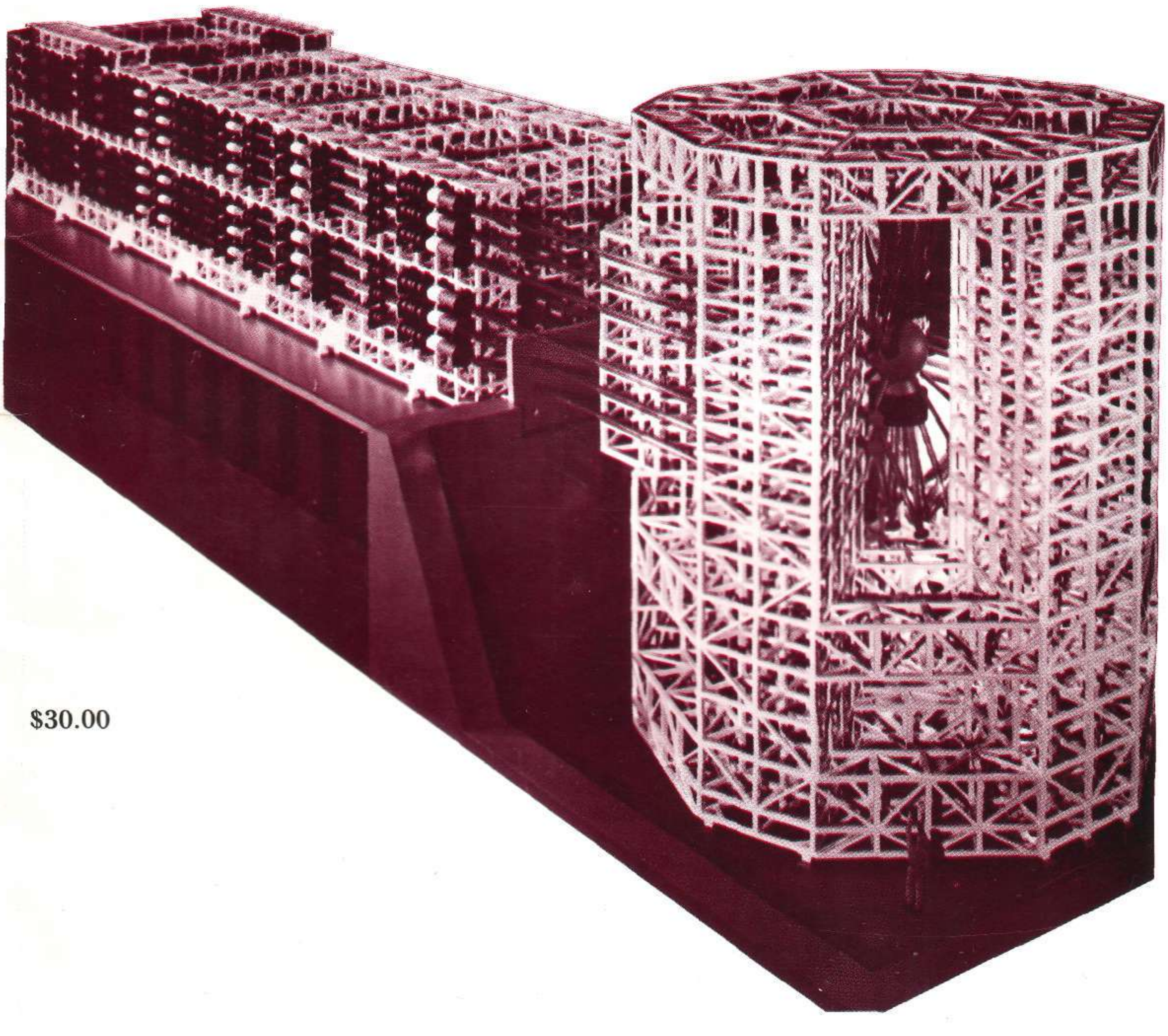
Proceedings of the

Conference on Energy and Jobs in an Expanding Economy (excerpted)



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Held in Detroit, Michigan, May 9, 1978

CONTENTS

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INVOCATION

by Dr. Arthur Farrell

Pastor, 9th St. Baptist Church of Cincinnati

Almighty and Eternal God, Giver of all good and perfect gifts, in whose wise providence a world was fashioned, and in the fashioning of that world certain gifts were given unto men, we give thanks that from the resources which have been placed on this planet there comes that sense of responsibility of stewardship that we may create in our time for our people a measure of Thy Kingdom which was first visioned when men were placed on this planet.

Instructed by your Holy Spirit to so utilize these resources that goodness and mercy and grace and peace might come to all men, grant that by the power of that same Spirit, with the quickening of our understanding the sensitivity to what your will is for Mankind, that we may so present ourselves as your servants utilizing your resources.

That peace may come on Earth as in Heaven, we pray in the name of our Lord, our Savior and our King, even Jesus Christ your son, amen.

GREETINGS TO THE CONFERENCE

by Joseph Spaniolo

Representative of IBT Local 299

I'm here as the official representative of the Teamsters' Local 299, and send the greetings of President Bob Lins. The local is the home-base of James Hoffa and Frank Fitzsimmons and is the flag-ship of the International Brotherhood of Teamsters.

I'm glad to see that industry is well represented at this conference. The Teamsters, and especially Local 299, would like to see ourselves continuing the fight of Jimmy Hoffa--the fight for industrial progress. As a major representative of labor, the Teamsters have played an important part in past labor-industrial alliances, such as the Star Port program.

I have been asked to report back to my union the proceedings of this conference and I personally think that the attendance and the events so far are very encouraging. Thank you.

Message sent by Clarke Watson

President, American Association of Blacks in Energy, former Advisor to the Congressional Black Caucus

"As a member of the organization in the thick of the fight to increase the jobs in the U.S. economy, by expanding it's high technology energy production, I wish to extend my greetings to everyone at this conference.

The future of the black population lies with the expansion of high technology jobs, increased scientific education for black youth and all youth and skilled jobs appropriate to an economy run by processes now at the frontiers of science.

The present industrial stagnation is epitomized by the fact that at the Colorado School of Mines, a major energy-related institution, there are only six blacks pursuing undergraduate studies, and one black pursuing a master's degree. Increasing the number of blacks in energy means increasing the high technology energy production of the U.S. As one member of the AABE involved in advising the NAACP on its energy position, an energy position which was reaffirmed by the Executive Board in Atlanta on April 17 I can certainly tell you that there is a press operation in this country which is designed to keep blacks away from an alliance with industry around the creastion of skilled jobs. A press operation which seeks to put blacks in the camp of liberal zero-growthers. The NAACP has stood up to that press operation and reaffirmed its commitment to nuclear energy and energy production.

In another case in point, U.S. Ambassador to the U.N., Andrew Young's recent call for programs of economic development for South Africa as the most basic foreign policy solution, has suffered a similar press operation in the U.S. We need in this nation a visible counterpole to the vacillation of the Department of Energy organized around a sound energy policy and people ready to stand up and be counted for it.

My best wishes that this conference may be fruitful."

Mr. Watson sent this message as an individual and the organization is for purposes of identification only.

RESOLUTION

The following resolution was passed unanimously by 200 conference participants:

BE IT RESOLVED

That the "Energy and Jobs in an Expanding Economy" Conference, held on May 9, 1978, at Marygrove College

- Calls on local, state and national labor, industry, political and religious organizations to begin a broad-based organizing approach to put the question of a positive nuclear power referendum on the ballot for the November, 1978 state, local and national elections.
- That given the recent economic trade agreements that have been made between the USSR, Europe, the Middle East and Africa, this conference affirms that the United States must make nuclear power the backbone of our energy policy and our renewed economic development. The United States must not be left out of this massive worldwide economic development now taking place.
- This conference calls specifically on Governor Milliken of Michigan, Governor Rhodes of Ohio, and President Carter to back this mandate and make this issue the energy policy of this nation.
- Lastly, that the spirit of this conference serve as the model for a national consensus on a national energy policy.

OPENING REMARKS

Dr. Morris Levitt

Executive Director, Fusion Energy Foundation
Editor-in-chief, Fusion Magazine

I would like to provide the immediate setting and background for the conference.

For those of you who may not be familiar with the Fusion Energy Foundation, we consider ourselves, pound for pound and dollar for dollar, the world's leading think tank for progress. We have a staff of about a dozen scientists and engineers supported by hundreds of members from the industrial, labor and scientific community, and we generally reach some tens of thousands of people each month through our literature.

I'd like to first cite very briefly a number of outstanding international developments that provide the context for the conference here today. I know that what is probably uppermost on most people's minds are the immediate concerns of the pressures facing individual industries of this region of the country. But I'm sure that it is also quite clear that these problems present themselves within the context of basic national problems that must be solved. And moreover, it is becoming increasingly evident that there is no solution to these problems short of a proper definition of the United States' role within the world.

Therefore, it is extremely fortunate that we find ourselves blessed today not only with a little bit of sunshine (the appropriate form of solar power), but that on the eve of this conference what is perhaps one of the momentous events in modern history has occurred -- unfortunately not yet with adequate recognition or discussion in the United States. That is, that the leading political official of the Soviet Union has presented himself to the entire population of West Germany on prime time television to announce that the Soviet Union and the Federal Republic of Germany have consummated a 25-year trade and investment arrangement whose highlight is captured in the statement by Mr. Brezhnev that he is opening up for investment and development, involving both the agricultural resources and energy spheres, an area larger than the country of France.

Now, the immediate question that we will be addressing, in one form or another today is: "WHY AIN'T WE IN THAT GAME?"

This has been, in the recent period, paralleled, in terms of the thrust and intention of the proposal, by the example of the Shah of Iran visiting the United States, meeting with numerous business groups and indicating that his nation is prepared to enter into $30 billion worth of nuclear trade arrangements with the United States. He is still waiting for a taker.

I would propose to you that this may have a little bit to do with those problems that we run up against, or we run our heads up against, in our day-to-day lives--whether it's me being crushed to death on the subway in New York every morning; people here worrying about whether ghetto areas will ever be properly rebuilt with access to skilled jobs; whether or not another endangered species, that can only been seen under the microscope, is going to be the basis for further destroying the industry in Michigan.

In terms of the reason why the FEF would be holding a conference such as this--it has been our major interest, since our inception in 1974, that if this nation were to commit itself to a program of development, a commitment to development of fusion energy--around about the end of this century--then there would be no question in anybody's mind but that we can go ahead and make full use of all existing types of resources. And even if it took us to 2020, if we had the national commitment, again there would be no question but that we could go ahead and fully develop all of those other resources which now present themselves.

We've had a number of remarkable offers in that regard as well that many of you may not know about or that had not been adequately, as far as I can tell, considered by the national government so far. A few weeks ago, there was a meeting of the Overall Joint Committee on Technological and Scientific Cooperation of the United States and the Soviet Union. At that point the head of the Soviet fusion program, who is also Vice President of the Soviety Academy of Sciences, E. P. Velikhov, proposed privately, but through top ranking officials, that since the United States and the Soviet Union would both, within a very few years, be in the position of moving to the final stages of development of prototype fusion test reactors, that it made a lot more sense for the two countries to take the last step of building a prototype reactor together in some third country.

Just last week, Prime Minister Fukuda of Japan, in a public speech before the Foreign Policy Association in New York on May 4th, indicated that his nation would like to put up about half of a $1 billion sum for joint U.S.-Japanese fusion development--that would not exclude any third countries.

So, there seems to be a lot of people in the world who, both trough self interest as well as long time attachment to the historical leadership role of the United States, are making us a number of interesting offers that directly cut the ground out from under any argument that could be tendered with respect to notions of our running out of resources; the necessity for labor intensive cutbacks; tighten your belt around your neck, etc.

This brings us to the general situation in this country and the problem we really address here. It's not simply the question of nuclear power, of how rapidly we should go ahead with fusion or how much we should invest. We are now at the third decisive testing point of our nation's history. Each of the prior two times the general broader issue was the same: would this nation, on the basis of having the most highly developed republican culture in the world, go forward, tapping the cultural level of the population, its enormous literacy, its enormous commitment to progress, to construct an industrial-agricultural-scientific base that would serve both as the model, the lever, and the means of making the resources available for the rest of the world leaving the muck of the past behind.

That was the issue in the Revolutionary War. It was not whether we were going to be independent; it was whether we were going to be something special. The same thing was put to the test in the Civil War. In the wake of each of those tests by arms, the country underwent its greatest periods of development and prosperity.

The irony of this, and the special reason why I focus on this, is that it is now put to us that we forget what policies and what programs existed in the past that made us prosperous and successful in the first place. We are now told that there are alternatives such as zero growth austerity, etc.--as if these were some new inventions! Something new and progressive on the horizon! As if our forefathers didn't fight the Revolutionary War precisely to defeat that outlook of malthusianism. As if they didn't fight the Civil War precisely to defeat balkanization and backwardness.

That is the framework for our deliberations today.

We will be focussing specifically on the question of whether or not it is a fact that the way forward is imminently feasible, in terms of the deployment of advanced nuclear technology. In terms of responding appropriately to the offers that most of the major nations of the world have indicated they would love to take up with us.

Panel One

ENERGY AND THE ECONOMY

O.B. Falls
Carol White

O.B. Falls

President, NucleDyne Corporation

Former Advisor to International Atomic Energy Agency

"It is the best of times. It is the worst of times."

Slightly paraphrased those are the opening lines from Dickens' story of the French Revolution, "Tale of Two Cities."

"These are the times that try men's souls" is another opening line, by Thomas Paine, from his famous essay "The American Revolution."

Both were written about revolutions wherein basic structures of long standing were assailed by the very people they served, but who felt they could be served better...

At the outset, let me warn that there are signs developing that American is in danger of losing its pre-eminent world position - politically, economically and technically...Chancellor Helmut Schmidt, also, used the term "irresponsible" in an attack on American attitudes involving world policy and world economic leadership. He called on the United States to "finally assume its responsibility" in regulating world economy..."It is unbelievable" Schmidt continued, "that the strongest economic power in the world has a balance of payments deficit at its current high level." I fully concur with Chancellor Schmidt's statements and accusations.

But, what is to be done about it? The three factors, economics, politics and technical achievement - are intimately tied together...This danger was rather well pointed out by an Englishman, Norman Macrae, writing in the "Economist" of London in 1976....

"There is a danger that the Americans, with all their power for dynamism and good, may be about to *desert* what should be their manifest and now rather easy destiny of leading the rest of us toward a decent world society and an abundant cheap lunch. If they do the leadership of the world may be yielded from American to less sophisticated hands at a perilous moment."

Mr. Macrae's comments were made within the context of belief that there is a creeping ethic of anti-dynamism developing in America. He blames this partially, at least, on a belief that "On campuses across the (American)continent a peculiar anti-growth cult is being taught to a generation of idealistic kids as if it was high moral philosophy or even a religion..."

The tragic part of this anti-growth attitude, though, is that political and technical growth are directly related to economic well-being which, in turn, is directly related to the availability of energy. If ample supplies of energy are not available there just cannot be economic growth nor, in turn, can there be technical or political growth and political stability. Ample supplies of energy, such as could be made available by nuclear sources, would guarantee the required levels of short-term capital-formation which could make feasible the up-grading and modernization of plant and equipment in many credit-starved American industries. In turn, this could result in upgrading the skilled-job capacity in the more advanced nations including the United States.

The ultimate result of a lack of energy in the economic and technical well-being and political stability of a country is quite evident when one considers the plight of many foreign countries....

To start with it is interesting to note that a new Quality of Life Index, devised by the Overseas Development Council, uses three criteria to measure how well nations are meeting basic necessities for food, sanitation, medical care and education. These are: (1) life expectancy, (2) infant mortality, and (3) literacy. Those nations which rank highest on this index (Sweden=100; United States = 97; USSR = 94) are all technologically advanced as well as very large users of electric energy per capita (Kwh/ca.) and with high levels of economy per capita (GNP/ca.). Among those measured, those nations which rank lowest in this index are China (59), Algeria (42) and India (39). These, also, happen to be among the lowest in Kwh/ca. and/or GNP/ca.

In the late 1960's some of the smaller developing countries of the world became aware that a lack of energy was directly affecting their technical and economic growth....As a result of the development of commercial nuclear power in this country in the 1950-60 period they began to realize that nuclear power might indeed solve one of the major problems facing them--namely, that they had been adversely affected by increases in world oil prices....

A Japanese expert on energy forecasting, Mr. H. Aoki, developed a method of forecasting the electrical energy demand which shows clearly the relationship between energy demand and economic status as measured by Gross National/Domestic Product.

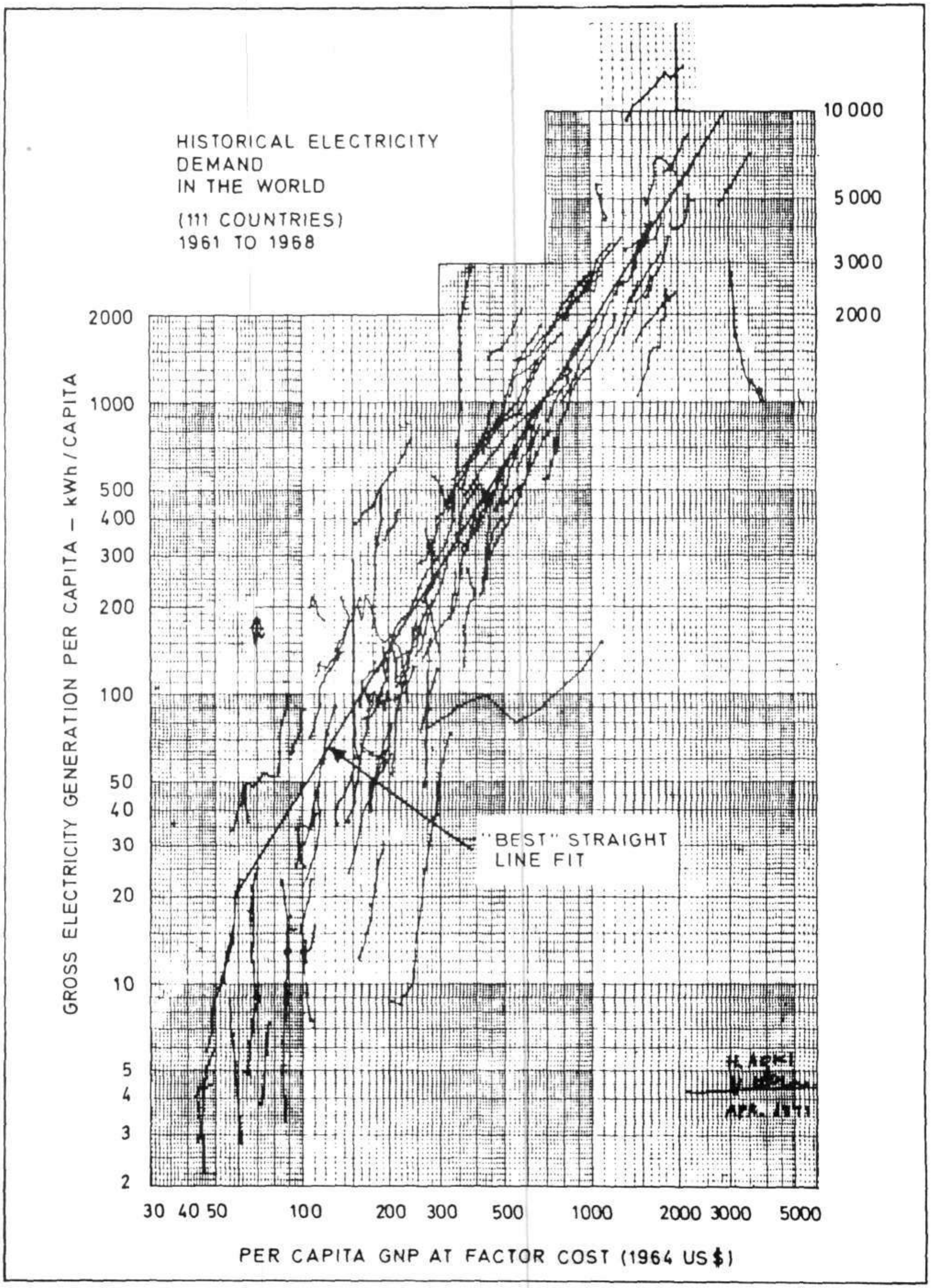
This slide (Figure 1) shows the correlation between historical data on electricity generation per capita and GNP per capita for 111 countries. The correlation coeffecient of the "Best" straight line fit, shown in this slide, is remarkably high. Since the data at the upper and lower end of the figure tend to fall below this line, it is obvious that a better fit could be obtained using a polynomial.

Using this as a basis, then, the "recommended universal curve" of the view (Figure 2) is obtained. Close examination of the individual country lines in the previous chart (Figure 1) shows that, in general, if the initial point representing a particular country falls above or below the line, subsequent points at higher values of GNP/ca. approach more closely to the trend line. It is, therefore, possible to draw a number of indicative lines on each side of the main trend line as shown. These will indicate the likely path that will be followed by countries whose present state does not lie exactly on the line. Accordingly, given that a forecast of the future growth of GNP/ca. is available, the future demand for electrical energy can then be calculated from this extrapolation.

A simplified plot, identifying certain of the countries studied, in the IAEA Survey, is shown in this next slide (Figure 3).

