantic Richfield Company**

Just so there is no misunderstanding of the availability of reentry into a hole, an abandoned well—a plugged well—is typically just that, plugged.

It's usually cheaper to redrill a well than go back into a plugged well. Just because there is an abandoned wildcat in a zone, it's good information but it isn't a physical asset. You still have to go back and drill that well.

**Lombard** Well, we are going to be looking for some shut-ins.

**Woodson** Are there any other questions or comments?

**Dorfman** I think everyone has just about reached the saturation point. I would like to say this. I would like to spend just a minute to tell you about our program here at the University of Texas. As Dr. Lombard indicated, we have been given a contract entitled *United States Gulf Coast Geopressured Geothermal Resource Management and Scope of Work Study for Generation of Electrical Power.* In addition to this, we have been given another contract from ERDA for resource assessment in Texas. A similar contract has gone to the Louisiana State University.

It is the intent of the resource-assessment studies to prepare a data base, using well logs on all of the various geopressured zones, so that we can print out any information that we may want to get: temperatures, pressures, salinities, thickness of sands at these different intervals, and whatever. We will coordinate our efforts with the research program going on at LSU. The scope of the work and management study will be structured along the lines of this conference.

It will cover principally four areas: the resource assessment; reservoir research and technology; legal, institutional, and environmental considerations; and surface technology and power systems.

We will also consider the nonelectric utilization of geothermal energy. The various chairmen of these sessions will be the principal investigators for each of these units. In addition to the work going on at the University of Texas, we also have subcontractual arrangements with an architectural engineering firm, a utility, and a large industrial company, plus access to a great deal of data from energy companies and the active participation on an informal basis of many other companies. It is our hope to coordinate our efforts with many other groups: private companies, research groups, and other universities, so that as a goal we might attempt to develop this resource and establish it's viability in the shortest possible time and, hopefully, at the lowest possible cost.

That sounds very idealistic, but, frankly, I think we are on our way. The fact that this first geopressured geothermal conference could attract 200 representatives from such diverse groups as we have seen here, I think, is an indication of the interest that there is in this subject.

I want to thank all of you for coming here. I hope you have enjoyed the conference. I know I have. I want to thank the authors of papers that I've not had a chance to contact individually.

I think we have had some outstanding papers during this conference. Thank you very much.

**Woodson** We stand adjourned. Thank you for coming.