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December 1993 reprint of 1985 luncheon address.

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WHAT WILL IT TAKE TO ACCELERATE THE FUSION PROGRAM?

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To the American Nuclear Society
Sixth Topical Meeting on the
Technology of Fusion
March 6, 1985

I am frustrated, as a lot of you are, that the fusion program is not able to move the way we all know it could move and the way it should move. My message is that I think there are three necessary and sufficient conditions for accelerating the fusion program.

Many times, when we think of reasons why the program should be accelerated, people will say "Oh, those are necessary, but not sufficient." So, I have tried to think of what are the *necessary and sufficient* conditions for accelerating the fusion program.

The first necessary condition is that there has to be *systematic progress.* The progress has to be systematic and publicly–understandable progress. We have been very fortunate in the fusion program in that we have always had systematic and publicly–understandable progress. We cannot survive as a publicly–funded program for 5-10 years without something to announce that's clearly along the path we say we are traveling. We have to show, and we have been able to show, that we are moving along the path to fusion power. The fusion program absolutely must have that progress as a necessary condition, if we wish to have an accelerated program. But such progress is not sufficient by itself.

The second necessary condition is that we must have conceptual designs of fusion reactors that are acknowledged to look attractive as potential commercial products. The fusion program cannot exist on scientific progress alone. This is a program for a purpose and it must be clear that we are intending to develop a commercial product. We must have such reactor designs, even if we don't know how every piece of them would work. We must have an embodiment, or several embodiments, that we are proud of, of which we could say, "If we can do that, somebody would want it." I wish I could say that we had such a design in the same way I can say we've had systematic progress. We have not yet been successful in coming up with designs that we're proud of as commercial reactors. We have had many attempts that have fallen short. After we finished our previous "commercial" designs, we were forced to say that we really were only using these to guide our R & D program; that we would never seriously propose to build the designs we had, because they would not be competitive.

As engineers we know that this sort of learning, a step at a time, and then next time doing better, is a traditional way of life. But it is damaging to us from a public point of view. The general result of all our work, from the point of view of the public image of fusion, was the Larry Lidsky article last year, that almost did us in, in which he states on the cover of Technology Review–"Even if the fusion program produces a reactor, no one will want it." He goes on to state the fact that even we wouldn't propose to build the reactors that we have designed so far.

This is an extremely serious problem. I think it's an urgent problem for us to fix. You do not have to make assumptions in these reactor designs based on today's physics, if better physics is needed to make the device competitive. Challenge the physicists to

do better! We need physics and engineering assumptions in the design such that, as soon as we publish it, every utility in the country would stand up and say, "Well I don't know if you can do it but, if you can do that, I'd buy it." Having such a conceptual design, as a target for our science and technology program to aim toward, is a necessary condition for accelerating the fusion program. We don't have it today. But you in this audience are the people who can do it.

I think the most important paper published in the systems area in the last year was John Sheffield's Generic Fusion Reactor study, in which he shows that there's no reason why such a design can't emerge. That's the kind of study we need. But we also need specific embodiments of those principles. I think it's urgent for this community to do such a design during the next year. Frankly I don't know that we have much more time than that to do it. We can't continue to survive in this national budgetary climate unless the public believes we have an attractive product. I think we can do it, but we haven't done it yet.

So those are two *necessary* elements for an accelerated program. But those two conditions, together even, will not lead to an accelerated fusion program. There is a third condition which, if it existed, would give us both the necessary and sufficient conditions for acceleration.

The third ingredient is that there has to be in the country a level of total R & D on energy technology that is commensurate with the energy problem that the country's going to face down the road. Fusion is not going to get accelerated because it's fusion. Fusion prospered in the 70's, and will prosper again, when the country realizes that energy technology has to be carried out at a level of financing and effort that is commensurate with the fact that it's going to impact on an industry that is multi-trillions of dollars of investment in the 21st century. Energy is big business, whether you measure it by the number of electrical plants and their costs in the future; whether you measure it on the value of imported oil, or whatever. The energy business is big business and the lead time for developing these technologies, so that they are ready when needed, is decades. There needs to be a multi-tens of billions of dollars spent on energy technology development per year.

What has happened is that the government has decided that it is not responsible for running energy technology development programs and that the private sector will do it. But the fact is that the private sector will not do it, because the private sector is going to do those things that impact on its profit bottom line in the near term. They're not going to spend a lot of money on things that will pay off to benefit the country 20-30 years down the road. So, there's a gap that's developed that nobody will take responsibility for. The government has washed its hands of the whole affair. The private sector sees no real incentive to fill it in. So there's this gap in the R & D area for those things that will pay off in 20 – 30 years. The work that's going on is not commensurate with either the lead time that's required or the magnitude of the problem in the industry that it's designed to impact.