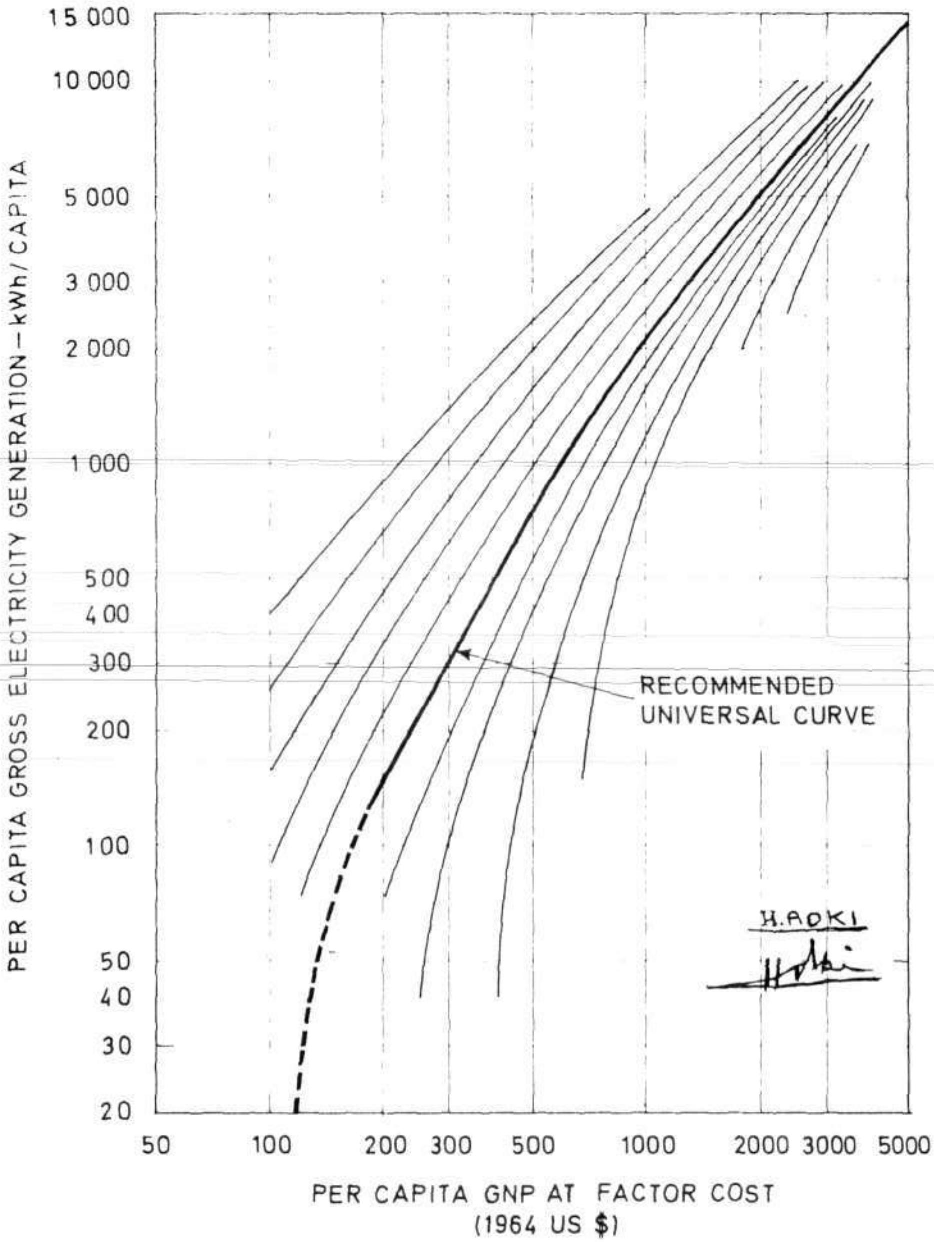
This clearly indicates that the poorer countries, like Bangladesh and Korea, have not only low electricity generation per capita but also low GNP per capita. Conversely the more affluent countries, like Mexico and Singapore, are higher on both scales. The United States would be nearly off scale at $4000 GNP/capita and 71000 Kwh/capita....

At present only eight developing countries (out of more than 100 or so classified) have nuclear power plants in operation or under construction amounting to less than 10% of their present generating capacity. By 1980 only about 8% of total capacity in all developing countries will be nuclear - contrasted to more than an estimated 15% - 16% for all industrialized countries. This, in



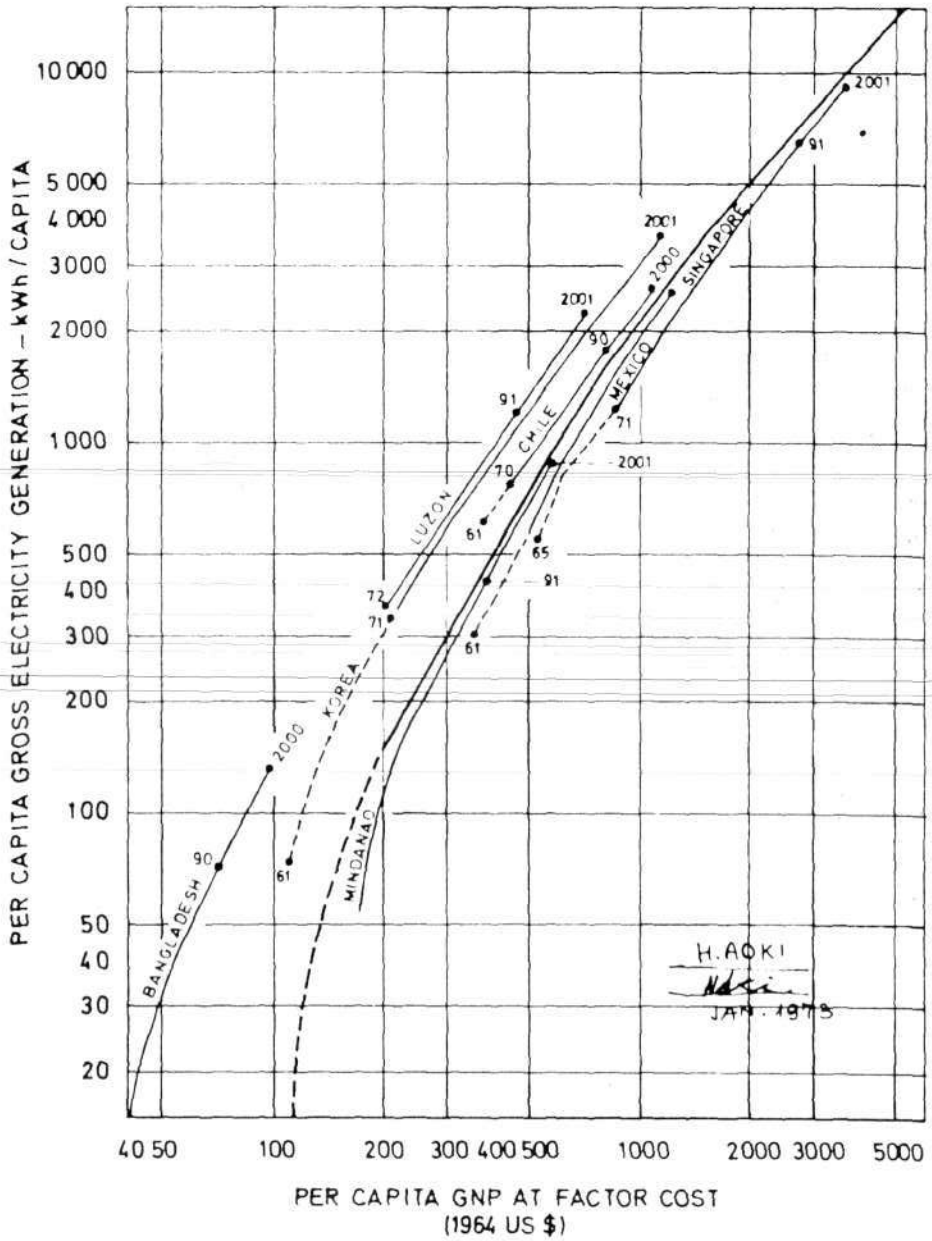
Correlation between Gross Generation per capita and GNP per capita for 111 countries for 1961-1968.

FIGURE 1



Recommended Relation---Gross Generation per capita and GNP per capita.

FIGURE 2



Survey countries plotted on Recommended Curve.

FIGURE 3

spite of the fact that most of the developing countries have minimal amounts, if any, of indigenous energy resources....

Contrasted to this, in the United States, it is expected that 15--20% of all electic energy will be generated by nuclear - fueled power plants in the same 1980--90 period.

The financing required for all the added generation in the 14 countries in the ten years was estimated to be $27 billion of which only about one-third can be supplied by the countries. The balance--$18 billion--will need to be supplied from sources foreign to the country. This may prove to be impossible in view of the very negative trade balances already in existence in these same countries. If these countries are to be helped it may be possible only through outright grants.

In addition to these requirements for foreign financial assistance there will be a requirement for a large number of adequately trained personnel to staff these projects. For example, in the 14 surveyed countries there will be required, in the 1980-90 period, of the order of 1000 highly trained headquarters support personnel and 4000 skilled plant-operations personnel. If all the developing countries were considered this number would be tripled....

Earlier I commented on the effect of technological and economic status on political stability. Again, this relationship is evident in many of the developing countries--as witness the following:

*most of the under-developed countries have governments of the "imposed" type--i.e., military or civilian dictatorships, etc.

*Nine of the 14 Survey countries have had one or more major governmental turn-over in the past 2-3 years.

*Essentially all utility systems were government owned or controlled.

*In Egypt--Sadat is still fighting for his political--and, possibly, human--life; although, recent happenings seem to indicate that he may have solved those problems, at least temporarily....

All of this political unrest, change, upheaval means that these countries do not have a type of government, whatever it may be, or the persons staffing it, in power long enough to prepare and implement political or social plans which could result in good, sound economic progress. Many of these countries are beginning to recognize that energy means economic and technological development which, in turn, can lead to political stability....

Now, what can be done about this situation? We must, I believe, "go back to the Garden of Eden" in the situation and find a way to persuade the people in these underdeveloped or developing countries that they must want to do something for themselves. We and the other industrialized countries of the world can provide money, equipment, and knowledge but unless the individuals want to help themselves these gifts will not produce any real results....

On the other hand, certain countries are doing outstanding jobs of "bootstrapping" themselves with substantial financial and technological aid from us. For example, Turkey, Korea and Pakistan need our continued support financially, technologically and militarily. We need both Turkey, Korea, and quite possible Pakistan, as military anchor points and should do all possible to assist them and to maintain good relations. The best way to accomplish this is to assist them to establish their own economic viability by helping them have enough energy to be able to build their own internal economic structures....

Developing nations scrape to buy life-giving petroleum energy at prices they barely can afford. Highly industrialized and developed nations, including the United States, refuse to take advantage of nuclear energy to supply their basic needs and continue to import massive quantities of petroleum as energy demands continue to soar, despite record prices....

With this overview of the energy situation in other parts of the world it is time that we take a look at ourselves. I believe this country's economic and technological level--the best the world has ever seen--has developed because of its high availability and usage of energy--particularly electricity. Actions--or inactions--in recent years have tended to negate its momentum; to the point that our very existence as a nation is threatened. Why? First, because energy is required to maintain our economic growth and technological leadership in the world. Our country's technological supremacy is one of our most valuable assets and one of the greatest deterents to war today. Second, because the ever increasing degree of governmental controls and environmental interventions are standing in the way of the normal development of adequate domestic energy supplies; the end result of which is to dangerously increase our dependence on external (oil) supplies chiefly from the tumultuous Middle East. In support of these contentions there are cited a few self-evident facts:

1. The world supply of fossil fuels (coal, gas, oil) are not inexhaustible....
2. The lip-service and promises of President Carter and his administration, including Energy Secretary Schlesinger, have produced no identifiable progress in solving the total energy picture in the United States. It would appear that the only suggestion they have is to conserve energy and have a no-growth situation....
3. Failure of the Federal government to come up with a viable energy policy and plan, on the one hand, and its extreme regulatory requirements, on the other, have resulted in preventing the private enterprise energy industry from developing adequate domestic energy supplies....
4. wind, tides, geothermal, etc., will take 25-50 years to develop commercially, if ever, and, with the possible exception of fusion, would supply only a relatively few percent of the demand if and when it is fully developed.
5. The two energy sources which are presently available in this country in adequate supplies for the next 50-100 years are nuclear and coal....

There is no activity where regulation and governmental intervention have done more damage to the energy picture than in the field of nuclear power....Nuclear plants are being built in foreign countries (Japan and Europe) today in four or five years and these countries have impeccable safety records.

Furthermore, in spite of the present attitude toward energy, in general, and nuclear power, in particular in this country, foreign countries are continuing their construction of nuclear power plants. In 1977 there were, throughout the world outside of the U.S. 138 reactors (47,655 Mwe). This compares with only 66 reactors (47,186 Mwe) in the U.S. Up to 1976, Belgium led the world in percentage of power generated which was produced by uranium fission, followed by Sweden, Switzerland, U.K., Spain and then the U.S. This year Sweden will lead the world with 14.6%. The Republic of South Korea, the Republic of China and Switzerland will exceed U.S. installed nuclear capacity of 8.9% By the year 2000, many First and Third World countries will have increased their nuclear capacity, as a percentage of total power, by substantial amounts thus assuring an adequate supply of energy at minimal costs. Typical countries are:

France--90%	Pakistan--60%	Iran--50%
Spain--67%	Denmark--54%	Egypt--43%
	Finland, Portugal and USA project--40%	

It is clear that the world intends to have a nuclear future--whatever the "moral" position wishfully desplayed by present U.S. policy makers.

There are steps this country could take to the advantage of both the foreign countries and our own country. If, for example, the present administration would take those actions necessary to permit and encourage the sale of nuclear power plants abroad the U.S. industrial share of global nuclear plant construction over the next five years could be in the range of 60 to 70 nuclear power plant orders. This could mean over two million man-years of jobs for American workers, over $4 billion in orders for steel in the U.S. and more than $20 billion in export dollar earnings. This would go a long way toward balancing off our present negative trade balance, as well as providing the needed energy in those foreign countries so that they could improve their economic and industrial status.

The real economic payoff resulting from a policy encouraging the domestic development of nuclear power plants could be stupendous. In what way? There could be several hundred large nuclear plants ordered and under construction by the year 1990. Each of these plants--1000 plus Mw each--would use upwards of 300,000 tons of concrete, 35,000 tons of steel, 1900 machine tools, 4,000 skilled workers working a total of 80 million man-hours plus 200 scientists and engineers. In the economic situation we find ourselves today this "carrot" alone would seem to be enough to entice our Federal Government to move into action....

There is much more that could be said about this energy situation. Let me leave you with these thoughts:

In our own country we have proven that we can take poor, uneducated persons, including criminals, and mould a great nation. Perhaps one of the most lucid statements I have ever read on this subject comes from a book "Letters from an American Farmer" written in 1782 by a Frenchman who examined the process by which, as he put it, "Europeans become Americans." The settlers, wrote J. Hector St. John de Crevecoeur, were a mixture of half a dozen European nationalities, having in common only their low status in their homelands. "In this great American asylum, the poor of Europe have by some means met together--From this promiscuous breed that race now called Americans have arisen." In Europe they were as so many useless plants. "Here they become men." "....He no sooner breathes American air than he sets out on projects he never would have thought of in his own country. Leaving behind his ancient prejudices, he receives new ones from the new mode of life he has embraced." "Here individuals of all nations are melted into a new race of men, whose labours and posterity will one day cause great changes in the world...The American is a new man who acts upon new principles; he must therefore entertain new ideas, and form new opinions." That, in 1782. Today, we have the finest nation this world has ever known. Are we going to let it go down the drain?

Carol White

National Executive Committee, U.S. Labor Party

Author of "*Energy Potential: Toward A New Electromagnetic Field Theory.*"

I'd like to begin by discussing some of the effects of the accord which Dr. Levitt mentioned which was signed in Germany between the Soviet Union and Germany by Chancellor Schmidt and Chairman Brezhnev.

Imagine for yourself the electrifying effect to the German population who lived in a country with extreme tensions between East Germany-West Germany; who've experienced the Berlin Wall. People are still alive who remember the incredible misery of the war--on both sides--the Soviet side and the German side. The electrifying effect of this event in which a 25 year trade accord was signed for the, in effect, integration of the German and the Soviet economy. Now that is an absolutely amazing international event! The Soviets are integrating the German economy in their five year plan.

The fact is that this is an absolutely major world-turning event. We may not like it, but it exists. And there's no one who can block that out.

Now the Soviets have made equivalent offers to us. For example, they have suggested that Alaska and Siberia jointly develop an electricity grid. And if the electricity could be piped under water, as it's extremely cold there naturally, you would almost have conditions of superconductivity which would make it a very cheap...make it very feasible and cheap to have the electricity piped back and forth. And because there's a 12 hour time difference, the question of peak periods...you would have a balancing of peak periods.

This Soviet-German deal is only part of a nexus of deals. The Soviets and Italians have made a deal to integrate their maritime fleets. The Soviets and the Japanese have concluded several major trade deals. At the same time, the French and Germans are moving into Venezuela and into Brazil with major nuclear development projects, hydroelectric dams. Similar development projects are being proposed for the Middle East.

Before we worry about this, the important thing to bear in mind is what Mr. Falls said. That if we have economic development then we can expect to see an era of peace and an era of democracy. It is economic development, economic growth, which correlates with the American way of life. And it's that which we have always been known to export. We have been, previous to this period, the people who have exported the American way of life. For people who grew up in the post-war period in Germany, the United States was the symbol of hope. It was a decimated country. There's something known as "the winter of the turnip" that occurred after the war. Tremendous, horrible poverty and emmiseration. And Germany was rebuilt, and it was rebuilt in partnership with the United States. And to the Germans the closest alliance they have had since that time has been with the United States.

The point of this is, of course, that it's before us now. It's a real crossroad. It's before this country whether we are going to be part of this nexus of deals, or whether we are not. That is a pretty devastating question. It's not the case, that we are simply in a position of waiting for a major disaster to occur...if we continue to sabotage our own development, because political events are not going to wait for that inevitable disaster to overtake us, and it's certainly credible that if we do not do something to enhance electricity production, that we can suffer an absolutely major blackout, only barring that we won't need this enhanced electric production because we've simply closed down our industry, which is the other horrendous alternative that affects us the way we're going now if we don't sharply turn around the political situation in this country.

But there's also the international situation to be concerned about. This country cannot afford to lose its hegemony internationally. The way has been spelled out by meeting after meeting where Arab diplomats, Europeans, Asian diplomats have come to this country and said: "Look! We want American leadership." Chancellor Schmidt said it; Premier Fukuda said it, calling for a billion dollar joint exporatation of nuclear fission resource facilities. This country right now spends a piddling amount on developing fusion. He's calling for a one billion dollar crash program. That's an appropriate scale.

An arab delegation recently toured this country, calling for investment in the Middle East, and they went to New York City and they went to Washington, and finally they ended up in Chicago, and they said, "Look, buddy! If we can't buy American, we are surrounded by neighbors who will sell to us. We will turn to the Soviet Bloc. We will survive. We will go in a development direction." The Saudis have said outright, "If we do not get the F-15 planes, if there is an anti-Saudi policy put forth by the government we will have to break with the United States; we will have to break with the U.S. dollar. We don't want to do that." Prince Faud, the major leader of the faction that is pro-American, has been off to Iraq to solidify an Arab bloc. This Arab bloc can work with us; they can control this Arab bloc; the Iraqis, the Lybians, the rejection front can actually be brought into a bloc which will work with the United States which can bring the Soviet Union into economic development plans in such a way that we obviate international tensions. Because it's working together, it's building together, it's joint exploitation of resources, it's joint scientific development. That's the American way that has always won. It's that what Henry Ford, after all, did when he built Soviet industry.

It's that that's behind the Basov proposal, all of the proposals for the joint exploitation of the nuclear industry. Because if you have a joint exploration of the nuclear industry, you no longer have an arms race. It's the best form of arms control there is. And then the other problems sort themselves out. But if you don't do that, then what alternatives have you? If this country in fact goes the way the environmentalists say, whilst the Soviet Union and Germany and Japan and Italy are all developing their nuclear power, then quite clearly, and we are going with solar power, you tell me what our national security is going to look like! I shouldn't like to be dependent upon it for my safety!

So it's pretty clear that we are operating right now totally irrationally politically.

High technology takes care of the problem of pollution. But if you DON'T have high investment, if you DON'T have high capital investment, then you have a pollution problem. And if you then try to deal with the pollution problem by shutting down industry, and we shut down Chrysler and we shut down Detroit, not only can't we conceivably build the tractors which they are going to need in that Siberian development project, but how the hell can we run an air force? How can we run our military complex? We're not going to be able to. Therefore what is proposed by the people who call for this deindustrialization energy program is an immediate confrontation with the Soviet Union in which hopefully, people like Schlesinger and Kissinger say, "Well, the U.S. will be tough, we'll talk tough, and we'll face down the Soviets and just as in the Cuban Missle Crisis, the Soviets will back down and that will be the end of it. And the United States will have hegemony; by using military force and by bluff, we'll be able to dominate the situation politically." It doesn't make sense. It's called bluff, "the aura of force" is what Schlesinger calls it; the "politics of irrationality and madness"; using deliberate irrationality in your bargaining stance, that's what Kissinger writes about. This is horrendous; this is not the American way. This is not how we had hegemony internationally; and it's not how we're going to survive as a nation. The result of this kind of policy, is one of two kinds of disaster. The first kind of disaster would be that the Soviets called our bluff and the world was devastated in a nuclear war in which perhaps the Soviets, because they have better civil defense capabilities, would have the marginal advantage and come out with 30% of their population destroyed, but they would still come out of it in a position to clean up in a war. This country could not survive a nuclear war. In no way.

But the other alternative is equally devastating. And that's the alternative that you get an eyeball-to-eyeball confrontation; we say to the Soviets, "You must get out of Africa." We allow the provocation of a conflict in Africa and then have a confrontation with the Soviets. We do that and what happens is that we are forced to back down, because the Soviets do not. And people think it out and they decide what can we do then.

I would like to lay before you, although I know it will shock many of you and surprise you, that there is a conspiracy in this country. And that this conspiracy is emmanating from London in particular, from forces in Britain. That they are actually looking to see the United States destroyed as a hegemonic power with the idea that they are going to reverse that unfortunate event that occurred in 1779; that this country will go back into colony status. That the IMF-the International Monetary Fund-give loans to this country, it is being said in the press. Everyone here has read that the dollar is weak, the dollar is being destroyed; it can no longer be an international reserve currency; that this country has to face the fact that progress is at an end; that we have to pull in; that the United States can no longer afford to consume so much oil. Where have you read those things before?

You have to read these articles and think to yourself, "Are they talking about the United States of America, or are they talking about Peru? Are they talking about Nigeria?" If you read the way the United States is being discussed by the dominant forces who are controlling the banking policy and the political policy in London today, and their allies in this country, such as Dr. Kissinger, such as the forces around Mondale, the Fabian forces in the Democratic Party, if you follow what they're saying, you would be astounded at the image. It's the image of this country as a colony! A bankrupt colony which is going to close down its industry to pay its debts. Now the American Banking Society actually testified before the London Banking Society. The American bankers were asked the difference between their practices and British practices. And it was very clear. They said: "Look, Americans go on turnover, they go on getting turnover; making something work. Venture capital; that's the basis of American Banking, venture capital. We want to see if something can make a profit, and we'll keep pouring in money even if they have a hard time, to realize such a profit. That is the way American industry operates."

Well, British banking operates on the principle of collateral. And if you don't pay your debts, the point is the bank makes its profit by being able to take the collateral. It's a gamble. And they are going to be able to get the collateral. You understand what it means when the British come into the United States and begin buying American industry and investing here. They are asset stripping it. It's what they did in Britain. I happen to have lived there for two years. And that's exactly what went on, this process of asset stripping in which you make your profit, you realize your profit by failing to reinvest. And you simply run an industry down to the ground, and after you've done that you tell the workers that they have to buy it. And that is what they did in England.

The same is true right now of Miller's policy in the Federal Reserve Bank. It's a pure speculative policy. And it's going to destroy this country. What he's doing is raising the interest rates so as to wipe out the savings and loan banks, and wipe out the real estate market. And the New York Times, and other people who are supporting him, are saying this overtly. They're saying, "Look, we have got to have a recession in this country. If we cannot get it through wage and price controls, we will get it by simply squeezing." Now, they have certain unholy alliances going. They have an unholy alliance right now with the commercial banks in New York who have been given the privilige of amalgamating their savings and their credit accounts. By doing this they're not so badly affected by the stringency on savings accounts. Therefore the independent savings banks are being wiped out first.

Now there are a consortium of people who are fighting to maintain this country and its economy. The Rockefeller Foundation is part of that group, and Nelson Rockefeller independently has another part of that group, along with major industrialists in Chicago, in Detroit. Rockefeller, for example, has come out and called for a $300 billion investment program in foreign investment, foreign trade, in this country. He has proposed an intervention into the Middle East with the same proposals as he had in the "Green Revolution," that is, for an agri-business on the same scope as the previous Rockefeller development program. And he is working on that.

You have other groupings of industrialists who are trying to pull together a core to see that the Ex-Im Bank gets at least a $50 billion backing, and the ability to act as a major financial instrument for world trade.

We had proposed a $200 billion base for the Ex-Im Bank. However, it's possible that private banking sources, together with the Ex-Im Bank, can actually model a credit policy for this country based on the Hamiltonian banking principles this country was founded upon. That is, banking principles in which you've got the Federal Government and private banking working together so that you do have a totally government controlled credit system, and you do not leave private industry to muster the resources on its own, but you have a partnership between government and business. And these forces are fighting to get the Ex-Im policy passed.

Now, I'd like to allude to the present political situation, because it's very, very dangerous.

What has happened in Congress in the last two weeks has seen the most devastating thing; the Republican senators have signed a policy statement to absolutely destroy the foreign policy aims of the Carter government in such a way that it is impossible that the Carter government can bring our country online and get us back in the hegemonic position that we must be in internationally. This has been deliberately and short-sightedly sabotaged. I don't think the people involved understood what they were doing. We have spoken to many of the senators who were involved in signing this policy statement which, for example called for dropping Taiwan and Korea and maintaining favored nation status with the Chinese Communist government, something that most Republicans do not agree with. Yet they signed it.

It called for support to the internal solution Rhodesian government, which most of the Black figures who had supported it have been forced to resign from because it's such a blatant cover story for a racist regime. Rather than putting extreme pressure on South Africa and Rhodesia, backing up Secretary of State Vance and Andrew Young, the Republicans supported this internal solution policy, and therefore guaranteed a confrontation and guaranteed that the United States would lose its hegemony with it's natural allies in Africa. Because when you do something like that, you're surely not going to have alliances with the Black states in Africa, or with the decent forces in South Africa. And the decent forces in South Africa, who would want to push for exactly that kind of stabilization and development, are being knifed by this Republican policy statement. The same flag-raising flag-waving on SALT. The same general Republican support right now on austerity.

Well, I think that the reason that the Republican Party is doing this is a very narrow look at gate receipts. The Republicans think, in a very disastrous way, that since Carter is a weak president, which we know he is, and since there's so much internal dissention in this country, that the solution for the Republican Party is simply to "Hooverize" Carter. But that is a disaster. What we need from the Republican senators in Congress, what we need is a farsighted program which gives support, CRITICAL support, to this foreign policy effort of Carter through Cyrus Vance, and at the same time forces through a development energy policy.

Now, as I see this situation, what we have is an unholy alliance right now, which is being orchestrated by Kissinger on the Republican side, and you have forces around Mondale, and the Fabian wing of the Democratic Party, who are working with this environmentalist terror deployment in this country, emanating from London, which is seeking to reduce this country to colonial status. And I think if you take this as a hypothesis, and check this out for yourself, you will be astounded to see how correct it is. Because you have to explain to yourself what's going on. Everyone in this room, I think, who has come here has actually fought environmentalists. It's not a question that you don't know who the enemy is, and it's not really, I doubt, a question that you actually have to be convinced as to the fact that we need development and technology, because I don't think that's really the case. I think the case is that you have to be convinced and we have to forge together for ourselves a working force that can turn the situation around.

Solar power technology is a fraud. So you say to yourself, why is it that this fraud goes? And that's a very good question. And I think that the question goes directly to what you also know, because you know who the environmentalists are. You know who the people behind Sun Day are.

A member of the FEF appeared on radio in Philadelphia and he spoke about Sun Day and the people who were organizing the Sun Day demonstration. And he referrenced their names, and someone called in and said, "My God! Those are the people who sold me LSD in the '60's."

How can this country sit back and say that we will allow ourselves to be governed by fear of terrorism? Is this Italy? We can't for a minute ignore the fact that if we do not organize a serious opposition to the terrorists, the same demoralizing, hideous fate can await us of political paralysis as has affected Italy. That is, people who say, "You have to bargain with the terrorists." The people in Italy are split between those people who say, "We will not bargain with the terrorists. These terrorists are fascists." Remember, for example, that Mussolini, and the Italians know this well, Mussolini looked like a lefty. Taking poor, deluded people, and very few of them, and getting them out as a cover for a fascist terror deployment. And these people are saying, "Even if Moro's life is at stake, we will not negotiate with fascists. We will not give them credibility. We will not bargain our freedom away to terrorists." And that is a very strong step forward, because in this country you have Kissinger coming out saying, "Terrorism is a sociological by-product and it comes from the fact that young people no longer have vision, that industry no longer excites people," and saying that we can expect terrorism to hit this country. Kissinger said that; we can expect terrorism to hit this continent. The person who's going around, one of the key organizers of the Sun Day project, the head of World Watch, his name is Dennis Hayes, spoke to a group of engineers in Seattle. He spoke about solar power and they answered him, but then he said, "Look fellas, you put in nuclear power, and you can expect a nuclear terrorist to put a bomb in the twin towers in New York and hold Major Koch hostage. You can expect that. You can expect terrorism if you go with nuclear power, you can expect terrorism." Now, there is no one in this room who has not heard that message.

Well, I don't expect it. And I don't think you people here expect it. But the way that we're not going to get it is if we organize and organize tough. If we don't pull our punches. If we call treason treason. If we call conspiracy, conspiracy. If we get together and flood this country, I'm not saying that the Labor Party has to do it; I'm saying that we all have to do it. You know, there are corporations in this room represented who have shows on television, you have commercials.

So we have an opportunity to take over television, at least to the extent of explaining things; to have a conference like this with the presentation of what nuclear energy is about on not 10 minute interviews of Mr. Falls, but how about a 2-hour show? With him and other scientific experts and other leading industrialists explaining to the American people what it's all about? It's that kind of a thing we have to do. We have to be hitting the newspapers. The American people don't turn out naturally for fascism and environmentalism. Look at what solar day was like. Actually no one showed up for it. Fifty people, 100 people, 200 people. But what they did was very, very horrible.

You have Governor Brown who said quite openly, "I think my pro-environmentalist anti-nuclear, pro-solar power policy is going to win me the governorship and is popular with the American people because the American people, because all people originally used to worship the sun!"

That's the problem in this country right now. That we're lacking the moral authority for our morality. That no one is speaking for science. And if you do not speak for science, you do not speak as an American. And that I think is the truly devastating thing about environmentalism. I think the devastating thing is the destruction of the sense of what it means to be an American. Because this country was formed, was fought for by a group of humanists who had a dedication and commitment to science. It is not by any means extraordinary or strange that Benjamin Franklin was a key person in electricity and not at all in the trivial way of flying a kite. It was that quality of person, a scientist, who was also one of the leading makers of our American Revolution. Because our country was based on the idea that was expressed in the prayer that we began this meeting with. That it is our place to make the world more beautiful; that man is a creative person; that man can be divine; that the divinity within man is his ability to be a scientist, to enhance God's universe as God meant it to be enhanced; to strive for progress, for perfection. That man has that creative ability, and you know it, every one of you, in the truism, "an American can always get the job done." "Yankee know-how"; Yankee ability to do what has to be done, to figure things out. The ability to solve a problem. Is there any problem so huge that it cannot be solved? And yet think what the environmentalists are going around to every college student and saying. They are saying, "Small is beautiful. Go back 100 years. Progess is evil."

But that deployment is a horrendous thing. It is to take away in strips the humanity of anyone who accepts it, who says their ability to use their mind, their creativity, their ability to apply their mind not as an idiosyncratic engineer or scientist, but their ability to apply themselves to enhance the quality of life for their own fellow citizens, for their countrymen, for people they've never met before in the third world; to know that they have contributed to progress; that they have exported the American way of life. That's their humanity. That's an American's inate, gut sense of humanity. And it's that that these environmentalists are seeking to strip away. I think that that is an incredibly horrible and dangerous thing. And I think the most important thing that the eight people from Consumer's Power and the people from Detroit Edison and the unionists who are here, and the religious people who are here, and everybody in this audience, that we have got to come out of this meeting as a core group to assert our purpose to go with that referendum and to go with that not on November, not as a pro forma thing, but to go out right now and to organize this country; to organize people throughout the country like ourselves; to take back the universities; to give morality, to again assert the morality of being an American, and not to have people cringing for it; not to have people apologizing that they're scientists; and not to capitulate and kowtow to these environmentalist terrorists.

Panel Two

ENERGY AND NATURAL LAW

Alan Salisbury
Darrell Lankford
Max Dean, Esq.

Alan Salisbury

National Committee, U.S. Labor Party

Author of *"The Political Economy of the American Revolution: The Civil War."*

We've have a lot of discussion this morning about new technologies, fusion power, what we're on the frontier of, and also some of the problems, some of the political impediments in the way of that development.

This process that's going on now is no different in a very real way than the process which occurred during the American Revolution and throughout the 19th century generally.

In the year 1776 besides what everyone knows as the Boston Tea Party, the American Revolution, the Declaration of Independence, there appeared a book by a British gentleman by the name of Adam Smith. That book was called "The Wealth of Nations". That book has defined a process of political intelligence operations against the American nation ever since it was written. And to demonstrate the point, the American Revolution was not merely a revolution for independence. It was not JUST that great men like Franklin, Hamilton, Washington and so forth wanted to just be independent of Britain. That was not the point. The point of the American Revolution was that what it accomplished was to consolidate a humanist country whose purpose, whose brilliant conception was to bring forth that same humanist conception throughout the entire world. That was the purpose of the American Revolution...

The outlook of the British royal families were very contrary to that notion. They believed very much in their rights of property, or the rights of interest rates and their property land values as opposed to this right to human progress. So for that reason the American Revolution was fought. And the book I refer to, Adam Smith's "Wealth of Nations" was a proposal for the Americans to adopt this notion of "free trade", or "laissez faire", which was not the American System. It was the way of the British hoodwinking the American who were fighting for their independence and, once the actual independence was established, to say, "O.K., you can have...," instead of the dirigist policy ennunciated and put into effect by Hamilton and others, instead of the dirigist economic policy adopted by the United State Congress in 1791, what the "Wealth of Nations" argued was a different way of subjecting the American nation to British colonial rule, or to colonial status. "Trade with Great Britain; you don't need to develop your manufactures, you don't need to develop your industry; Britain will give you your industry, will give you the products of her industry and you can remain an agricultural nation. You can supply cotton to us. You can supply raw materials to us, and we'll sell you back the finished goods."

And that's the way Britain operated throughout the world. So today when we sit here and say, "Well, the government controls too many things," we ought to be very careful about what we mean when we say that, when we say we're for "free trade" or we're for "free enterprise," and so forth....

Let me just lay out the fundamentals of Hamilton's dirigist policy. What Hamilton said was this. The credit mechanisms of a country, of any nation, should be subordinated to actual industrial progress. That's number one. That's why he created a national bank to provide credit for industrial progress, for scientific research, and so forth. By no means should the credit instruments of the nation be equal to or on par with or destroy the actual real value, real productive wealth of the nation in terms of its industry. Point two, was what was called the policy of internal improvements. What the internal improvements program did was to effectively order the investment of private industry. He said, "Look, what we have to do is wed the nation together with the industrialists of the country. We have to wed the industrial interests of the nation and the national government has to become one. The government has to encourage it." From that standpoint, we have a dirigist economic policy; that of the federal government encouraging a dual policy of gridding loans to internal projects, canals, railroads, etc. Other private entrepreneurs could gauge their own investments appropriately. How many of you today, if the federal government were to say, we will support a fusion power program, we'll throw in a billion dollars or $100 billion, or whatever amount it takes. How many of you would say, wait a minute, we need free enterprise! It just doesn't work that way. This is some of the linguistics tricks that have been inculcated in our culture. Since people don't have a very good sense of what American history actually is....

Now, the American economists said, look, you guys are not economists. And they weren't. You don't have a theory. What you have invented is a system for explaining the policy of Great Britain, and that's what you are doing. And they said it quite bluntly. No crap about the "invisible hand," or how the "free market" operates. These people operated with a conception as the ruling conception for a humanist, capitalist nation. That conception they called the "labor theory of value." That was the core conception. That you have to judge the wealth of a nation, the wealth created by a nation, in terms of the growth of not just the wealth of the nation itself, but the growth in productive powers of the nation's labor force. Now that labor theory of value, that conception had been attributed to, by present day historians, to Karl Marx. Now, true, Marx had that same conception about the labor force. He had that exact same conception. But it was first ennunciated by Alexander Hamilton in his "Report on Manufactures" in refutation of Adam Smith. Then the same thing was done again as American sought to have their own economic texts for the nation's colleges to combat all this British crap that was coming over here. It was further ennunciated by Daniel Raymond, Henry Clay, Henry Carey, Matthew Carey and was the ruling conception of our presidents until Jackson. Later is was quite explicitly the ruling conception of Abraham Lincoln, and later still, McKinley...

Thats the exact same ruling conception that governs most of the population in the Soviet Union, with the exception that the American population looks to the federal government to ennunciate the kind of credit policy and economic policy to achieve rates of growth. The Soviet population, in a different way, looks to the Five Year Plan to accomplish the same thing.

Throughout the 19th century there was always a convergence of both the United States, Russia, not the Soviet Union, Russia in the 19th centry, and Germany, were always converging upon alliances throughout the 19th century to finally do away with the nominalism menace once and for all from Great Britian. In fact, during the Crimean War in 1856 U.S. economist Henry Carey, who I mentioned before, was chiefly responsible for bringing out the United States on the side of Russia during the Crimean war where Great Britian was using surrogates to try to destroy the Russian government at the time. Now because we did this, during the U.S. Civil War the Russians reciprocated by sending their fleet to the United States' harbors, both in New York and on the west coast, to prevent Great Britain from launching atrocities against the United States, which they were fully prepared to do during the Civil War. That's essentially one of the key ways in which our nation was saved during the Civil War from being Balkanized; through Russia's intervention on our behalf against Great Britain....

After the war what Lincoln did was to immediately institute a policy that would sever this nation's credit mechanism from the credit mechanisms of Great Britain. That's how you got the greenback, the dollar in your pocket. That's one of the things that was done. He initiated the greenback and for that period we got off the gold standard, etc. He tied our economic policy to policies geared toward growth, industrial growth. At the same time, Lincoln's commitment was to industrially reconstruct the South and to use as the basis of labor power in the South, new labor power in the South, the newly freed men. He said, 'look, we're going to have plenty of skilled technicians.' As a matter of fact, his last public speech before his assassination was laying out a policy for apprenticeship programs, the fact that we needed skilled workers, skilled mechanics in the South. That's in effect what Lincoln and the leading industrialists were able to accomplish, as well as many other things such as the Bessemer process for producing steel which, I think, was introduced in 1863-64....

I don't want to take up too much time because we've got other speakers, but I would just like to impress upon the audience, one: why you've never heard of the people I mentioned before. Some of you may sit on the board of various colleges around the state and you go to a history class and you go to the college and what you see being taught is Basket Weaving 101, or you see people reading Adam Smith. No one reads Hamilton or Carey or Lincoln. The stuff is not taught in our colleges anymore. So if we are going to be able today to carry out many of the fine ideas, fine examples of technologies just over the horizon, in order to successfully mobilize the population to accomplish that task, the population will have to have instilled in it a sense of where they come from; a sense of what this nation was all about; how did we get this far? Who were the people responsible for it? What did they believe? What was guiding them? What was the nation that Hamilton, Lincoln, and so forth left for us? And we, as their posterity have to take that responsibility. Thank you.

Darrell Lankford

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In addressing a conference such as this it seems odd that only ten years ago, or possibly less, a great many people in this nation had only the vaguest notion of the meaning of the word "environment." And the spin-off term, "environmentalism," was scarcely a part of the language. Emerging as it did in the great debate over Vietnam, the new concern for the environment stuck up--or snuck up, rather--on most of us--stuck up on some of us. Someone calling himself "the Fox" dumped garbage in the offices of the Chairman of the Board of U.S. Steel Company. College students celebrated a day called "Earth Day," which disappeared from the scene about as quickly as it appeared. And there was a lot of talk about eating things such as bean sprouts and crunchy granola. In those respects the fledgling environmental movement had all the looks of another fad, just a passing cultural happening.

But there was a serious side to environmentalism, as it was soon called, and there was a compelling logic in it with which about everyone basically agreed, including the business community, although business was consistently pictured as the villain in the environmental scenario. Nonetheless, business realized it was in the best interests of all of us to begin paying closer attention to the twin problems of pollution and waste....

There was no basic disagreement whatsoever with the environmental concerns. But what disturbed business, and what the business community time and time again attempted to point out was that there were costs connected with cleaning up the environment and the balance must be struck between those costs and having the pristine environment on the one hand and a viable economy on the other. In other words, yes, environmental concerns must be addressed. But society had to decide where to draw the line, because not everything could be done at once--at least not if society also wanted to keep its factories running and its men and women working.

Then came an event which for the first time brought the question of the environment versus economic concerns into crystal clear focus, and at the same time drew the energy industry, including the nation's utilities into the very heart of the debate. Of course I'm referring to the oil embargo that the

Arabs put upon us. Immediately some seized upon this oil stoppage as the ultimate vindication of their own views. The finite limits of a valuable resource had been demonstrated and henceforth only rigid conservation could save us. But when those of us in the energy business replied that conservation alone was not the answer, that even the most rigid conservation alone was not the answer, that even the most rigid conservation could not stop worldwide population growth, and thus the need to produce more energy; when we pointed out that to produce energy in the absence of cheap, abundant oil supply would mean turning to greater reliance on coal and nuclear fuel; when we said all that, the answer we got was, NO. You can't burn coal because it's dirty; you can't use nuclear because it's unsafe.

So there we stood, and here we sit, with the dilemma still unresolved and confusion reaching new heights at all times. It would be very, very funny if it weren't so deadly serious. But look what's happening to us today.

Not long ago, in the pre-oil embargo days, both industries and utilities converted many of their facilities from coal fire to oil fire units because, even though oil was a little more expensive, it was cleaner to burn.

Now we have pending before the Congress of the United States a national energy plan which would require industry and utilities to convert back to coal from oil, which of course the coal is in greater supply. That's quite a turnabout. But even so, on the face of it, it could make sound sense. It could reflect the realization on the part of the government and others that the time for striking a balance between environmental and other concerns is now. That the urgency of our need for energy must be regarded at least equally with the handling of our environment. I say the plan COULD be all those things, but in fact, it's nothing of the sort.

It says, we will convert to coal to meet our energy needs, but it does not say how. It does not ease restrictions on preventing us from mining the coal, nor from burning the coal. What in effect we are being told is that air quality standards will not give an inch; strict mining laws will not give an inch; regulatory concerns will not give an inch; they will not give an inch on scrubbers, precipitators, and other high cost, anti-pollution technology, but still we must produce the bulk of our power with coal. In other words, we'll have our cake and eat it too....

My own company's J.H. Campbell generation plant was equipped with precipitators, devices for removing the fly ash from the plant's emission. Those precipitators were capable of removing up to 95% of the fly ash in the course of electric generation from the plant. That, however, was not good enough. To ensure compliance with the Michigan Air Pollution Control Commission (MAPCC), emission limits were modified at the plant's facilities. Those modifications will increase the fly ash removal efficiency of existing equipment by about 4%. In other words, it'll go up to 99%. But what will this contribute to the air quality in the vicinity of the plant? Nothing. What will it add to the plant's electrical output? Nothing. What will it cost Consumers Power Company, and ultimately the rate payers themselves? Twenty-five million dollars. This is not our idea of sound environmental concerns....

In a somewhat similar case, last year my company requested that the MAPCC modify a January 1, 1980 requirement for the reduction of sulfur dioxide emissions at three generating plants. The company pointed out that if it was required to convert to low sulfur coal at those plants by 1980, its customers would have to pay $595,000,000 for those conversions between the period of 1980 and 1985, based on the cost of adding precipitators to two plants, and using the more expensive low sulfur coal at all three. However, a more gradual phasing in of the environmental requirements allowing two plants until 1983 and one until 1985 to comply, would cost $95,000,000 over that period, thus saving the customer some $500,000,000. And while the delay would be much more economical, it would not compromise the air quality in the area adjacent to the plants. Well, in this instance we won at least a partial victory. The Commission granted a compliance date extension for the Campbell plant until 1985, which will save our customers an estimated $130,000,000 between 1980 and 1985. However, the request for the other two plants were turned down, and thus the opportunity for additional savings was lost.

Again, the issue is not the case of clean air versus dirty air. The extensions which we requested would have had no significant impact on the air quality. What was at issue here, as in similar cases throughout the nation, was the cost versus the benefits of the environmental regulations....

Perhaps the classic example of this dilemma is facing the Dow Chemical Company in Midland. Dow's fossil fuel plant at Midland has been found to be in violation of the air quality standards, and the company has been told to either clean up the plants through extensive and expensive new equipment, or shut them down. For its part Dow has said it intends to close down the old plant as soon as it can replace their output with purchased power from my company's Midland nuclear complex. In addition, the Midland complex will supply Dow with large quantities of processed steam for Dow's manufacturing operations. It would seem an ideal solution. Consumers Power Company needs the new large generating complex to serve its customers. Dow needs the new resource power in order to retire the old fossil fuel units. However, the State regulators want the Dow units modified or replaced because of their impact on air quality. The Midland plant will operate on the cleanest, least expensive fuel available: nuclear fuel. There's just one problem. Dow's deadline for either modifying or replacing its own units is running out, and my company's Midland plant is not yet completed. And here's the final irony. The reason the Midland plant is not completed is the fact that it has been delayed time and time again by so-called environmental grounds by the Intervenors.

If this is all beginning to sound like a bad joke, or a vicious plot, be assured that it's neither. It's no joke because energy is the lifeblood of this nation. And anything which threatens to cut off the lifeblood cannot be regarded funny. And it's not a plot either. Quite the contrary. It's the very lack of a plot or a plan or of any reasonable blueprint for action that's creating the thickening morass. It is again our seeming inability to create a workable balance between environmental concerns and energy needs. Coal and nuclear power, most experts agree, must bridge our future, as far as energy is concerned.

I have spoken of environmental impediments to greater coal utilization; the unbending mining and emission regulations; yet in turning to the nuclear option, the other half of the new energy mix, the problems are even worse. The nuclear industry in our nation today is not being permitted to develop rapidly enough to meet our needs. A number of projects have been deferred, others canceled, and new plant orders are trickling in to the manufacturers. It is not because of the fact that nuclear power is unsafe, or unreliable. On the contrary. With each passing year the safety record of the nuclear industry becomes more and more impressive. Likewise, each new energy crisis in this country further underscores the importance of the nuclear option. A year ago, when the record cold throughout the eastern half of the nation froze coal piles and stranded oil barges in ice choked rivers, nuclear power bailed the country out. And the same was true this past winter when the coal strike threatened the energy supplies throughout the east. Nuclear power has demonstrated the role it can play in our energy picture, and that role is well recognized by utility and its planners.