Until the required level of R & D on energy technology is established, the necessary and sufficient conditions for accelerating the fusion program do not exist. So you may say, "Well, then it's hopeless." Well, I don't think so, because I think the fact is that we ought to be able to articulate the problem and we ought to be able to find ways to fund energy technology R & D at a level that's commensurate with the problem. I will give you one example: there is something called the Synfuels Corporation that was given a budget of something like $15 billion dollars just for synfuels R & D. There is an example of a lot of money being set aside to try to work on a problem at a level that is commensurate with the difficulty and the lead time of the problem. How was that done? Well, it was done by a tax on oil imports, I think, or on oil in some way. And, with a very small tax, $15 billion dollars all of a sudden materialized. Now suppose the Synfuels Corporation wasn't the Synfuels Corporation. Suppose it was the Energy Technology Development Corporation and they had $15 billion dollars to spend on a large number of energy technologies. This money is in the bank. It can come in all the time from a small tax on oil. It isn't a line item in the budget. The Congress doesn't have to appropriate it. It isn't a part of the budget deficit because it's not on the profit and loss statement of the federal budget. It's a trust fund. The highway trust fund is another trust fund to be used to build highways. It's not part of the annual budget appropriation of the Congress, and yet huge amounts of money can be raised this way. So, what I'm proposing is that we can get this third condition, that energy R & D is carried out on a sufficient level, if we fund it in a different way – through a tax on energy use, a mil per kilowatt hour on electricity, or a dollar on a barrel of imported oil. You can create a tremendous amount of money and you can earmark it for energy R & D. The utilities are doing this on a limited scale in nuclear power. They put a small tax on electricity produced by nuclear power plants and they put it into a nonprofit association, based in Atlanta, to fund research on the safety of nuclear reactors. So the principle, I think, is a good one.

I think that this is the kind of idea that has to be put forth. It ought to be acceptable to a Republican administration. It does get the money from the industry that is eventually going to be the beneficiary. With a small amount of tax you can create enough money that it is commensurate with the problem. And, if you do then fund many energy technologies at the level they require, fusion will be one of those and fusion will benefit by the fact that it's no longer perceived as being a drain on the public treasury that's out of line with the size of other budgets in the DOE, etc., etc.

Now, that idea may be feasible or it may not be. There are other ways to do this. The tax system could be revised so there are real incentives to private industry to do long range research. Right now there are tax incentives to industry to do R & D. But they can do short term R & D and get the same tax benefits. This is more attractive to them from a profit and loss standpoint. So the tax incentive here would have to be set up so that the only way you get it is if you can show that this R & D has a long term payoff for the benefit of the country. It would have to be a very attractive tax incentive. It can't be 50¢ on the dollar. It has to be more like tax shelter type writeoffs, where it's $2 – $3 on the dollar. It has to be, again, commensurate with what it takes to really give an incentive to industry to do the kind of R & D that's necessary. So that's another way that this could be done.

There's a third way, which I hesitate to even mention but, in fact, it may be a realistic way in view of what's been happening to the federal budget recently. And that is to transfer the whole responsibility for energy technology development to the Defense Department. This is not as crazy as it seems, because the fact is that our national security in the 21st century probably depends a lot more on our solving our energy technology problem than it does on building more missiles. I believe that. I'm not opposed to defense. But I think there's a certain imbalance in perspective in the defense community if they don't realize that they have a responsibility to the economy of the country and that energy technology is in fact a national security issue. And so, since they seem to get almost everything they want, and if they really were to go after these technologies, clearly they would do it on a scale that the Energy Department would never do it. So that is another way to get the level of energy R & D up to the dollar value that is commensurate with the problem.

So these are the three *necessary and sufficient* conditions for accelerating the fusion program. We need systematic, publicly – understandable progress. We need, urgently, an attractive conceptual commercial reactor design. And we need a level of energy R & D in this country that is commensurate with the problem. You may say, "Well, what can the fusion community do about the last one?" One of our problems in fusion is that we mostly think only about our own field. We only worry about ourselves. We don't participate very much in the national political process as a community. But we are smart enough. And nobody else is doing it. So I suggest that we take responsibility for proposing and helping to develop this idea for all energy technology, not just for ourselves. We will benefit if we can solve this problem for all of energy technology.

I suggest that, in your home institutions, you form discussion groups and talk about these kinds of ideas. I suggest you write them down and develop thoughts on how these ideas could be implemented. Publish your ideas in widely read journals and newspapers. I suggest you talk to the management of your organizations and ask them to talk to people about this problem, about the level of energy R & D in this country and why it's important. Write letters to TIME and similar magazines. Send your views to your congressmen and your senators and to the President and to the Energy Department. Call them on the phone and talk to their staffs. If you're in town, go to see them, two or three of you, and say, "Our discussion group has got these ideas, what do you think?" Get pushy about it. I know it's not our style, but if we don't do it, it isn't obvious that anybody else is going to do it. And it's our program that's going to suffer if somebody doesn't fix this problem. I think it's fixable. I think there are precedents for it. But I think there's a tremendous leadership gap in this country to do it. The leadership can come from anywhere. I suggest that it's in our interest to be the ones who take the lead to get this thing rolling.

So that's my message. I think "the glass is half full." I think we can get it filled the rest of the way. I don't want to spend the next 20 years of my life working in fusion, only to find that we're still trying to figure out how to build an ignition experiment. But that's what's going to happen if we don't do something. It's not going to be sufficient for us to just worry about our own technical problems. We are going to have to solve the problem of energy technology development in this country before we are going to get our program moving again.