But the viability of nuclear power under the present licensing system is a matter of concern to planners, and with good reason. Nuclear generating plants are huge and expensive projects to undertake even in the best of circumstances. But with the added complications of the licensing process, the construction of a nuclear power plant can become a nightmare. There is all the bureaucratic red tape with which we are concerned; the hearings; the long waits for decisions after these hearings; the appeal of the decisions; and the rulings of the appeal boards. Often there are appeals to the courts and more long waits for the courts' decisions. And with each further delay, the project cost rises; new financing must be found to carry out the needed capital; rate cases must be filed to provide a sound basis to attract new financing. In short, the resources of a utility in time, manpower, and capital are stretched to the limit. This is the situation which now exists. This must be taken into account by the planners when they decline whether or not to make the commitment to nuclear power.

But there is an even more unsettling fact which they also must face. Because of the numerous delays already built into the nuclear licensing process, the lead time for building a nuclear plant is more than 10 years, so the planners must try to anticipate what further problems could appear during the more than a decade in which the resources of the company must be committed to that nuclear project.

And look at what they face in trying to make this long term assessment. On the one hand the government talks of streamlining the licensing process to speed up nuclear development, but on the other hand, legislation appears in Congress which would even add further to the time and expense involved in the current process by requiring utilities to provide funds for the intervenors! Already the delays that the intervenors, who have often no specific issue to raise, are staggering. Imagine the situation of any person or group for any reason could step into the proceedings without any funds at stake whatever--except, of course, those of the utilities and the customers. And, too, the planners cannot help but be unsettled by those instances which took place at Seabrook nuclear plant in New England, where all the procedures were followed, and approved by the Nuclear Regulatory Commission, to the letter. However, a regional director of the Environmental Protection Agency, a body not even charged with the responsibility for nuclear planning, stepped in and declared that the plans for the plant were unacceptable.

Again, my own company knows all too well how capricious the process can be. In the process of constructing our Palisades plant, we were confronted with the possibility of additional cost delays by a group insisting on the need for cooling towers at the plant. We built the cooling towers, at a cost of some $25,000,000, and subsequently settled the situation with the intervenors. However, studies have affirmed our original belief that those towers were unnecessary. Indeed, Indiana and Michigan Electric Company's Cook nuclear plant operates quite safely and efficiently without cooling towers in the vicinity of the Lake Michigan shoreline. But the hard fact that we had to face at that time was the cost of the cooling towers, while substantial, was less of a burden on our company and customers than would have been the cost of further legal delays and regulatory proceedings.

More recently the construction of the Midland nuclear plant has presented similar problems. Once again, after having gone through the prescribed licensing process, including public hearings, we were suddenly faced with the challenge of the validity of our construction permit for the plant by the decision of a circuit court for the District of Columbia. Further hearings were thus necessitated and those hearings could be dragging on even now if our petition to the U.S. Supreme Court had not been successful. Perhaps the Supreme Court decision marks the turning point in regulatory affairs. Perhaps the unusually strong language which the Justices used to express their disagreement with the circuit court's action, and their firm declaration that the courts should play "only a limited role in the regulatory process" will indeed have far reaching significance in cutting through the needless delays which now impede nuclear growth.

But while we can hope that that will be the case, I think it would be foolish to imagine that all of our problems are solved. To get back to the central thesis of my remarks, we in this country still must reconcile our energy needs with our environmental concerns. We know we need more energy in the economy to continue to prosper. If our people are to continue to work; if our society is to provide opportunity for those outside the economic mainstream of the American life. And we know, too, that in order to have the energy we need, we have only two viable alternatives for the forseeable future, coal and nuclear. And we know, finally, that given the present pseudo-environmental ideas as far as the economics of coal and nuclear are concerned, it's simply going to take us too long, and cost too much, to provide the energy which we so badly need.

Once again, lest there be the slightest doubt of the meaning of what I'm saying, let me say that neither I nor anyone else in the energy industry is suggesting that we ignore safety, ignore the quality of our air and water, or ignore the proper use of our land and resources. We are saying, just as we have been saying since the first days of environmentalism, that we must meet a balance between cost and benefits, human as well as monetary. What we are saying is that the present state of confusion and contradiction in goals is costing us, every one of us in this nation, time and money, and we are already short on both. The cost of energy will increase, and there's no way around that fact. But we can keep the costs from damaging our society needlessly if we are permitted to plan reasonably and on a sound cost vs benefits basis. Likewise, it will take time to reach the position where the stranglehold of energy imports on our ecomomy can be broken and we can again approach energy self-sufficiency. But we can shorten that time if we are permitted to use it wisely, not to protract it in increasingly meaningless debates over questions which should have been settled many years ago. That prudent, conscientious planning and construction of facilities forms our bridge into what we can hope will be a more secure, less troubled energy future. Thank you.

Max Dean, Esq.

Attorney of Record before the U.S. Supreme Court in an Amicus Curiae brief in Consumers Power vs. Aeschliman.

I believe the reason I'm here today is that I did subscribe the brief that was filed in the U.S. Supreme Court as a Friend of the Court with the Court permission on the side of the Consumers Power Company and the Midland Plant litigation and I would like to tell you how it came about. I can't think of anything that I gained more pleasure from or am proud of than being associated with filing that brief amicus curiae and I suppose that it's only natural that the people who had an input into that brief feel that it was extremely significant in contributing greatly to the Court's decision. I think we have reason for feeling that way. I realize that it was the petition of the Consumers Power Company that brought the case to court and it was excellent that that was done because if they hadn't done it we would never have had an opportunity to support them in that effort. But nevertheless, I think that if I tell you a little about the brief and the way that the brief was composed, that you will see that it was an important addition to the materials that the U.S. Supreme Court had that it reviewed on this fundamental question.

The brief was truly the product of the National Caucus of Labor Committees and their active participants in the U.S. Labor Party Legal Department. I'm now somewhat of a celebrity, I'm told, because the Labor Organizers Defense Fund has published the brief and is selling it at all major airports around the country. I feel that I am perhaps getting more than my share of the credit because I want to say that the collective thought that went into the brief and the viewpoint derived, was truly to represent in a legal form, the philosophy of the U.S. Labor Party and the organization that inspired it, the National Caucus of Labor Committees. This philosophy, I think, is crucial. I think that it is worthy of consideration by all people who are interested in seeing that our society progresses and does not retrogress.

The brief reflected an effort to abstract the essence of the formation and what the creation of the United States of America actually was. That is, to try to find the meaning of the creation and to establish what the Constitution really meant in the context in which it was adopted.

This makes it more significant than ever that the people with whom I was associated in preparing the brief had done research also in the fact that within the current of Islam that there is a humanist faction and it all boils down to whether or not man is capable of further perfection. Professor Rice from Notre Dame Law School was talking to the Labor Party people and saying, "At least I can talk to you, you understand what politics and law are all about and I may disagree with you on current political issues or some aspects but I can discuss things with you; I cannot talk to liberals because they are cultural relativists, they don't believe in anything, they don't believe that there is any natural law, they don't accept any ideas." So I posed this question to him: "Do you believe that man was created perfect or do you believe he created capable of further perfection?" It didn't take him very long and he gave me his particular brand of Catholicism (because there are a variety of brands of Catholicism) and he said that he believed that man was created perfect and he was incapable of further perfection. Now we know that the Islamic thought of Avicenna, for example, believes that man has the capacity for further perfection. It gets down to the invocation that was given here where the minister referred to the resources being in stewardship and asking that mankind be given guidance to utilize these resources...

Now I think that the philosophy that was expressed in the brief filed on behalf of the U.S. Labor Party was strictly this; that implicit in the creation, in the historical context of the United States Constitution that it was a period that man was capable of further perfection and that it was through the advance of scientific knowledge and through the mastery of technology, the mastery of the environment, and that there was no contradiction between man and his environment, and man can master his environment and that you do not save the environment from man.

Now this is a view that permeated the brief, it was a view that was contributed to by Ed Spannaus, who has written very excellent articles that appeared in New Solidarity on natural law, the history of the Marshall court, Story, and he's a non-lawyer. David Heller, who's a lawyer on the legal staff, and Gerry Kaufman, who contributed. We feel that the method was that we felt that we were attempting to elevate in that brief as a matter of constitutional principle that the United States is committed to industrial, technological and scientific progress, and that conservation is unconstitutional. That conservation of energy is unconstitutional. Conservation is anti-scientific, anti-progress, anti-human. This is what we were trying to put forth. We were trying to put forth the idea that there is not a problem that mankind is capable of posing that mankind is not capable of solving. If, in more immediate terms, the question of energy conservation is to obtain any viability, that the rest of the world, which desperately needs the contribution that the United States can make to its development, will be deprived of that contribution.

It is our industrial plant, it is our skilled workers, it's our machine tool industry, it is our capabilities of producing what the world needs which will elevate the standards of living in the rest of the world.

If we conserve energy, what is going to happen to the needs that consume 20 times as much energy as we are presently consuming? That is if we are actually going to bring about an improvement in the standards of living of the people of the world, we would have to on a world economic basis consume 20 times as much energy as we are consuming today. So to talk about a 15% conservation in the United States is actually condemning other people to death.

Now the humanist natural law concept says that there are certain laws that exist independent of man, and it is through man's learning and knowledge that he can affect these laws. That these laws exist, and this is an important concept in a republic because it means that the laws are discoverable, and that we can have a basis for peace for other people of the world who accept and believe in these same universal laws that affect the universe.

It is not a question of splitting a limited pie. It's not a question of laying the foundation for future war. It's not a question of fighting over fossil resources that are limited resources. We feel that this is a humanist viewpoint; that this is a natural law viewpoint that reflects the progress of mankind and mankind's self-conscious capacity to learn and develop and progress and further perfect human society. We feel that this is totally consistent with every major, every civilized religious outlook; that we refuse to be boxed in on the grounds that mankind is evil, and this is actually the problem that confronts the American environmental movement of today. When you see the hostility and opposition to the capabilities of man to solve their problems, and their hostility to all of man's endeavors and when you travel and look at the world, you realize the world is a garden, the world shows evidences in every aspect, the hand of man. Whether it's in the United States or France or anywhere you go, that there's no part of the environment that does not exist now except by sufference. An it's all subject to change. And that we have the capacity and I'm not even using the term balance, because I think that we have immediate pressing problems and no one can agree upon whose point of view that that balance must stem.

We have a terrific population problem. This population problem is a problem when we do not have production. When we do not have expanded energy. When we do not create the basis upon which people can live in peace and develop and grow. I think Mexico is a country that's confronted with this problem. And Mexico is solving the problem under an adminstration committed to growth and development.

There are people in the United States and Britain and other parts of the world who feel that people are pollution; that the solution to the problem is the reduction of population. There are organizations--and I get their mail--that believe that there should be negative growth. They advocate that the population in the United States should be reduced to 100 million; that the population of the world should be reduced to 2 billion. Now all of these questions are implicit in the approach that we take that the United States government--the United States of America--formally and legally as a constitutional republic, has an obligation to address itself to these problems, and solve the problems and create the climate in which there's production in which these human needs are met on an ascending scale and increase our capabilities to solve them in the future. That was the thrust of our brief.

When I was in high school we debated the question of should the electric utilities companies be owned by the government or by private ownership. This was a national debate topic. This was in 1937, in the Depression, and there were people out of work because the boom of preparing for the oncoming war had not yet put people back to work. So the question framed was not should we have more electric power, not should we produce a lot more electrical power cheaper, but the question was who should own the electrical power. Now about forty years later the debate is should we produce electic power. I think that we are now debating the proper question. Forty years ago we debated who would own it; and now we are at this position, and I think that we should produce electrical power. I think that any concept of natural law as far as what the human society needs, and what its progress means.

Now there are other people who do not believe that we should produce electric power. It's just incredible to me that James Schlesinger can be head of the Department of Energy. James Schlesinger used to be in the Defense Department under Gerry Ford, and his great contribution was advocating the forward troops of NATO be armed with atomic weapons, and to Ford's credit, he canned Schlesinger. Now, the significance of delivering atomic weapons to NATO's forward forces was to ensure, if possible, that the events that were announced this morning--the trade deal between West Germany and the Soviet Union--would never take place. That if there is any single fundamental, basic purpose of British foreign policy, it is that the United States of America and the USSR should be at each other's throats. It is only by keeping the USSR and the USA at each other's throats that the British can continue to rule the world. Only by having the two great powers at sword points can British with its junkheap of an economy, tilt the scales, wheel and deal, and continue the role that they have continued for the last 300 years. Now this has direct bearing on the struggle in the United States and on the question of energy, the question of environmentalism. The question of destabilization, what's taking place in Europe. And it gets down to a question of, if you can't control, you destabilize.

Now I want to point out that the British are experts at giving away property that they don't own to other people when it's occupied by someone else, so that they are continually called upon to maintain peace. This is impressed upon me by Indians, Pakistanis, everybody I've talked to around the world, tell me about this particular British talent. Now I would say that the environmental movement in the United States is in great part a British creation. Just as Baider-Meinhoff is a British creation, and just as the Red Brigades are a British creation, I recently had the occasion to read a book called "Law and the Rise of Capitalism", for the purpose of reviewing it. And again we come down to the question of law. In this book, written by Michael Tiger, a lawyer, he puts forth the idea that law flows from force. That there is no law unless you have the power to compel other people to do what you tell them to. That law comes from the end of a gun barrel.

Now, the natural law concept is that there is law that exists in the ordering and regulation of human affairs, natural affairs, in the universe. That there is an order that exists. I would say that the fundamental law has been that society progresses with energy consumption, with energy through-put. Civilization, by the indices that were mentioned today by Mr. Falls, all of these are directly related to energy consumption. I think that the point I was making about the Red Brigades the Baider-Meinhoff, the environmental movement in the United States--people are anit-people, they're anti-natural law and they have absolutely no understanding of the necessity to continue the process that we're I was making about the Red Brigades, the Baader-Meinhof, the environmental movement in the United States--people are anti-people, they're anti-natural law and they have absolutely no understanding of the necessity to continue the process that we're engaged in of building a better society based upon utilization of science and technology to control the environment. Thank you.

Panel Three

ADVANCED ENERGY TECHNOLOGIES

Jon Gilbertson
Dr. Morris Levitt
Dr. Michael Monsler

Jon Gilbertson

Nuclear Safety Engineer, Advanced Technologies, Inc.
Formerly with Combustion Engineering.

There are a couple of other things in the form of an introduction I'd like to start off with before I get into the main topic of my discussion. On behalf of two other members of the Board of Trustees, the Advisory Board of Trustees of the Fusion Energy Foundation of which I am also one of the members, they wanted me to express their support for this conference and are sending their greetings and hope that it will be the success that it already is. These two gentlemen, William Cornelius Hall, who is president of ChemTree Corporation, is a member of the Board of Trustees, and he's a rather up-front, outspoken person that is out promoting nuclear power much like the talk we heard this morning from Mr. Falls.

The other Board member is R. Thomas Sawyer, a world renowned figure in the area of gas turbines, their application to high temperature gas reactors. He's still very active in the gas turbine division of the ASME. He's on the Editorial Board; he actually set up that group from the start. He was also a founding member of the American Nuclear Society back in the old days after the war when it was getting started. He has sent his greetings along with Mr. Hall.

So with those introductory comments, what I'd like to do is extend what's been laid out very well by the two morning keynote speakers, and provide some of the back-up information that will provide the ammunition for those of you who need it, or for those of you who are not convinced of what was being discussed and presented this morning, this should help convince you and this information is available in various publications which I can later direct anybody to who wants it.

It's basically this question of labor power. The development of labor power. And by that, we don't mean pick-and-shovel labor power. Labor power is applying intellect to advancing the whole society. Labor power is engineers; labor power is skilled workers; labor power is people who build the nuclear power plants and upgrade their skills as the technology advances. That is labor power. It provides more leisure. That's what progress and development of a culture is all about. And in order to do that you have to satisfy certain criteria and essentially you can do that in the area of energy by looking at three basic criteria.

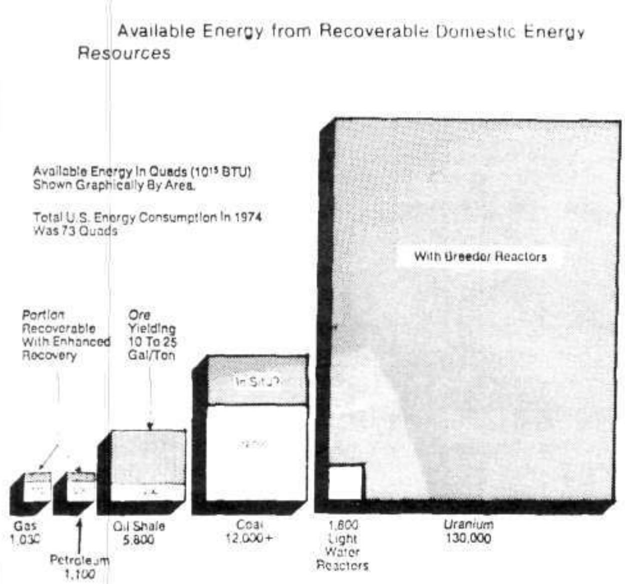
The first one is the quantity of the energy resource. The quantity, that's an obvious one, if you don't have much of the resource, then it's certainly not going to go very far and you can pretty much forget it at this point. So quantity is important, and we'll get back to the subject in a minute....

The other one that goes hand-in-hand with that is the question of density. How concentrated can make that resource. How concentrated can you locate it and get it where it's needed in large quantity. Those combinations, quantity and density, obviously affect the economics and in fact, economics turns out to be the key major of those two quantities. And that will be defined in a minute.

And then the third criterion that you have to use to judge a competent energy program is does it provide for going to the next level of technology. The next level of energy production. Do the technologies that you have that you're currently using, or currently developing, currently bringing on-line, have within them the nucleus of going to the next advance, where we have to be 20 years from now, 25 years from now. In this case, does nuclear fission provide the basic technology for nuclear fusion? Obviously, it does. I think most people in here know that. But we don't have such an energy policy currently in this country. The energy policy that was proposed almost excludes fusion, it's hardly mentioned, and fusion is downgraded and, in a sense, being stopped by the energy policy that's been put forward by the current administration. So, unless the energy policy is judged on those three criteria, you really don't have an energy policy, if it does not meet those three criteria, you really don't have an energy policy. You have some kind of an economic policy like we have now; an economic policy of austerity....

Alright, the question of the quantity. I really don't want to spend much time on it. I'll just show this slide which some of you may have seen (see figure 1). It was put out by ERDA (now the Department of Energy) and it gives basic quantities in the U.S. of the key resources. Now two that aren't on here that I'll get to in a second. It didn't make any sense to put them on here because they're essentially, for the scale of this particular graph, infinite. But let me start to get some relationship of gas, petroleum, and, in this case, oil form oil shale, as compared to coal and then compared to nuclear fission power. First of all uranium 235 would be the current fuel for light water reactors, and then the potential for breeding plutonium 239 from the uranium 238 that exists in very, very large quantities and currently is not used. That's just meant to give you the relative proportions. The resources of biomass, wind and tide, and so

FIGURE 1



Source: A National Plan For Energy Research, Development & Demonstration, ERDA-48 (1975).

forth, I think they were pretty well taken care of this morning. They don't even fit on here. They wouldn't show up.

Now the two that I left off here are solar and fusion. Now those are essentially as far as the resources are concerned infinite. There's a lot of solar energy in quantity, practical solar energy is another question, which we'll get into in a minute. And then fusion for all practical purposes since it is fueled by deuterium which naturally occurs in water and we have 10 million years of it available. So for our purposes that's infinite.

Now, therefore the quantity is fairly straightforward. I should add that the total global quantities are somewhat in similar proportions to what I showed you there. They may vary some if you do that on a world basis, but in general the relationships still hold. We are obviously running out of oil and gas. We have a much larger amount of coal; we're not running out of coal, but coal, practically speaking, and economically speaking, should be used for other purposes especially in petrochemical areas, synthetics and so forth, where their value from a productivity point of view is much more important. We shouldn't be burning them up inefficiently for the next 50 to 100 years as some people propose. There is a much more efficient way of producing electricity. Now the criteria of energy density in this case, energy flux density--which is a surface area measurement--gives you an idea of how you can concentrate this. And how you can concentrate it, and how well you can concentrate it tells you how much that this is going to cost. If you can build a plant small and compact, the capital costs are going to be down relative to the one that is much larger in equipment and plant and so forth....

Now I've put a model in here. I've put four different solars, and then fossil, and then the nuclear sources. Now herein lies the problem with solar. From a technical point of view this should put to rest the whole question of solar as any kind of significant contributor to what we need (see figure 2). Now I will convert this to dollars and cents in a minute, but basically you get a feel, it's very, very diffused. It simply is not concentrated, so that in order to collect it you've got to have a tremendous amount of surface area, and therefore an immense amount of capital equipment. In fact, so much that it's ridiculously expensive and impossible from any economic point of view on a wide industrial scale. Solar may provide heat for some homes in certain climates. That's not even a point for argument. If it can compete with the local energy, fine. It generally won't be able to, but if it can, fine. It's a luxury, really.

So you get different levels. You've got it in biomass; you got it in near surface; you've got it in near-earth orbit; you've got it in near-solar orbit. There may eventually be some possibility of getting solar energy in a more concentrated form if we run satellites near the sun and microwave it down, but that technology is far, far in the future, and even then, the calculations indicate it's not anywhere near what fossil has given us here. Fossil, of course, is concentrated solar energy in the form of coal, oil and gas, and so forth.

And then there's fusion, first generation fission, which we have now, at 50 megawatts per meter squared. The breeder will go up to close to 200 megawatts per meter squared; fusion, in the future, can go up beyond that, depending on the concept. Those concepts are not practicable at this time. This will be developed later in tonight's discussion. A considerable amount of information will be developed on those.

The third point is an overview process calculation that gives you a convergence cost of nine different resources. If you were to produce 1,000 megawatts of electricity from it, remember that, it's producing electricity. Electricity is the way we're going to be operating for a long time to come, since it's the most convenient and condensed way for getting city power around. So that's the legitimate basis (on a large capacity, large industrial base comparison) to compare all of these. Because that's what we want. We want a large percentage of our power to come through these large concentrated resources....

I'm just going to pick out a couple of things on here. I won't dwell on this. I believe a copy of this is actually in the brochure that was given out his morning. This column gives you the current inflated costs, inflated energy costs of gas and oil and

FIGURE 2

ENERGY FLUX DENSITY

MW/m^2

Solar — biomass	.0000001
Solar — earth surface	.0002
Solar — near-earth orbit	.001
Solar — near-solar orbit 5 million miles	1.
Fossil	10.
Fusion [first gen.]	2.-50.
Fission	50.-200.
Fusion [theoretical]	trillions

FIGURE 3

COMPARISON OF COST AND PRICE OF DELIVERED ELECTRIC POWER

	Total Energy Costs (mills per kw-hr†)	Total Energy Price (mills per kw-hr‡)	Energy Payoff Time (years)	Net Cycle Efficiency (percent)
Oil	25.1	45.7	0.2	26.6
Coal	24.2	31.7	0.2	32.4
Coal Gas	41.7	55.7	0.4	17.5
Coal Liquid	46.3	58.8	0.5	19.4
Light Water Reactor	27.8	28.5	0.4	24.9
Liquid Metal Fast Breeder Reactor	33.7	33.9	0.4	34.7
Fusion	*45.2*	*45.2*	*0.4*	*24.6*
Solar Collectors	490.0	490.0	8.3	2.6
Solar Cells	680.0	680.0	48.0	3.9

†Real, non-inflated costs
‡Fuel costs based on 1975 fuel prices

uranium (see figure 3). And this column gives you the cost if you didn't have that cost inflation going on, the hiked oil prices and so forth. So we'll look at the one today that is realistic. This was in 1975-76 so these are a little bit out of date.

You see immediately that the light water reactor in a nuclear power plant is by far cheaper than oil. That's a pretty well known thing, in fact they're cheaper than coal in most places. In fact, utilities will generally, if it weren't for all the political and safety problems, would almost every time pick a light water reactor to build.

Jump down to the solar, just to fill that out in terms of cost, and you see the cost disadvantage of having to build the structure (even though the fuel is "free"). And this says nothing about the fact that you would have to cover up a good portion of Long Island on the east coast to generate power for New York. A number of people on Long Island would be living in the shade or in the dark. The cost is basically the capital cost. It's impossible from any economic point of view.

So this also gives you the energy pay-off time, and you can see it's important. These are in the order of just a few months, all of these, and you get down to solar and clearly, since you don't have the concentrated, dense source, the pay-off period for solar, given the tremedous capital costs is years and years.

A low cost energy program is composed of course, primarily of these dense energy resources: fossil, the different fossils, and fission in our calculation. Fusion we didn't include because we don't have practical fusion on-line at this point, and won't probably for at least 10 years.

We also took one of the high cost mixes and then we took a compromise which is a rotten compromise because you take a little of the good, and a little of the bad, and mix them together and you've got something that's pretty rotten. And that's what you end up with.

Now let's jump down to Table 4 (see figure 4). If you've got your energy being produced from dense, efficient, economic resources, you've got a situation where you're producing a net profit to your economy, your society. You're investing, you're continuing to run your economy, and in fact you're investing in other areas of the economy at the same time. Energy is cheap; you're making that profit, and that profit then goes on to reproduce and continue to expand the economy and society; that's what capitalism is all about, industrial capitalism. The U.S. was founded on that, so it's nothing new.

FIGURE 4 **The Results**

	Low-Cost Energy Plan	Rotten Compromise	High-Cost Energy Plan
Price of electricity	$.027/kwh	$.047/kwh	$.20/kwh
Price of fuel	$4.30/bbl	$8.40/bbl	$25.00/bbl
Net reinvestable profit	$36 billion/year	$14 billion/year	$4.5 billion (loss)
Project labor	500,000 jobs	550,000 jobs	650,000 jobs
Total jobs created in economy	3 million	2 million	500,000
Real wages	+60 percent	−20 percent	−70 percent

kwh—kilowatt hours
bbl—barrels

You jump over to the expensive one and you find that your investment essentially goes to produce a net loss to your economy, because it's so darned expensive to produce. There is *no net* profit to society, in fact, there's a net loss, and you're going to destroy your economy by that type of an energy program. And I'll just point it out to you clearly the direct relationship between the economy and energy and that's an historic fact, it doesn't have to belabored. And then there is this compromise. It is so bad you end up with a net loss on that one as well, even though you've mixed in some of your good stuff.

The important thing that we get there also, and these numbers simply give the net reinvestment profit per year: $36 billion for our program, $14 billion for the compromise and $4.5 billion for the high cost program. This gives you the jobs that actually go into the process. If you spend that $100 billion in these different areas, these are the amount of jobs of actually building the devices that produce the energy. It's true, there are fewer jobs in this low cost alternative. In other words, building solar plants and these other labor intensive devices will create more jobs. But they're a pretty sad lot of jobs and jobs that people aren't going to want. In fact, they're jobs that destroy any semblance of society and labor power. The other very important thing is this question of reinvesting this profit into related industries. That initial $100 billion creates this amount of jobs in related industry. And that's the key. That's the key to developing the basis to eliminate unemployment and upgrade the standard of living and labor power. So this shows you the difference between the high and low cost. That's the key in terms of jobs and in terms of dollars and cents.

So I think that's enough said on that. I'll just get into the third criterion and illustrate what I mean by being able to upgrade your basic skills, your technology and so forth. Being able to supercede the technologies which exist now through the technologies that you're creating to advance from where you are now.

And that's most clearly seen in terms of nuclear power since that is clearly the way that we have to go. And the relationship between nuclear fission and what it provides in terms of the basis for nuclear fusion. Now, I'll just go briefly through a few examples. One very important near-term goal which has not been achieved yet, in the area of nuclear fission and it will also be important in fusion, is the question of mass producing power plants. In order to meet those goals that we laid out this morning, those expected goals that existed a few years ago in the third world and other nations of the world, clearly the only way we can provide that energy is through mass producing nuclear power plants in the advanced sector, in the United States, Germany, the Soviet Union and in France and in other countries that now produce fission plants. This is a picture of one such mass produced reactor (see figure 5). This plant is going to be located off the coast of New Jersey by Public Service Gas and Electric and has been delayed again and again. The concept is simply to produce these plants in a large coastal shipyard in segments and float them off into the ocean and float them where they're supposed to go anyplace in the world. Westinghouse and Tenneco originally got together Jacksonville, Florida and designed and started building the plant. Westinghouse now has full ownership of the thing. And it is basically a very large ship-type operation. Floating nuclear power plants instead of submarines. An island was built. In this particular one it is $2\frac{1}{2}$ miles off the coast of New Jersey.

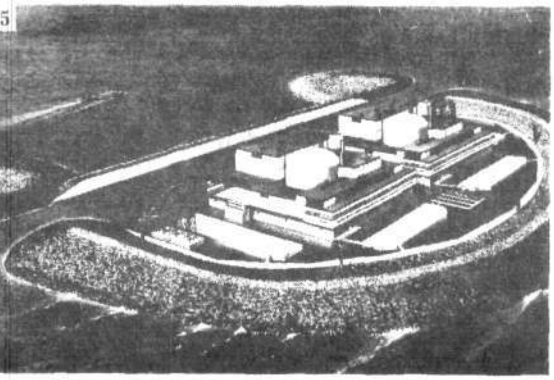
This is the mass production facility, (see figure 6) and it is being constructed in Florida, in Jacksonville by Westinghouse, and it's going very, very slowly at this point because the orders have been canceled and the few that are left, are delayed. This plant was built to construct one nuclear plant a year. This is the plant ready to be towed out to where it goes. And there are three plants in progress. They're talking about taking roughly 3 to 4 years to build these nuclear plants on a mass production basis. That could even be decreased, and they agree, and you could upgrade the plants and build more of them, more than one a year.

The Soviet Union has the simplest facility under construction on the Volga River, which is called the Adamak facility and it will do the same thing. And they intended to export reactors that way as well....

Now the other area that I wanted to address is this concept which has been thrown around and designs have been put forth for at least 15 years now. That is this idea of building what's been termed the Nuplex, which is really an integrated industrial complex (see figure 7). Taking a nuclear power plant, or several nuclear power plants as the central source of power, since it's concentrated and you can put these plants side by side, and then build up industries either agricultural or manufacturing around them and use the various sources of energy. Mr. Falls actually presented that concept in a variation this morning when he said the process heat from this underground nuclear plant would be used to provide the process heat for Ford Rouge. That concept has been put forth for Third World development by the Third World designers themselves, India in particular. Basically the concept that they designed was the nuclear power base to provide all the energy needs to start their agricultural industry. Now that means not only desalination of water, but also providing the energy in terms of heat to make fertilizers and so forth which would then be distributed in the area. Now these are all concepts, they are not new; they've never been developed practically at this point. The economics has been worked out. It's just a question of the whole political aura around nuclear power.

Now this concept is also very important in terms of fusion power, and developing it through fission, developing the various technologies that are going to be developed in the process of expanding fission power. Take a look at a fast breeder reactor, which is the next generation fission system. We're going to be providing the basic technologies that are needed to bring fusion on-line sometime before the end of this century. Now for example, the liquid metal technology associated with the liquid metal fast breeder has the same kinds of cooling systems that are going to be needed for the fusion system. In fact, they'll be needed also to provide the mechanism for breeding fusion fuel within the fusion reactor itself.

FIGURE 5



An artist's rendering of the Atlantic Generating Station of the Public Service Electric and Gas Co. of New Jersey.

These technologies are essential for bringing fusion plants on-line. Fusion is going to be the most difficult thing that we've ever addressed and that we'll accomplish this century. It's much more difficult than the man on the moon. The technologies don't spring out of the air; the technologies spring from the development that's going on now, the development of nuclear fission, the fast breeder. The transition from fission to fusion will very likely be fission-fusion hybrid reactor, which is simply using fusion neutrons to bring plutonium or uranium from thorium. It will breed it much more efficiently than the fast breeder itself. We simply don't have that technology available yet, and we won't have it until we go through the fast breeder stage.

Now, finally, I just want to point out what fusion power ultimately means in terms of the question of resources. Again, providing the capability to supercede where you are now by the advanced technology to go to the next level....

Resources are limited, not only the energy resources, which we've covered in some detail, but the resources of aluminum and steel, many metals. Copper is already running low; zinc is running out. We're running out only because we don't have an economic way of extracting it from the many low grade ores that are available. So, that's where fusion comes into its own. It is the only nuclear power system that can provide the basis for actually removing what seems to be a limitation on the various metals that are obviously going to be much needed as we build more and more power plants and other industries. It's the basis for actually busting through that barrier. People say, "We're going to run out of this." That's hogwash. We're never going to run out of it. We're only going to run out of it to the extent we don't apply our scientific know-how, our intellect, to providing a solution to the problem. G.E.'s slogan used to be "Progress is our most important product." That's been historically what has been done in this country and other countries as well. I think the best example is this country.

Fusion will provide us energy not only to produce electricity. We can produce electricity in fusion plants by a typical thermal cycle. Simply extracting the heat from the fusion reaction and through a liquid thermodynamic cycle. A very inefficient way of doing it, but it's the best way we've got now. It's certainly not the best way to go in the future. In the future what we want to do is go to direct conversion.

I'm not going to go into a long, drawn-out technical discussion of direct conversation. Fusion plasmas essentially exist as charged particles; you have the energy already in a medium of charged particles. The fusion plasma in a TOKAMAK is simply a large volume of charged particles which is needed to produce the fusion reaction. Much work has been done on working out how we can actually get that energy out correctly. Don't go through the thermocycle; let's take the charged particles directly and take the energy off the electricity in that form. Conversion will be 90% or better. Compared to the 30 or 40% of the thermodynamic heat transfer cycle. Fusion allows us to use the fusion plasma directly....

There's a device called the fusion torch, which at this point is a far out idea (see figure 8). For those of you who are at all familiar with it this is the solution to that question of limit of materials, limits to growth because of the "fact" that we're running out of materials. There has already been a considerable amount of theoretical work done on this device. You simply bring a stream of plasma out of the reactor, you inject at some point downstream in the taconite ore or worse grades of ore that are not economical to extract at this point to use in the steel industry, and the kinetic energy of the plasma is transmitted to this ground up taconite ore and you vaporize the whole mess in there and at some point further downstream the process is cooled down and you selectively pull out the elements you want....

FIGURE 6 **Mass Production Facility For Building Floating Nuclear Power Plants. Under Construction in Jacksonville, Florida.**

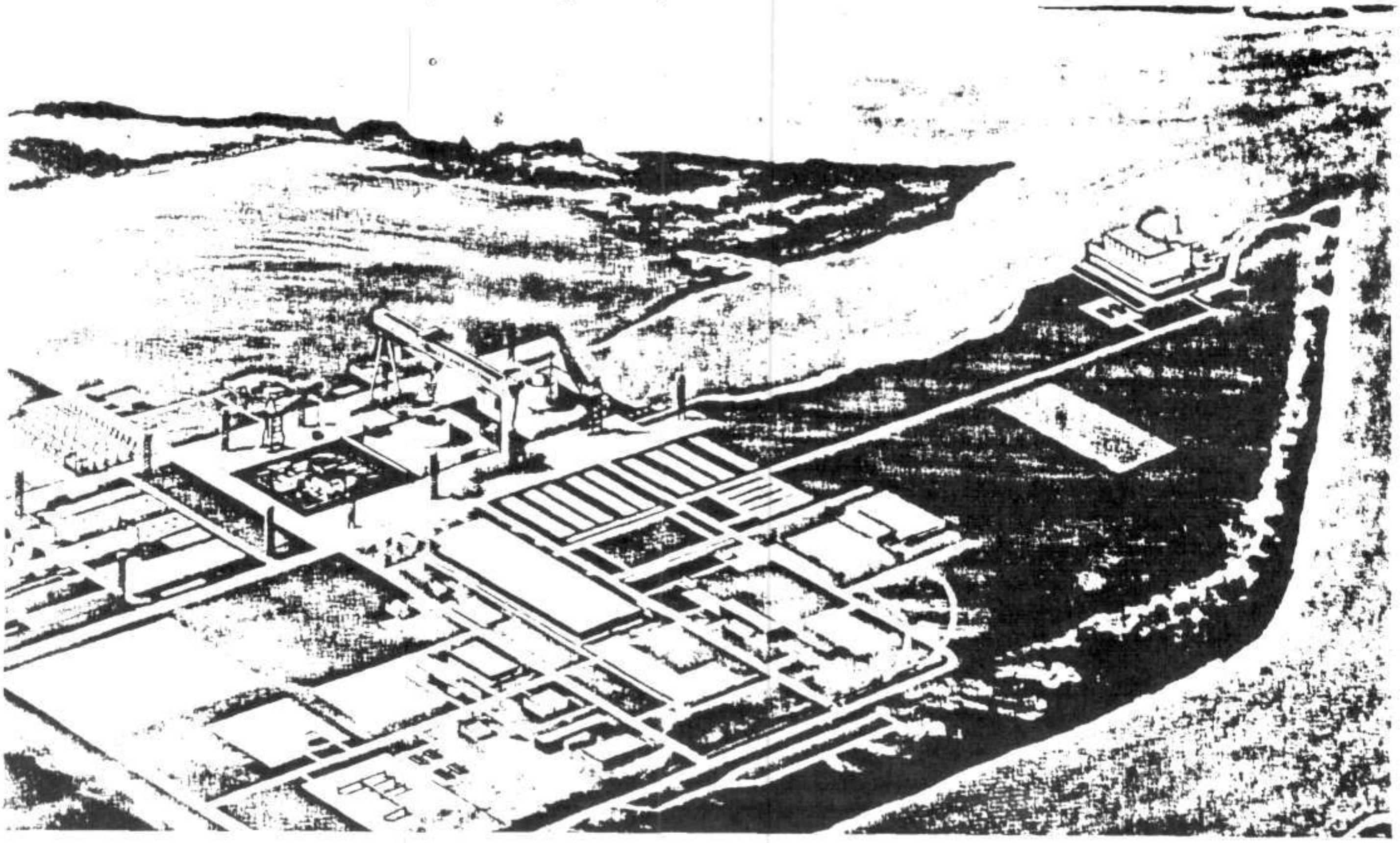
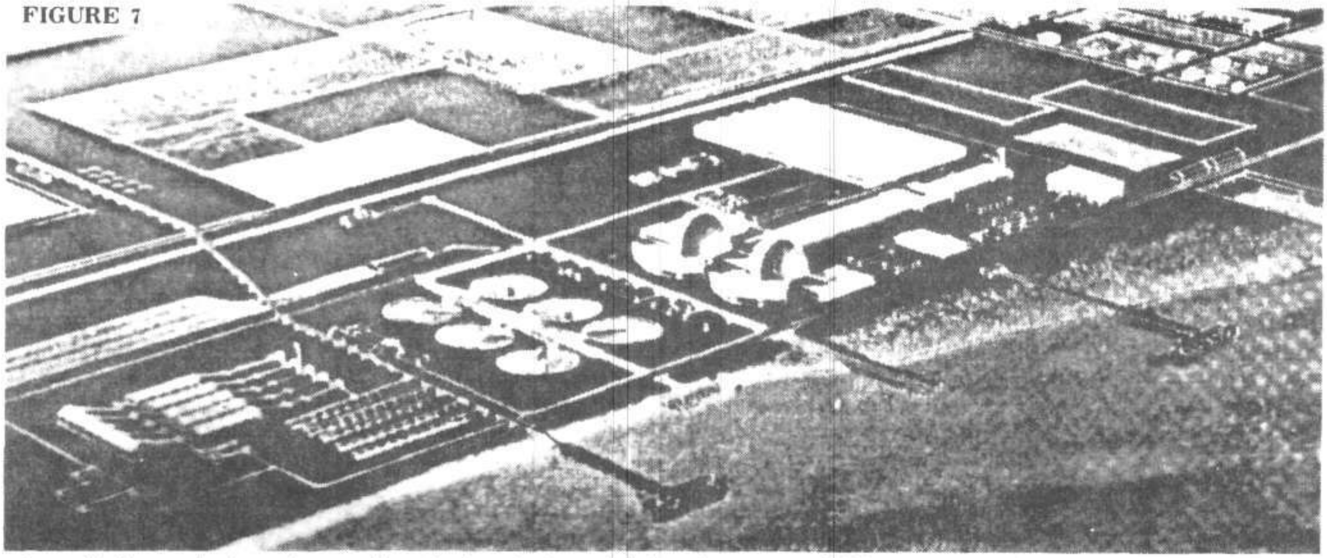


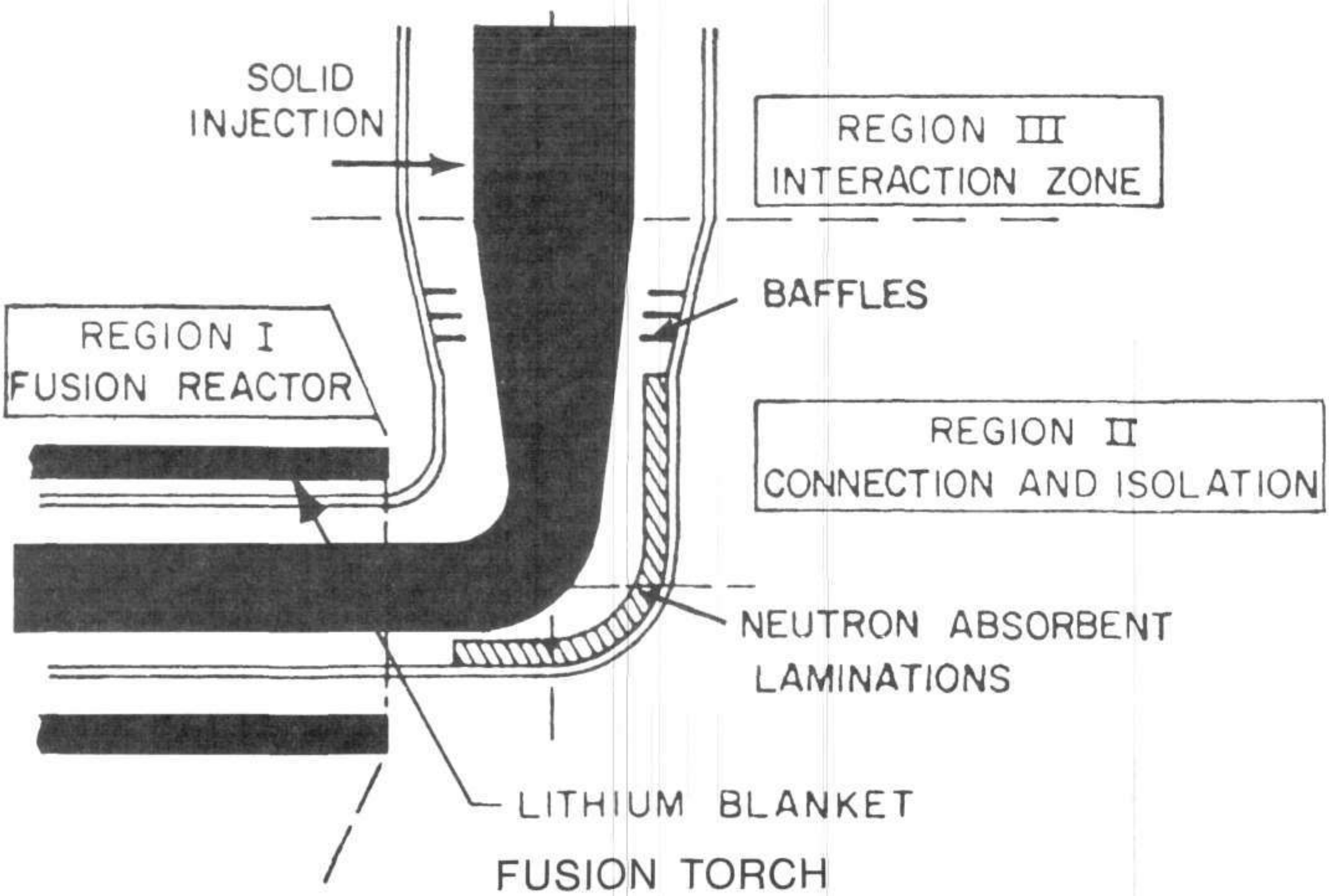
FIGURE 7



An artist's rendering of a nuplex design that could desalt up to a billion gallons of salt water a day while generating more than 2,000 megawatts of electricity and helping to feed 6 million people.

So basically I just wanted to leave you with those ideas about the next level, which are based on where we are now and where we're going. What is crucial is an energy program that directs us in that direction, and we don't have one right now. We had one; we had one four years ago. It may not have been going there as fast as we would have liked it to--but we've been moving very quickly backward since then, and its a tragic situation. This is something that should cause everybody in this room concern and motivate them to do something about it. Thank you.

FIGURE 8



Dr. Morris Levitt

Executive Director, Fusion Energy Foundation.

Editor-in-Chief, Fusion Magazine.

There are basically three things that I want to talk about, because I think if you don't ask Dr. Monsler a lot of questions, you're missing a good opportunity.

We know that initially after Carter was elected, for example, surrounded by his coterie of sun worshipers, very early on there was a briefing set up with Carter and Schlesinger by top officials of the fusion program. We know that the response to this sort of briefing was essentially the statement on the part of Schlesinger to the fusion community to get lost. And that attitude has not changed significantly since then despite the fact that there has continued to be major progress.

Now, most recently one can juxtapose the following three coupled sorts of events. One is the type of result you've seen indicated here. And I'll just very quickly indicate that there's certainly a parallel line of development in magnetic confinement. The second is an unprecedented string of offers, public, semipublic, private all rendered in utmost seriousness, however. Now these include a chain of events that we've reported on in Fusion Magazine where we're in the process in one case of trying to get legal counsel to get access to documents that are still being maintained under this totally artificial rubric of "classification".....

We had a string of events in which the Vice President of the Soviet Academy of Sciences, E.P. Velikhov, who is the titular head of the Soviet fusion program, has on two occasions come across with offers that would have the political significance of coupling together major parts of the U.S. and Soviet fusion research efforts.

So, Velikhov, noting that the United States had abandoned one of its lines of research, which is something called Cylac, which is a donut shaped device in which you dynamically compress the plasma with a time-dependent magnetic field and a nice big power supply, proposed that the Soviets bring one of their imploding liner devices and we plug it in to the Los Alamos power supply and that would be a nice bit of collaboration. Now the first thing we heard after that proposal was that suddenly this line of research had been classified, and we rushed to the presses to get another exclusive scoop for Fusion Magazine. No sooner had we printed the stuff than we found that it had been de-classified. But now there was no funding for the line of research here, so this created something of a technical difficulty in hooking up the U.S. and Soviet programs here, unless they were willing to underwrite our half also.

Now this comes in conjunction with another offer which I'm going to discuss at the end, because I think it raises a number of extremely interesting questions. We received word from our Chicago spies this week that Edward Teller gave a presentation and he was questioned afterward about the proposal from the leader of the Soviet laser fusion program. I don't know whether Dr. Monsler considers that the competition or something that helps keep him in business, but in any case this is one area where there is a strange situation. The Soviets have quite a different approach conceptually, hardware-wise, to laser fusion. Basov has proposed using large thin-walled pellets with very modest laser energy. And there's certainly a number of people in the U.S. laser program who are suspicious of his claim that the Soviets have achieved break even conditions on this basis. That's a question I want to take up in the context of discussing some of the scientific implications of fusion research at this point....

What's important politically is that at a conference in the Fall of practically all the living U.S. Nobel laureates in physics, Basov flew in. He was one of the signatories to a call signed by most of the living U.S. Nobel laureates for a vast expansion of our efforts in nuclear power development and specifically, fusion. At that time, Basov, in the context of announcing this now controversial assertion that the Soviets had reached breakeven, also offered that the laser fusion program's much more heavily couple together and that this be another area for joint research. This would clearly also have implications in terms of the word that kept appearing in the upper left hand corner of all of Dr. Monsler's slides. They all said "unclassified." And in order to have a collaborative effort the question of whether or not one could continue to classify any part of the energy oriented research program would certainly be called into question....

Then we had the Rudakov case which many of you are familiar with. Rudakov is the head of the Soviety E-beam program. You will recall, he electrified a U.S. audience on the West Coast and elsewhere detailing a number of the specifics on how the Soviets had achieved the first major provable fusion burn by impinging electron beams on the same sort of targets you've seen here. That of course led to the impounding of the blackboard that Rudakov wrote on, and the classification of every line of evaluation of his presentation and from our standpoint even more disturbingly, classification of stuff that clearly by no stretch of the imagination could trail off into the realm of making weapons of various sorts....

So in a nutshell we've had this blast of constant offers from the Soviet Union of collaboration in just about every area of fusion research.

Then most recently, in an address before the Foreign Policy Association in New York last week, Premier Fukuda of Japan indicated that Japan was putting on the table a fund of about one billion dollars for joint U.S.-Japan fusion research which would not be restricted to those two countries....

Now aside from the importance of those deals, I'm referencing them in order to pose for you as sharply as possible what is therefore involved when we get word this week that it has come down through the pipeline in the DOE and into the fusion division and its various research programs, that as a result of the wonderful success of Sun Day in Rocky Flats, Colorado (where 50 demonstrators were sitting under tarpaulins because it was raining), the Administration, largely through Schlesinger's engineering, passed the word that we had to squeese another $100 million out of the extravagant energy budget for solar energy. Now the specifics of that as far as we know, the fusion program has been told that in the next fiscal year it has to cough up $30 million, and in the following fiscal year, $100 million. We are already in a situation where the program is absolutely resource limited. That is, no one could say with any reasonableness how fast the program could proceed until it runs into those problems which it creates for itself by virtue of throwing up scientific or technological problems that we are now in a position to deal with. The program is limited by the cutting off of resources just at the point when in terms of its own self generated dynamic it would be in a position to move ahead as rapidly as possible.

Now that has very much to do with the more general problem that we addressed here today. We have allowed the opposition to set the agenda. As long as you're living in a universe that's defined by the linguistic nightmare of conservation, of what the Office of Management and Budget calls "cost effectiveness," or "zero-base budgeting," how the hell are you going to apply that kind of systems analysis to the type of research you just saw indicated here? You're talking about technological steps that no one has ever seen before.

Now that's the standpoint from which a consideration of fusion becomes crucial. I could not, I think, in honesty argue here that unless we have fusion in the year 2000, or the year 2005, you will all be guilty of genocide, or some such thing. It is the case that if we were to somehow manage to steer our way through the ennumberable number of economic and political crises in the world today, through wizardry at diplomacy that we've certainly not seen from many, many would-be statemen on this side, the sheer amount of energy available from fission is certainly adequate to meet some arbitrarily determined historical energy growth rate. You pick it: 5%, 7%, if we start breeding the stuff, you begin to get limited in how rapidly you can develop because there's a limitation to how rapidly you can breed new fuel....

I think the more fundamental issue, and what we would be talking about if we are approaching the situation with the sort of challenge that actually makes sense for humanity to be talking about now, would be the colonization of the solar system. Instead of the agenda being set with the charts that show how many barrels of oil and tons of copper, and so on, we would already be planning for ourselves how to transform the atmosphere of Mars and Venus; what's the resource inventory there; how do we use them as a launching pad for the next wave, the next burn wave of development of the human species. And this isn't science fiction. It would be the appropriate stage of development that the human species would be at today. And that would indicate that we would be setting the right kind of agenda.

Now that's why a discussion about fusion can never be hinged on "if we don't commit the resources, we may run out of energy in the year 2002 or 3003." That's not the issue. Fusion represents that frontier area of science and technology which gives us a very clear index of how well or how poorly is the human species doing in terms of its ability to self-consciously set its own agenda and to politically take control over its own future development. So certainly to the extent that we're not able to do that, we're going to run up against a lot of associated problems. With the present kind of fusion program we cannot say if we will ever have fusion.

But the point I want to stress here with respect to fusion is that until we can say that the program is going as fast as our ability to stimulate creative inquiry, it is not going fast enough. And that can't simply be measured in dollars and cents. At the same time we're stuck with the practical question of maintaining the program on levels so that self-evident significant progress continues to be made, and we avoid what would be the disaster of allowing the program to be set at funding levels so that key research groups are literally chewed up and demoralized. We have a situation in which a handful of scientific cadre, who have committed themselves to solving the most fundamental technological problems we face today, literally require tremendous amounts of moral support above and beyond that which they get from their own work precisely because they are in imminent danger at any moment of any of these lines of research being cut off, and of the fact that they exist in a universe where there is nothing like a clear commitment to going ahead with the program.

Now let me briefly show you some of the results for the type of fusion research that involves the confinement of a plasma with a magnetic field that indicates that something that sometimes is bandied about by people like Schelisinger in public meetings. Their favorite line is that fusion has always been 20 years away. That's quite a remarkable statement. I don't even think Schlesinger could spell fusion 20 years ago. The budget back in that period was on the order of perhaps a million dollars or so. We have seen over the last 2 to 2½ decades an almost direct correlation between money into the program and results out. So anybody who says that money is some dirty thing and doesn't buy results: I'll show you the approach toward ignition temperature; the approach toward density of plasma.

It's almost sufficient to show some of the main categories, or parameters for the main line of research, the donut shaped Tokamak, in terms of looking at the progression in orders of magnetude of approach toward the conditions that are needed for what's thought to be a reactor. If you recall some of the slides that Dr. Monsler showed you.

If you look in the upper left hand corner, (see figure 1) the confinement time per plasma; in the upper right hand corner it's the temperature of the heavy ions. The lower left is the product of the density times the time that you can confine the plasma. And then finally in the lower right, sort of the same thing, is the confinement time. You can see every hatch mark indicates a factor of 10. Now you can see that from 1955 say through 1975 two decades, typically in each one of those categories there's been an increase by a factor of 3 or 4 orders of magnitude to the point where we're almost at the confinement time that would be required, that is, something on the order of a second. We're crept up to something like a 10th second in experiments at Princeton and in the Soviet Union. A machine has just been turned on in San Diego, California, called the Doublet III, at General Atomic, that it is hoped, will get us up in the regime, that means we're talking about near breakeven conditions.

Temperature is something fusion scientists like to scare people with in terms of getting up to 50 or 100 million degrees and so on. Another way of measuring that is in thousands of electron volts, and there are all sorts of schemes to do that from passing currents through the plasma to bombarding it with neutral beams, and again you can see that we're getting up within an order of magnitude of the required condition. We're getting up to some tens of thousands of degress in this type of machine. In mirror machines at Livermore, next door neighbors to the laser people, these mirror machines quite easily get 200-300 milion degrees. Now the pay off comes if you can get the thing dense enough and hold it long enough so that enough fusion reactions take place. The product these has to be, for a D-T reactions, something like 10^{14} particles per centimeter cubed x seconds. The small machine, call the Alcator at M.I.T. reached that quite some time ago, back in '75-'76 or so. Again, the machines that are now under construction at Princeton and are just turned on at General Atomic, are expected to put us on the other side of that breakeven condition...

There's another way of looking at the whole situation graphically. Back in the old days there were just isolated pockets of fusion researchers, purple one, green one. They suffered from low temperatures, and the product of density x confinement time was down also by several orders of magnitude. This is the early donut shaped machine. This is the mirror machine. These are torodial pinch machines that try to squeeze the plasma with changing magnetic field. That was in 1974. Now this is about the period where if you looked at a plot of fusion funding, it looked something like a linear increase in the early '70's. And over the last few years that linear increase get us all these nice blotches moving toward the promised land in the upper right hand corcer (see Figure 2). In the last few years, the line of budgeting increase has reached a plateau, which if you take into account inflation, and so on, it probably represents almost a decrease in the overall resources available. The group at M.I.T. took advantage of an idea that had first been proposed by someone in the Soviet program, Artsimovich, and built a small clean machine that used a high magnetic field that they are capable of building at M.I.T., and moved right up into roughly the breakeven situation. The French in their TFR;

likewise the Soviets with T-10-PLP, which were bigger machines with somewhat lower magnetic fields. We started to get tremendous temperature increases in the mirror machine at Livermore, the upgraded version of that, and Oak Ridge came in with a very nice machine to study these processes scientifically.

What is projected for just the immediate period ahead: Further increases in product of density and confinement time, as well as temperature. The Alcator C was finally approved on the order of $5-$10 million concept is ultimately suitable as either a pure fusion reactor, or to product neutrons to very efficiently breed plutonium in the fusion-fission hybrid...

Then in here you've got the big machines that are planned by the Soviets; the joint European efforts; and this red-hot Japanese effort here, the JT-60, with various other developments trailing behind. Until finally it is conceptualized that on the basis of all these efforts some machine will be built which combines the appropriate set of features with an actual experimental power reactor, depending on what the level of funding is, anywhere from the 1990's to somewhere off in the unforseen future.

The way that the Division of Magentic Fusion tries to estimate when it's going to arrive at machines that look like real power reactors is by referencing the total operating budget per year. So that you're taking into account: are there sufficient increments, or increases in the budget from year to year, such that as it becomes appropriate to bring in all sorts of associated engineering, technological backup, that that is coming in pace with your scientific results, so that you're coverging on a whole machine. Not where you turn on the plasma and somebody tells you, "oh, by the way, we never did get around to discovering a first wall material." You can see, with a variety of rates and increases of funding critically in the late '70's, early '80's, which determine how quickly you're able to put together the scientific and technological package, then 'you pretty much coast in to the next couple of decades, building the stuff, testing it, de-bugging it, and so on, and depending on how fast this thing goes up, you converge on a reactor anywhere from 1990 to the year 2000 or so. However, if you fall below a certain critical threshold level, in this critical gestation period that we're going through now, at least so far as concerns the Tokamak, you reach this never-never land, called Logic I. And if you look at the numbers, we're now into this land of Logic I which, guess what?...never converges....

So in most cases when somebody gets up, as happened today, and gives you some kind of shopping list of problems that fusion has yet to solve, it's very likely that for most of them you're talking about situations where you're in the situation where the funding has simply not been. It's one of these round-the-bush things where the funding is constantly cut to prevent you from getting the data which you could then put up here and say, "look, there's the same palpable progress we gave you for your money as occurred in every other line." So that's the second thing, then. Having not set the agenda in the appropriate way, having not posed fusion as that line of development by which we can

FIGURE 1 **Progress in Magnetic Fusion Energy.**

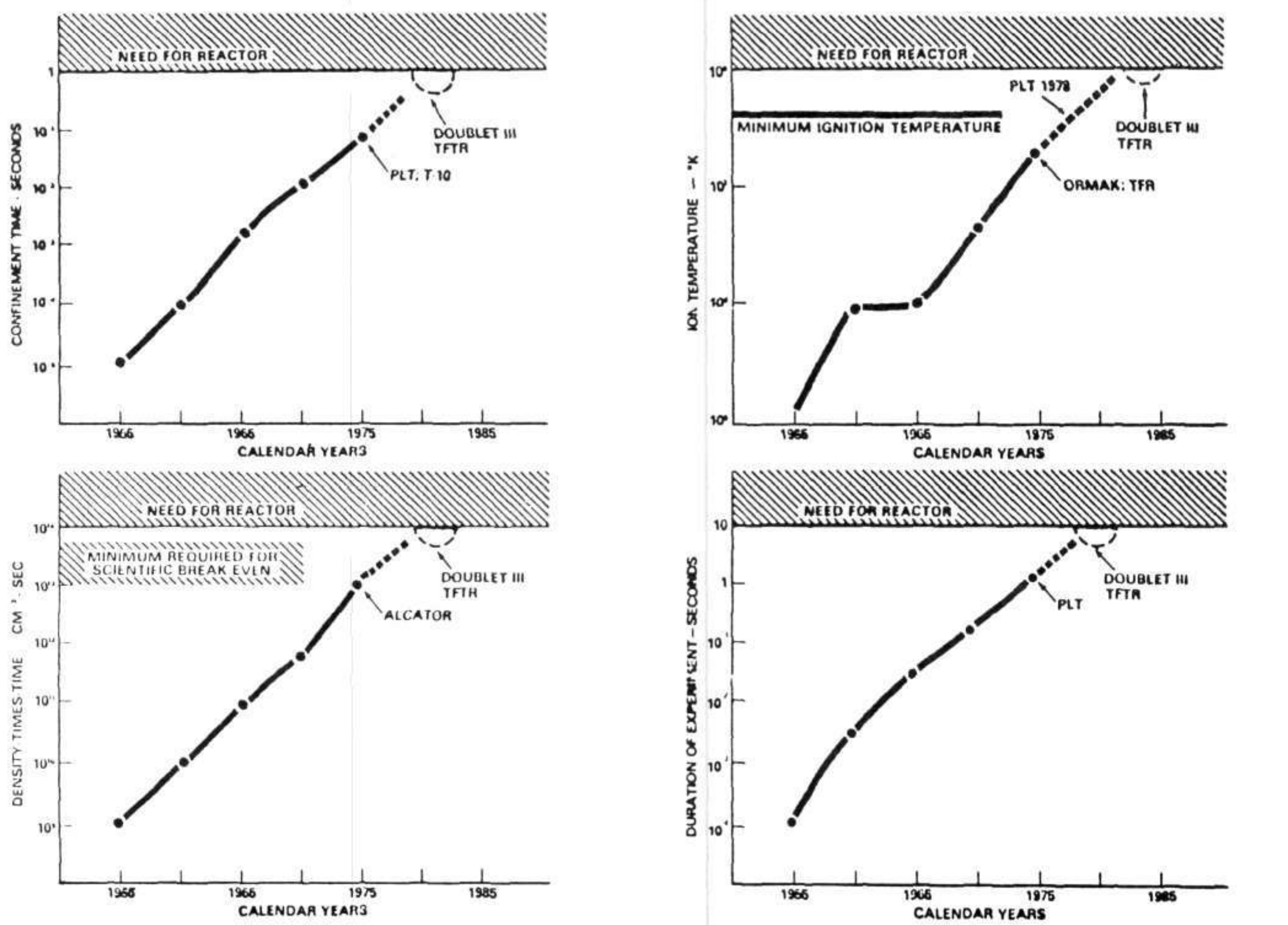


FIGURE 2

TECHNICAL PROGRESS AND OUTLOOK IN MAGNETIC FUSION

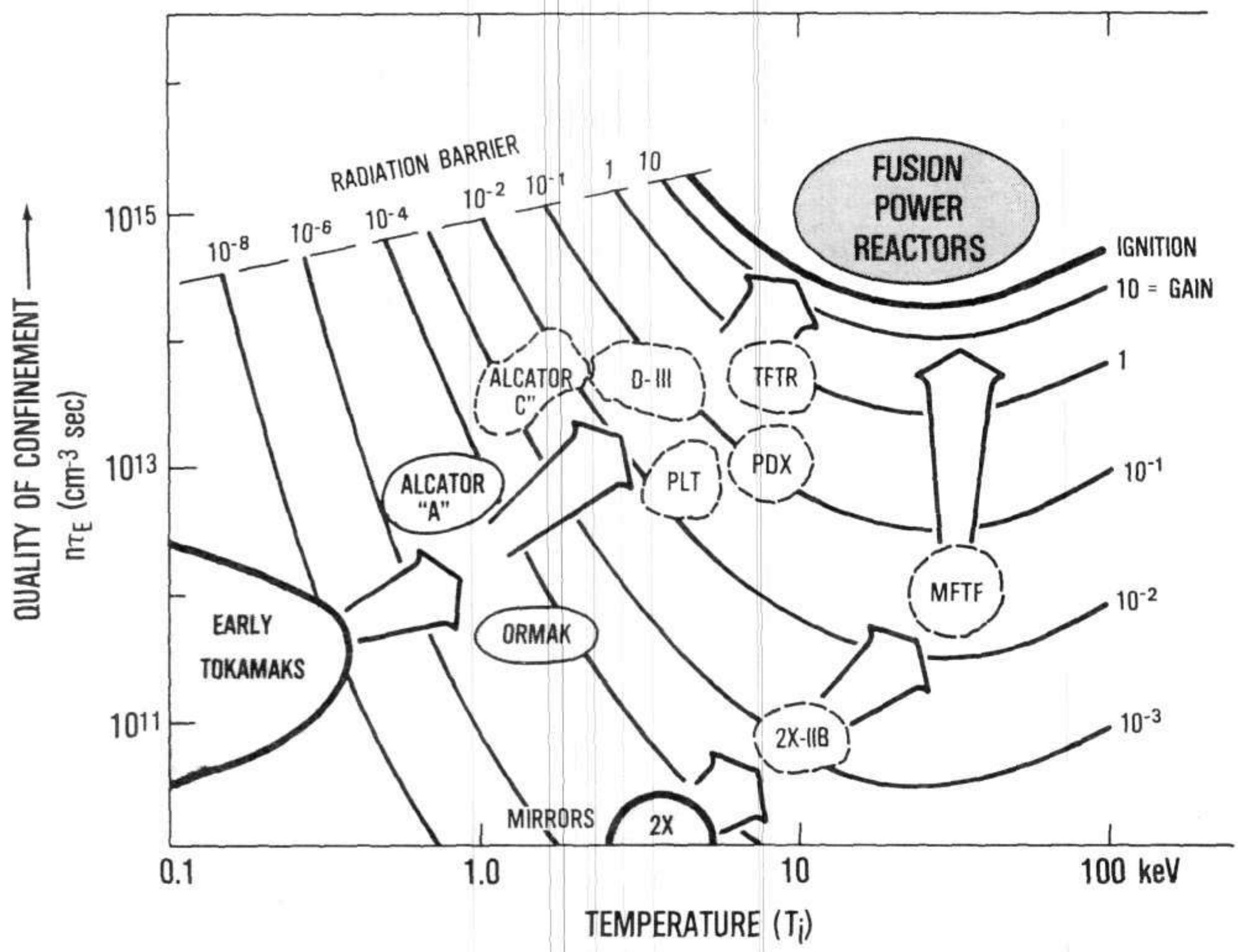
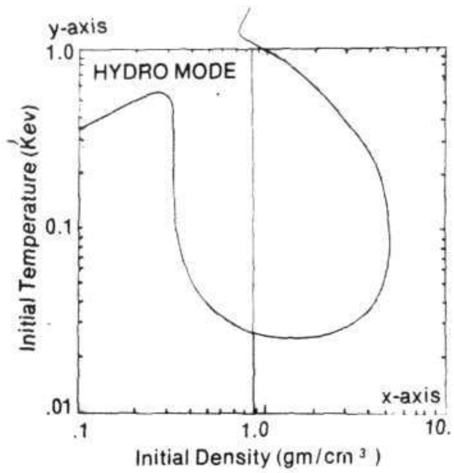


FIGURE 3



"WINDOW" TO FUSION?

This graph prepared by Ronald Kirkpatrick shows an area in which the nonlinear, self-stabilizing properties of laser-fuel pellet interactions in the fusion process may provide a "window" to fusion at much lower laser-energy input than existing U.S. computer models have shown as possible. The y-axis shows the temperature of the plasma, and the x-axis shows the initial density of the fusion pellets. Both scales are logarithmic. That is, increments are by a factor of 10. The line perpendicular to the x-axis at approximately 0.8 grams per cubic centimeter is the maximum initial density that can be achieved in fuel pellets.

The unshaded area in the upper left, marked 'hydro mode', is an area in which U.S. computer models have predicted ignition to occur. This area is characterized by the requirement of very high laser energy input to heat the plasma. Soviet researchers, however, report near-ignition conditions achieved with much lower plasma temperatures. The "window" plotted on Kirkpatrick's graph [unshaded area, center] shows an area where, by taking advantage of the nonlinear properties of the fusion reaction, such reactions may occur with far lower laser input.

measure the extent to which we've unleashed our scientific creativity, we find ourselves in the situation where despite having achieved progress which converges on the break-even condition, into a situation where the timetable for producing a commercially viable reactor is now essentially resource limited, with the general price tag being placed on the order of $15 billion....

Now what does fusion research itself tell us about the nature of the physical universe? This brings us back to the Basov thing.

We reviewed a paper that Los Alamos had published recently in which a number of the same type of computer codes whose results you saw here indicated (see figure 3). Some of you may remember a picture of what looks like a teardrop. What that teardrop represented was the region of conditions under which the computer told you, don't go there; you won't get much energy from fusion, whereas if you were in some other region, you were expected to get fusion. Given the constraints that are placed in actually manufacturing these things, it turns out that you are therefore restricted to a relatively narrow volume of what's called phase-space, the range of physical parameters under which you could expect to get significant amounts of energy out of laser fusion. The interesting thing was that when you point on that plot where Basov said the Soviets were achieving laser fusion, it was out in the no-no territory. As a question of fact either those results have been achieved or not. In any case, what struck us was that many U.S. scientists, and especially in laser fusion programs, took it for granted that given the results that you saw here in terms of matching the theory and experiment, that that must necessarily hold for every conceivable kind of physical condition. What we posed at the time is rather that in looking at the special energy dense conditions you obtain in plasma research, there would be every reason to believe that you could obtain fusion under conditions where the computer would tell you, "don't look; don't operate there." Now, I'll remind you of some of our more favorite results of this sort.

There is solar energy being produced by fusion (see figure 4)—now there is a hell of a plasma and if you look at this thing from enough sides with the help of NASA, you can see that what you have there is a giant vortex sheath of plasma. That is a highly ordered structure despite the fact that you are talking about distances here in which the earth would appear as some kind of spot on the picture. This is our back cover of the latest FUSION for our celebration of Sun Day.

Then there are results that many of you have seen in terms of the extraordinary array of filamentary vortex structures that are produced in small fusion machines called plasma focus coming from the laboratory of Dr. Stephen Bostick at Stephens Tech in New Jersey. Now keep those two pictures in your mind (see figure 5).

Let me end by summarizing for you a situation that poses a special challenge jointly to our colleagues who are engaged with such valor in the fusion program, and also those industrialists and especially utility people who are making some sense out of the situation they find themselves in. Earlier, John referenced the article by Dr. Wells from the University of Miami which is in the latest issue of the **International Journal of Fusion Energy**, which is a powder blue book on the back table. Wells produces

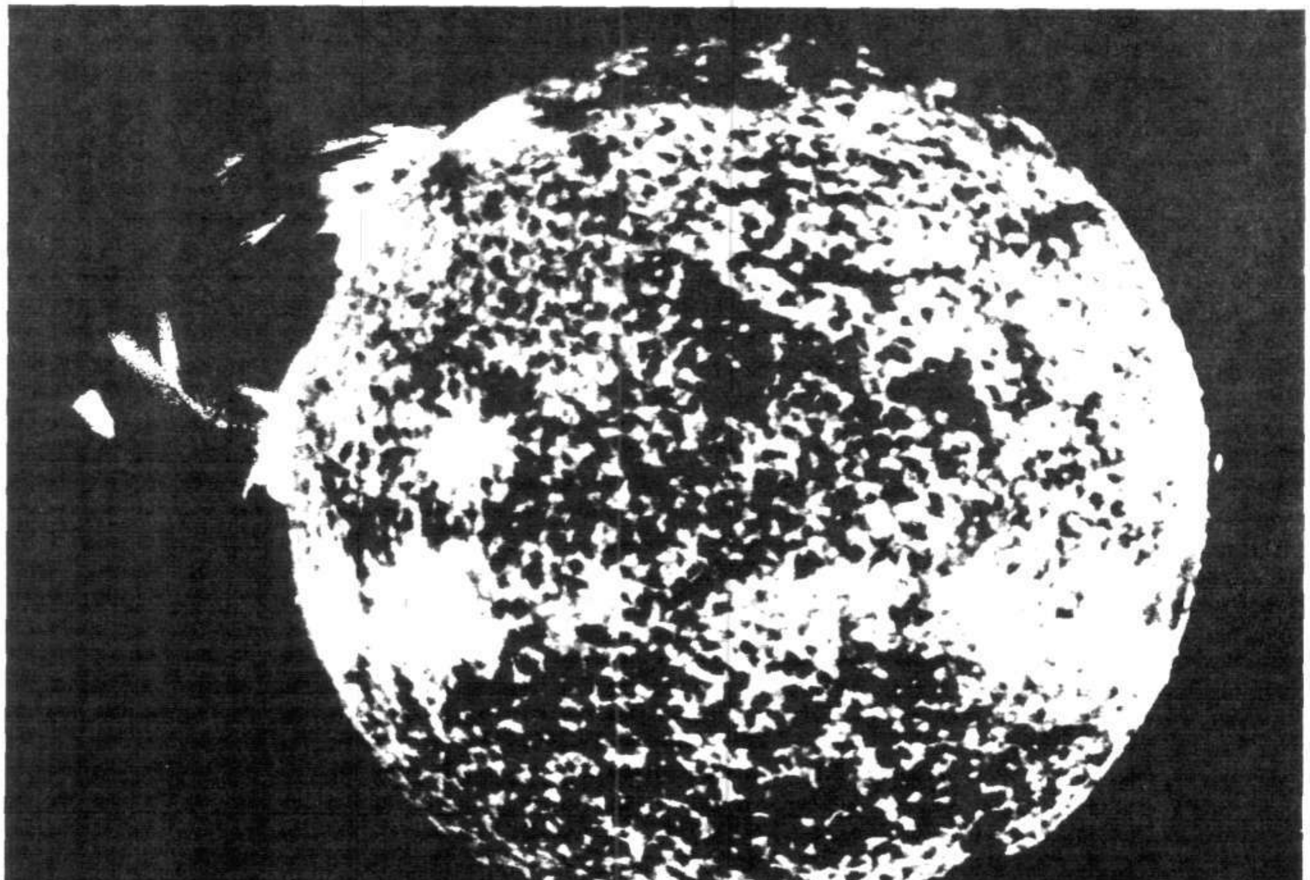


FIGURE 4 **Sun Flare: a highly ordered, giant vortex sheath of plasma.**

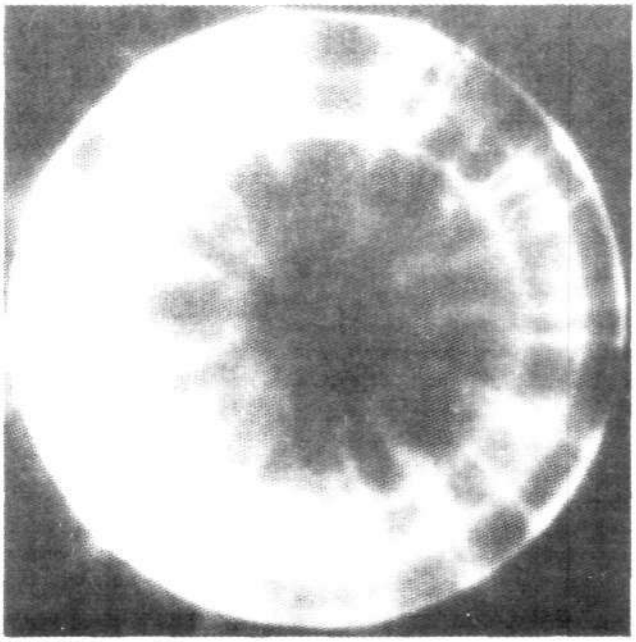


FIGURE 5 Filamentary vortex structures.

things that look something like the picture I just showed you, except they are large scale donuts of plasma, and he blows them off from two different electrodes and they come off rotating in opposite directions against each other. Now quite aside from the fact that this may turn out to be a means of efficiently confining and heating a plasma, Wells has shown theoretically, that that type of structure in an sense minimizes the amount of energy that you have to deliver that system in order to form a plasma in a relatively stable geometrically well-defined structure. That is, there is an interesting kind of reciprocity there. The highly ordered stable structure, in a sense, is the physical universe's way of mediating the minimization of the efficient use of energy which you deliver when you plug your machine in and turn it on.

Now, there is a whole line of physicists, natural philosophers, principal among whom were Leibniz, who were quite pleased with finding the result that one could generalize this kind of situation. That there was this kind of general minimum principle operating. Yet we have a different kind of problem when we look at the mysterious Basov results, or experiments that are done when you allow an energetic electron beam to go into a simple cylinder of plasma. There you find that you get highly ordered structures like this huge concentrations of energy intense electric and magnetic fields. But that there is no stable structure. The minute you seem to achieve one, that seems to become the precondition for the system immediately evolving into a different geometry, further differentiation, and when you look at that theorectically, if you had a computer following this thing, precisely at the point where the system appears to achieve its highest organization and it's obeying the equations that you get from this minimization of energy principle and the computer is not reading "tilt", it's got all these things you put in, as you do in the lasnex code--at precisely the point, in very simple experiments, where you finally get the maximum concentration of energy, because all the little disturbances merge into one big one, your computer reads--tilt. You get a result that apparently has infinite self-energy. Or you can no longer add up the numbers in the thing.

Now that, I think, locates, to bring things a full circle, the problem in conceptualization that we face when we put forward the question of what is an appropriate fusion policy. What is being demonstrated directly in those experiments and what we have seen in terms of the moments of compression of laser fusion, where one geometry of energy density then creates the condition for a totally new set of physical laws to come into play, is the creation of the conditions then yet for further absorption of energy and more efficient compression: What we're seeing there is the universial process of self-development taking place.

Now the challenge that the fusion community will face is, at some point, its going to deal with the question of--will it be able to produce efficient enough fusion reactors to give us full access to the energy densities and the resource base that humanity will need in the future without taking that fundamental feature into account? Is it going to be able to move off the safe territory of computer simulations of fixed physical laws; of maximizing efficiency with respect to such laws through the principle of minimization of free energy? Is that going to be good enough conceptually in dealing with people who want to keep this at Logic I in the fusion funding? Is that going to be sufficient for scientists to understand their roots in people like Benjamin Franklin when they ask themselves how can these budget cuts come; how can this licensing procedure be so irrational; how can these terrorists environmentalists be so irrational?

I would leave for you that these kinds of structures and this kind of evolution that we see in plasma reminds me of an operation that Ben Franklin pulled off in his attempt to convince his more backward neighbors about the benefits of using artificial fertilizer. (Burning environmental issue of the day). And it gets to the question of having good pedagogy. Franklin would use artificial fertilizer on his clover fields and they would come up tall. But since they were pretty much even throughout, he had difficulty making the case to his more backward neighbors that this was in fact the result of using artificial fertilizer, rather than having the local animals unleased in the region. So, in one year's planting, he very carefully selected the geometry of the planting and when spring came the clover in the area that he covered with his fertilizer came up very distinctly above its surroundings and spelled out something to the effect of--"look you dummies, this area was sprayed with artificial fertilizer."

That's how I think we have to use these results from plasma physics. So that we can get beyond the situation of Logic I budgets, not only get the adequate funding that's required to assure convergence on a solution well within the century but also, so that we can begin to set the agenda. Thank you.

Dr. Michael Monsler

Physicist, Laser Fusion Systems Studies,
Lawrence Livermore Laboratories.

Tonight I want to describe to you what I think is one of the most exciting, promising and fast-paced energy programs in the world today. It's called laser fusion, or actually, inertial confinement fusion. I'll explain what that means in a minute. This is a means of converting fusion energy into electricity that's fundamentally different from burning oil or coal.

You can think of this first in the near term as a program just to understand how Mother Nature works. We're just doing physics right now. And, second, our goal is to substitute our technological capabilitities of the United States and of the advanced countries for non-renewable natural resources which we are burning up at an alarming rate. I'll show you how we think we can do that. Now I'm going to stay pretty fundamental in my talk and I apologize to those of you who are already fusion experts. You can use this time to just sort of devise diabolical questions for me.

One thousand megawatt electric power plants of various types consume a lot of fuel (see figure 1). We're talking about 190 trains of coal for a year's operation, or maybe 100,000,000 barrel supertankers for an auto plant. Fission plants have much more compact fuel requirements, about a railroad car full. If we can make fusion work, we're talking about deuterium fuel that would fill up about a pickup truck. There's a lot of forces in the nuclear, binding forces that we can release to give us this energy. Basically what we're after is, we're going to take deuterium-tritium, which are isotypes of hydrogen, and we're going to get that from sea water by a very inexpensive process. And when we cause them to fuse, and all that requires is getting 100,000,000 degrees temperature, we can turn that into helium and a neutron, and the helium and neutron carry off the extra energy which we absorb in a blanket. Once we get enough heat we can produce electricity through an ordinary steam cycle, or through a number of advanced processes. But you can think of it as just like a coal-fired power plant only replaced by another heat source.

Now, just to dramatize the energy worth of deuterium-about one out of every 6,000 water molecules is a deuterium oxide molecule instead of hydrogen. And the deuterium is simply hydrogen with an extra neutron, with a neutron attached. And that has a much more favorable cross section for undergoing the reaction so we use it even though we have to extract it from water and that's an extra step in the process. We're talking about one gallon of water, the energy, it it is about 850 gallons of gas. So if we can do this, use this fuel, we're in business.

Obviously, it's not easy. It takes some technology to do that. But we do have a lot of that fuel around, so the incentives are high.

For example, just looking at the deuterium, we could have it cost up to $4,000 a ton and still have an economical process. It's just no problem processing sea water to extract it at that rate. The current cost of deuterium I've listed down here as $2.00 a ton. So there is no problem.

We need lithium. I will show you one of our reactor concepts that uses a lot of lithium. We extract that from sea water also, or it's a by-product of a number of mining operations. So these reactors do use somewhat different elements, but we are not resource limited in these elements.

Now the inertial confinement fusion concept differs from the magnetic confinement concept. Friendly competitors.

What we are going to do is take a small portion of dueterium and you should picture a very small pellet of deuterium (it's going to be more sophisticated) which I'll show you later, but imagine that we're going to hit it with lasers on all sides. The lasers are going to cause the atmosphere to vaporize, and I mean vaporize within a billionth of a second, which is about the duration of a laser pulse. And when this happens the gas streams off at extremely high velocities. It's just like a rocket, actually, at a reaction force. Only the reaction force is all inward. This crushes the pellet up to any where to 10,000 times the density of ordinary matter. When it does so it comes up to 100,000,000 degrees without any problems. When we get to that level, the atoms fuse (see figure 2). We've done this in the laboratory; we know that part of it works, what we want to do is fuse and burn the remaining material and cause the nuclear reaction to occur in the remaining material BEFORE it has time to fly apart. In other words, it's confined just by its own inertia. Once we get it going it can't fly apart fast enough. All the hot material, the radiation in nuetrons and x-rays are just absorbed in the big blanket designed to safely absorb all this radiation, and we do this once a second, and it's a pulse energy source just like an internal combustion engine, and we can make steady power using this source. I'll go into a reactor on how to do that.

This is the Lawrence Livermore Laboratories Inertial Confinement Fusion Program. We're looking at a number of different drivers (lasers) or we could even use beams of electrons or ions, and different targets. We use a particular kind of laser called a neodymium glass laser. I'll show you photographs of them. We're looking at advanced lasers and gas lasers, pellet fabrication techniques. We have to make one of these pellets per second, drop them in the chamber and we need different reactor concepts to get the heat to produce electricity.

Now here is a complicated graph (see figure 3). This is a whole campaign. On this side you've got the pellet gain and it's just a

FIGURE 1

ANNUAL FUEL REQUIREMENTS FOR A 1000 MW_e POWER PLANT*

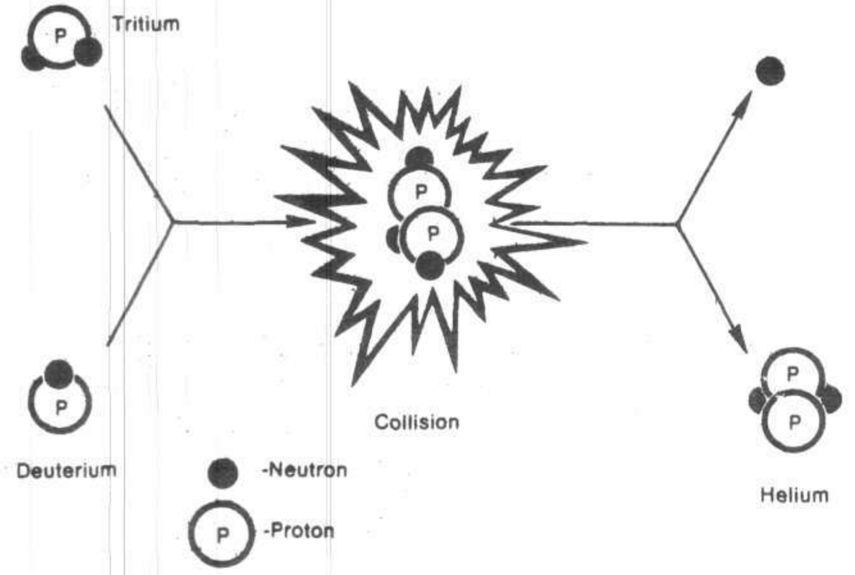
Coal	2,100,000 tonne	191 trains (110 cars each)
Oil	10,000,000 barrels	10 super tankers (10^6 bbl each)
Fission	30 tonne UO_2	~one rail car load
Fusion	0.6 tonne	½ ton pickup truck

*75% capacity factor

FIGURE 2

THE FUSION PROCESS

In the deuterium-tritium fusion process shown here, the deuterium nuclei [D], which consists of one neutron and one proton, fuses with a tritium nuclei which consists of one proton and two neutrons. The result is the formation of a helium nuclei with two protons and two neutrons and one free neutron. Since the total mass of the fusion reaction products, the helium nuclei and the free neutron, is less than that of the deuterium and tritium nuclei, the difference in mass becomes expressed in the velocity of the products.



ratio of the energy out from the thermonuclear reaction compared to the laser energy into that little pellet vs. the calendar year. Now in 1974 we went to Congress and we said that we were going to build, we're proposing to build a series of lasers, and they had these names, Venus, Cyclops, and Argus, and so forth as code names, and when we do that our computer simulations show that we're going to get a certain performance. As we improve the amount of energy we put on target, the efficiency is going to get better. So even though here, in 1974, we don't even get a billionth of the energy out that we put in, in fact we can barely measure it, by the time we get to 1984, we're going to be getting scientific break-even, and in fact what we want is a 100 times more energy out than we put in so that we can afford to run the laser and sell the power. Computer calculations that show this are incredibly sophisticated based on primarily the kind of computer calculations that are required to design an atomic bomb or a hydrogen bomb, the kind of capabilities that Livermore and Los Alamos have had since the 1940's.

FIGURE 3

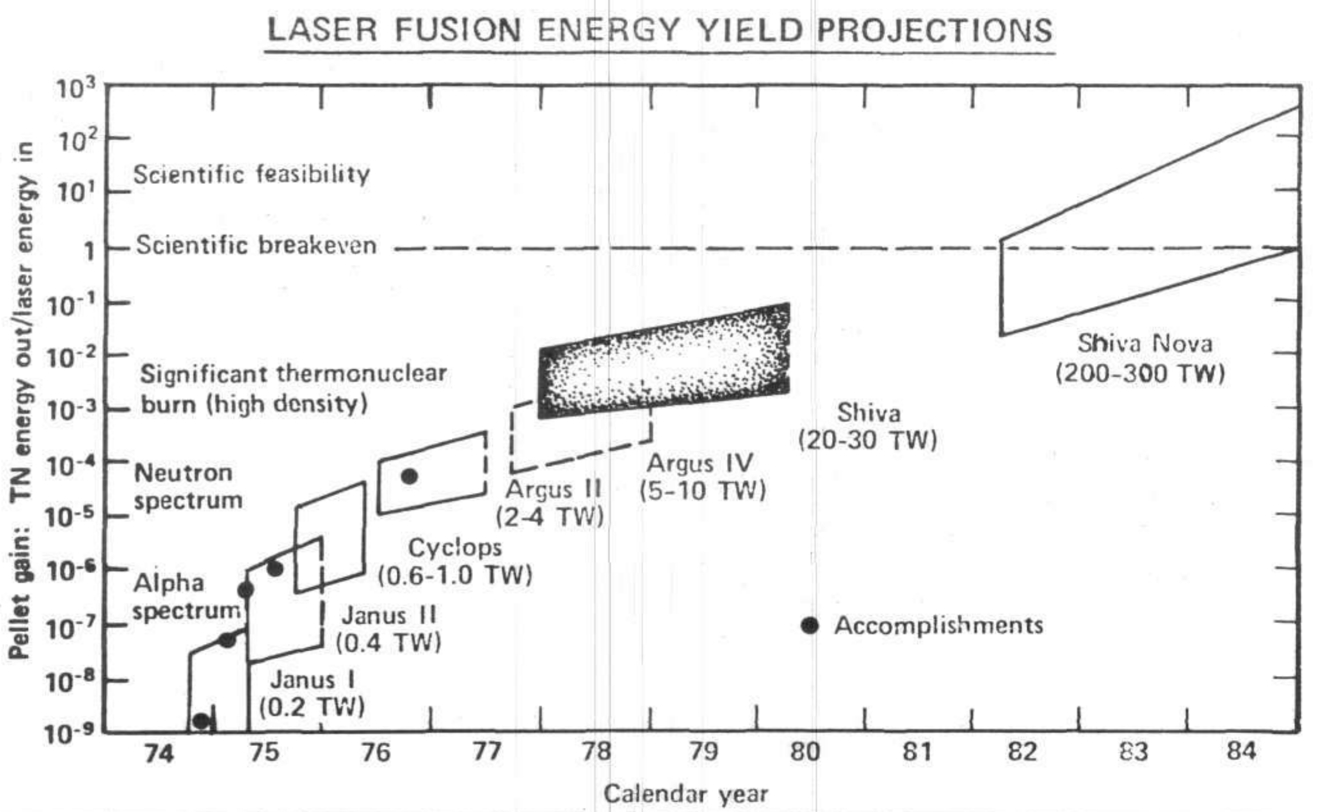
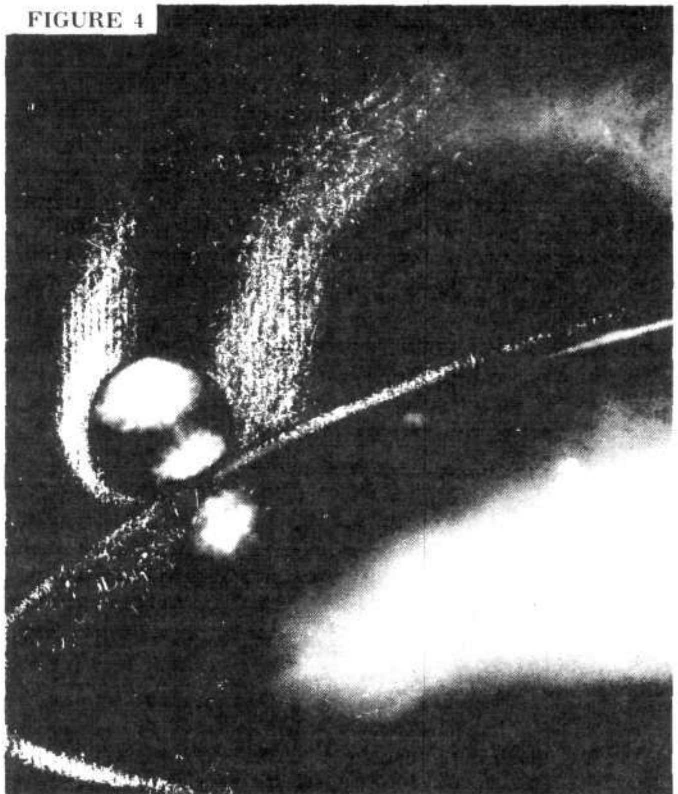


FIGURE 4



A model of the laser fusion target used in the U.S. Lawrence Livermore Laboratories program, shown here dwarfed by the head of a pin. The LLL laser research began in 1962 as part of the weapons program and is now the nation's largest laser effort.

Using these kinds of capabilities we are able to design these pellets and the lasers that go with them. The red dots are the results we've already got. In fact the Argus results, Argus IV, there should be a brown box in that box there, in fact just at the end, beginning of 1978, that's a little higher. Shiva is the blue box. It's a laser that's up and ready to go. The lasers work but we haven't shot any pellets yet. And the Shiva-Nova is something that we're going to break ground on within a year. So this is a program that is marching right along.

Now, we have a room full of lasers called the Argus lasers. What happens is we start with a very small laser pulse that's about a millionth of a jul of energy, it's a very small amount of energy. It's a pulse of light that's about a billionth of a second long and goes about two feet. This pulse is started out and it keeps going through a set of amplifiers. It just keeps increaseing the energy and the power of that pulse, and then it's split into two and continues to be amplified, and it keeps going through a cascade of these amplifiers until it gets up to the level that's a terawatt. You know what a 100 watt light bulb is. Well, this is 10^{12} watts. One with 12 zeros after it, power in a billionth of a second. A lot of energy in a short time. What we do with that is to put it into a target chamber and shoot at a pellet.

What does one of those pellets look like? That's a pellet on the head of a pin (see figure 4). What we have to do is put all of that energy on that small of an area. When you do that you get very hot temperatures. But it's not simply a matter of putting it on that pellet. It has to be done very uniformly. It's very easy to get it a little off center, and so forth, and you do not get the kind of spherically symmertic, perfect implosions that will carry the material into the core, and cause the nuclear reaction and get the neutrons out, get the energy out. The reactor pellets are going to be a lot larger. The reactor pellets are going to be about a quarter of an inch, or so. In fact in many respects we are doing the most difficult experiments now because we have to use pellets that are very small, and just the accuracies required are more difficult now than they will be in a reactor situation....

The surface finish of the pellet is good to 100 to 200 Angstroms. That's about 50 atoms, a bulk of about 50 atoms size. And, of course, then you have to get the laser light aimed equally and uniformly. When you do that you're set. Again, for a reactor size model, it's much easier, but because these lasers are so small, we have to take extraordinary steps to do this.

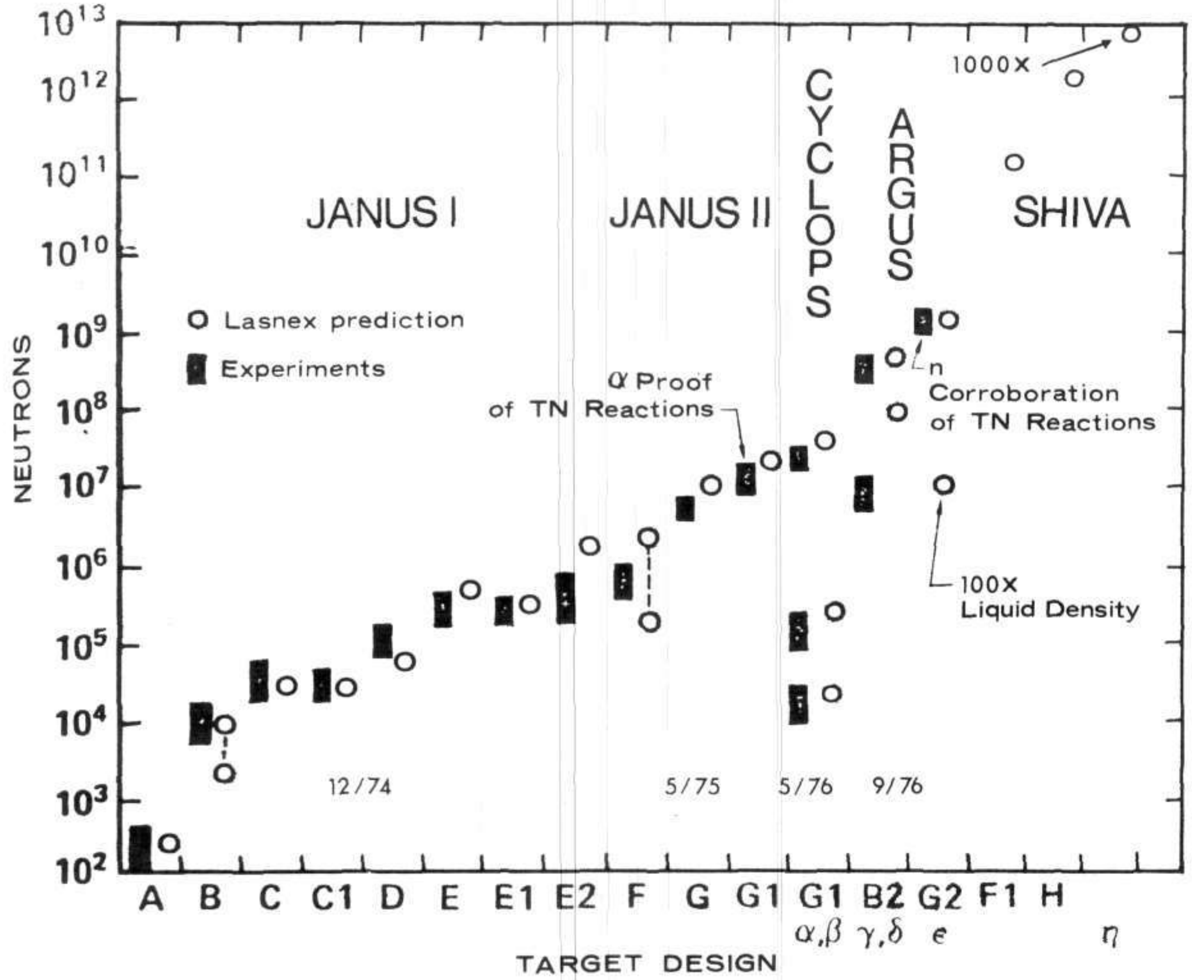
Here's the target chamber (see figure 5). It's about a meter in diameter. The beams are about 20 centimeters in size. They come in from both sides; are focussed down by lenses and focussed on the two sides of this pellet. The remainder of the space around the chamber is just bristling with diagnostic instruments of all kinds, which measure all the particles that come out; measure not only the energy but the range of energy of this, all the range of velocity of the process or reaction, so that we can tell what happens, so that we can change the computer codes and change our theories and bootstrap the theory in experiment. That's how we learn how Mother Nature works and how devious she is....

FIGURE 5

The heart of the Livermore fusion lab is the shiny target chamber. Through tubes attached to the top and bottom, beams will bombard a tiny sphere of hydrogen for a billionth of a second with more power than is generated in all the U.S.

FIGURE 6

NEUTRON YIELDS — EXPERIMENTS VS. LASNEX



Now this our most important view graph (see figure 6). It's a little complicate. On this field here we have neutrons from a 100 to a million to a billion, and above. This is per shot. I have just designated the different target designs here. There are a wild array of target designs that go into a laser, so we've just got them scaled like this. You can see our results. The red dots are the computer predictions. LASNEX is just the name of a computer code. Scientists love to give reality to these codes giving them glorious names, treating them as if they're human beings. They do do a fantastic job. Some of the times we've changed the dots of the computer code to see what the effect of different assumptions are, and so forth, that's when you see the dotted line. But these computer codes will give a prediction, a certain target designer's best guess as to what we should do next, and then we go off and make a target that looks exactly like he says it should, with certain finishes and sizes and so forth. So months later we get around to shooting it, and then the results are the experiments in the green box. Over 7 orders of magnitude, as we call it, seven factors of 10, were within a factor of 2 or 3 of our predictions each time.

Our latest results are up here in this corner at about a billion neutrons per shot, and we have to get up many, we've got to get 10^{18} to 10^{19} per shot for success, for break-even, for feasibility.

Here we have what we call an optical bench (see cover). It's a place to hang mirrors and lenses and lasers. It's made out of square, 6 inch steel framework and it has a dimensional stability to something like a millionth of an inch over that whole barn-sized building. It has to be kept at plus or minus a half a degree temperature, and there's air conditioning, it's a clean room, and all that, because when we're doing very sophisticated optical experiments, misalignments, Livermore earthquakes, and such things, really do us in. So there's our optical system.

There are big capacitors, just like in your camera, to store the energy just prior to flashpoin. The energy is piped up into the laser amplifiers, and the beam, represented by the red tube, the beam goes through all the amplifiers, gets put up into the folding gear and comes in two clusters of 10 beams each through the top and bottom, and are focussed on the pellet. Again, all the diagnostics are arranged around there to measure the results.

This is a laser amplifier (see figure 7). Lasers don't create energy; they're just an energy conversion scheme. What we do is take electrical energy and make light. The way we do it is we have these disks of laser glass. It's rather ordinary glass, but it is carefully compounded from a material called neodymium. Neodymium atoms have really favorable properties for making lasers. When you fire all these flash tubes, these are just flash tubes just like in a camera, there's this tremendous blinding flash of ultraviolet light that pumps up the atoms in tremendous two disks, and all the neodymium atoms in there are all excited, they absorb the ultraviolet radiation and wait around for about a

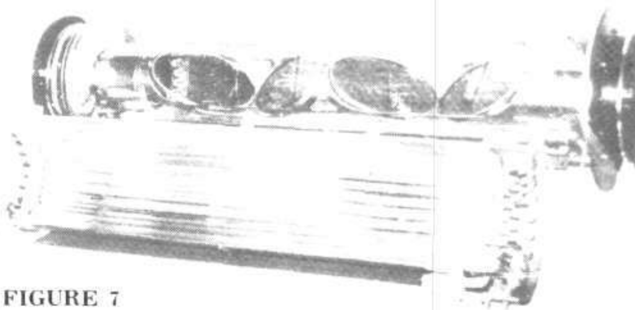


FIGURE 7

BETA ROD AMPLIFIER, **top**, *contains a glass rod 40 centimeters long and 50 millimeters in diameter, and requires 40 kilojoules of electrical energy into its flashlamps. The 38-cm-diameter final turning mirror and gimbal* **center**, *provides angular resolution of one microradian. The gamma disk amplifier,* **bottom**, *has a 15-cm clear aperture; flashlamps require 210 kj*

mili-second, a long time. Then you take a laser pulse of low energy on one side of the amplifier and it's a billionth of a second long pulse, and when it sweeps through the laser disks it stimulates all those atoms to emit their energy in light of the same frequency as the incoming light in the same direction. So a laser is just light amplification by stimulated emmision of radiation. The little tickler light coming in stimulates all those atoms to give up all their light instead of flourescing and radiating in all directions, and it all gives it up in the same direction, and then we just cascade. We keep going from smaller ones, we blow up the beam a little larger so it doesn't blow apart our optics, and we put it through another amplifier, make it go to a larger diameter, and stick it in another amplifier. We keep doing that. There's a limiting situation. One is the optical coating can only be made to withstand so much energy, so much energy per square inch, and then we have to blow it up to a larger size. So that determines one thing. Another is we get noise. When you have a hi-fi amplifier, whenever you amplify from section to section, you've got to filter out the noise so that you don't get noise; what you want to do is amplify the music. But our music is a nice light beam of constant intensity. We get funny ripples on it and we have to filter it. So besides amplifiers, we have small spatial filters. What we do is take a lens, focus the light beam down and put it through an extremely small hole. It comes back out the same diameter, but all the light that wasn't going exactly the same direction can't get through the pinhole, and so it's a filtering process. So by cascading through filters and amplifiers, it's a very simple way of starting off with a tiny, tiny controlled pulse and coming out with a big mother pulse.

When we run out of technology on this we add more beams. The Shiva laser uses 20 beams and it is within the state of the art of our technology now to have all these computer-aligned beams aimed and fired and get there at the right time. To do that, by the way, you have to control the length of each one of those over a football field's length right down to about the milimeter, say,. about a 10th of a quarter of an inch. We do that by sending out laser pulses and coming back and timing them....

We are breaking ground soon for Nova. Nova is twice the size of the Shiva, and 10 times more powerful. What we are going to do is, the Shiva building right now is this building. All the lasers are here, and the target chamber is here. What we are going to do is build a new set of lasers with improved glass. Shiva's already obsolete, in a sense. We had to order all those parts 2½-3 years ago, and we've improved our knowledge immensely since then. So in a building of about equal size we're going to put 4 times as much energy, stored in those laser amplifiers. We start doing experiments in this target chamber while we're still doing them on the others. When we do Phase I, then we close down the Shiva and we replace all of the laser glass and we put in our new technology, and then some time in 1983 we break open the wall, connect the two up and shoot the whole thing at once. So with just a factor of 2 increase in size, we get 10 times more power, because we understand how to put more amplifiers on, and how to get laser glass which has more power, and then we can add more lasers. This is the facility where we hope to achieve scientific feasibility . That is, we will not only break even, but we will get more energy out, we'll get 100 times more energy out.

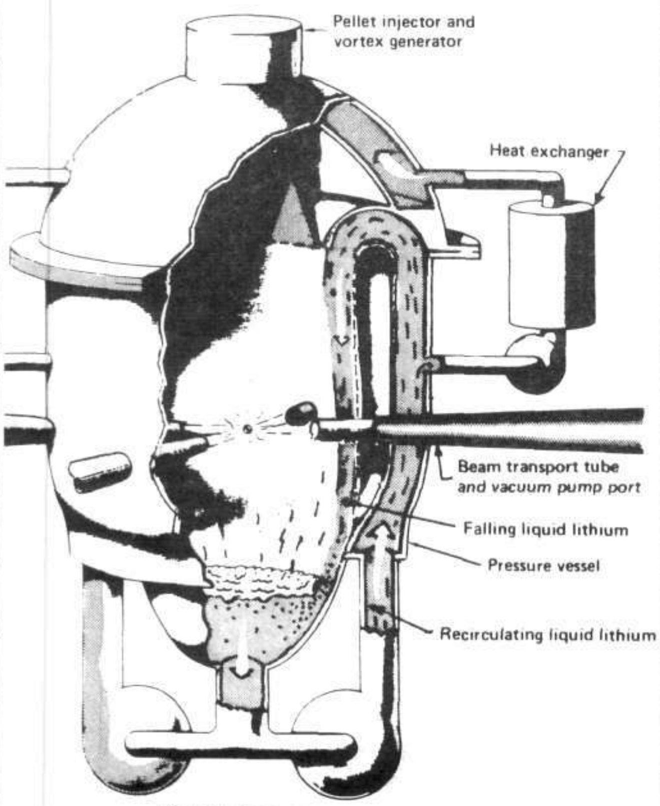
That's not enough to make this facility break even, because this is a quite inefficient laser. This laser is about a 10th of a percent efficient. It is not the kind of laser system we would use in a reactor. What it is is the quickest way we can do scientific feasibility experiments and convince the world that here is something that will work and should have significant development money, not just physics money. So that's why we've chosen these glass lasers, not that they're the best. In fact, they don't have the capibility right now to fire once a second....

I want to be direct with you and tell you how much it costs to do these kinds of experiments. The Shiva facility is working right now. It's this 10 kilijul system, and it costs about $25 million. It's about a 100 man-year effort, and it is operational now. We are just starting to do experiments with it. The Nova facility, the larger one, will come in two phases in 1982 and 1984. It's about a 500 man-year operation, and it will cost about $195 million over it's six year construction period. It's the one that will demonstrate the high energy gains and the scientific feasibility of inertially confined fusion.

Now, you don't have to use lasers. There are advocates of using ion beam, electron beam, different ways of beaming energy onto a target. The ion beam approach, for example, and all the other lasers are all looking toward the Livermore program to demonstrate the whole fusion physics. Once that's

FIGURE 8

LASER FUSION REACTOR: LITHIUM WATERFALL CONCEPT

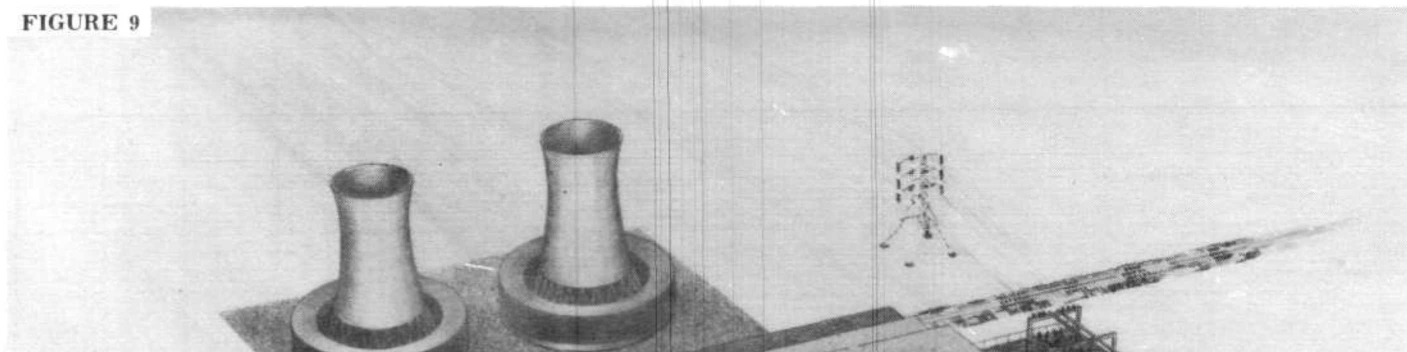


demonstrated, most every physicist will agree that another source of energy which could cause the implosion could be used. So we don't have to do a break even experiment for every possible source in order to prove that we can do it. That saves us a lot.

We intend to do a lot more than just do these physics experiments. We must have a high average power drive. That is, not just power in one pulse, but essentially 10 times a second, and it's got to operate 70% of the time. It should have electrical efficiencies greater than 1%. We must have a first wall, a first structural wall that's able to handle the radiation coming out. We have to have structural material that can withstand the cumulative damage of all of this neutron radiation which causes steel to get more brittle. We have to have focussing elements, mirrors and lenses, to get the light in that can withstand the radiation coming. And we have to have the technology to cheaply produce these fusion targets at the rate of one a second. All this has to come together in the time that we're doing these physics experiments, and in the time required to get to a demonstration power plant in the year 2000....

Let's talk about the reactor. We have a concept called the lithium waterfall reactor (see figure 8). Lithium is a liquid metal. Maybe when you were in chemistry class you threw some sodium in the water and watched it burn. It's a sort of lustrous metal that becomes liquid at these temperatures, and you pump it around like water. When you do so, you pump this around so that you have a 50-100 centimeter thick wall of liquid metal all around the pellet. There are no solid walls exposed to the flux. So what we have is a reactor concept that can have its first wall destroyed on every shot, and on every shot we re-establish it by having the waterfall come in and in one second, about 5-10 meters per second flow, 30 feet per second, we can re-establish this and what we have is a way of containing these fusion microexplosions. We do that once a second, and all of the neutron energy and x-ray energy is absorbed is absorbed into this liquid metal. In fact, it only raises the temperature of the liquid metal by 10 degrees and we keep circulating it, and we put it through a heat exchanger and take out the heat, make steam and generate electricity the standard way. We've done extensive modeling systems like this with different geometries for the thickness of the fall, arrangement, so forth, different way of bringing the laser beams in, and it appears to us that we can use standard steel. It appears to us that instead of changing this reactor wall out once a year, like some of the designs in other fusion concepts have,. we can go the whole 30 year power plant life time without changing the wall. Because all these neutrons go through all of this lithium before it gets to the steel, the spectrum, that is, the energy distribution of the particles hitting the wall is very similar to what would be in a normal nuclear reactor, fast breeder fission reactor. That gives us a lot of confidence. I don't believe there's anything in this kind of a concept that is not within the current state of the art. With the exception of the fact that all the neutrons come in a pulse, whereas in all the other reactor concepts, fission, for example, it's just a steady

FIGURE 9



A reactor building with a Lithium Waterfall Reactor.

source. We don't know yet how materials react when the same amount of energy is applied in pulses with long waiting periods....

So this thick layer of flowing liquid lithium is our wall. That eliminates the replacement of solid first walls in reactors. That means we don't have that radioactive waste problem. At the end of the 30 years cycle, we're not going to use that steel to make cars. We don't have the kind of fission waste product that is causing us the problem in the fission industry.

We have to account for the power to circulate all the lithium around. That we can get down to 1 and 2% of the total reactor power. And we can solve the focussing optics issue because we have target designs now that will allow us to take those mirrors or lenses and put them 50 to 100 meters away. Once you've done that, the flux of radiation on those final mirrors is down to the level where it looks like the mirrors will last a year or so....

This is a reactor building with a lithium waterfall reactor (see figure 9). It's got lithium liquid metal pumps and so forth, and heat exchangers and electrical generation equipment. The laser is in a separate building where it can be easily maintained. The beams are taken down into a concrete trench and piped out and here's where the mirror is, way out here, 50 to 100 meters away....

I want to mention one more thing about the optics. One of the ways to make the optics work is to have a little beam sticking through the fall, the lithium curtain, at about 5 meters away. The mirror is out to 50 to 100 meters away. Then we put in a region of Zenon gas, zenon's a gas like helium with a higher molecular weight and it absorbs all of the x-rays and debris, all the bad actors, in this small region of low pressure gas, and only the neutrons hit the mirror. But the neutrons go whistling right through the mirror and are absorbed in the blanket behind it and it's this kind of damaging radiation that gets caught in that gas and does not disturb the surface of our mirror so that it looks like that mirror can last, or such a design can last for a year.

Now for reactor targets, the targets are more sophisticated. In fact some of them are classified because if you knew what they looked like, it would teach you too much about how to build a hydrogen bomb. That is why parts of the laser fusion program are classified. The lasers are not classified; the reactors, the electricity, and it's sort of an embarrassing issue. I believe that it will be completely declassified by the time this goes up. That's a personal opinion, not a Livermore opinion....

So we go through the manufacturing process in detail. How did you take all these little pellets and sort of suspend them an electrostatic way and coat them with different materials, rotate them, hop them over to the next station, coat them with something else, fill them, and every one of those steps look so simple and a lot of them look easier than the kind of technology which we now use to make those little calculator chips. We have conceptually designed factories to do that and it looks like we could have one of those factories along side the power plant and it's just a sort of 10% issue as far as the cost is concerned. It's not a big deal. One of the things we have to do then is recover the tritium and the target materials and recyle them, and that also can be done although you know, these are now conceptual designs and involve a tremendous amount of engineering. The pellets will be injected by a repeating gas gun, it'll look like a Daisy repeating rifle. It's not a problem. They're shot into the chamber; they are literally tracked with a little viewing system, and the laser pulse is sent out at just the right time and the right place. That is within today's current state of the art. Right now, you can buy that kind of a system in the optics industry today.

To summarize, we've achieved record-breaking thermonuclear conditions in terms of numbers of neutrons and the amount of burn. The predicted capability of our computer codes has been confirmed by the diagnostics of laser implosions. We've designed very high gain targets; gains of 100 to 1000 energy efficiencies which really relaxes the driver efficiency and target cost considerations because with these higher gain targets we can afford to make more expensive targets. Techniques have been conceived for low cost, high volume reactor pellet fabrication. We've got low cost, simple, long-lifetime reactor concepts which really look good. The laser heavy ion reactor drivers appear feasible. We have lots of work to do in advanced lasers, but we have enough options that I really think the probability of success is very high. Also, in the Defense Department there is a lot of work on very large lasers, very large E-beams, and this all enhances our success in the energy field. Experimental facilities are being planned that are capable of igniting high-gain fusion micro-explosions in the early to mid 1980's and we're breaking ground on that.

Thank you very much.