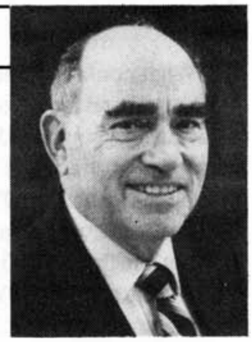
Interview: Dr. Bertram Wolfe on Nuclear's Future



Dr. Bertram Wolfe

'Magic will not solve our energy problems'

Dr. Bertram Wolfe, vice president and general manager of General Electric's Nuclear Energy Operation, has been involved in the research, development, and application of nuclear power generation for more than 30 years. A past president of the American Nuclear Society and a member of the National Academy of Engineering, Dr. Wolfe was just given the American Nuclear Society's Walter H. Zinn Award for 1990 for his outstanding contributions to the advancement of nuclear power. Dr. Wolfe was interviewed in March by Marjorie Mazel Hecht for 21st Century Science.

Q: To get from where we are today—a political standstill on nuclear—to meeting the estimated need of 100 to 200 gigawatts-electric capacity in the next decade will take some major political and economic changes in this country. It seems clear from your congressional testimony to the House Subcommittee on Energy Research and Development in February that nuclear technology is not the problem. How can we get the job done?

Wolfe: Several things will have to happen, one is that we need a licensing system that works. We've developed a licensing system that worked initially, but over the years, especially in the seventies and early eighties it got to the point where it took so long, and its outcome was so uncertain, that even the chairman of the Nuclear Regulatory Commission (NRC) couldn't predict whether a license could be issued in the future for a new plant identical to one that his agency had just approved. The uncertainty on licensing is something that just can't be tolerated in a business involving billions of dollars which is trying to meet public needs in a timely fashion.

We need to develop a licensing system that is predictable and consistent. My hope is that the new NRC initiative (10CFR52) in which the NRC has set conditions for licensing standardized nuclear plants will be a vehicle that can break the present licensing barrier. General Electric, as you know, is the first organization trying that new licensing system with the Advanced Boiling Water Reactor (ABWR).

Q: What is the new licensing system?

Wolfe: It prelicenses the plant. In the past what we've had in this country—which clearly isn't right now and didn't work in the latter part of the seventies—is a system where a utility company applied for a license and then had the plant designed and went through the licensing process as they were building the plant. The new Part 52 will allow a company to prelicense a plant in advance. In principle, therefore, General Electric with its ABWR, Combustion Engineering with its System 80 Plus, and then later on Westinghouse with its AP600 would be prelicensed. The plant sites would also be prelicensed.

In principle, then, a utility that wanted to build a reactor on its prelicensed site would tell the NRC that it was going to build a General Electric ABWR, or a Combustion Engineering System 80 Plus and, in principle, it would be able to start building right away, because the design was preapproved. It would just have to demonstrate to the commission that it was building the plant in accordance with the preapproved plans, and there would be inspections to see that the construction was done according to the plans, that the equipment was according to the plans, and so on.

Under the new system, the utility builds a plant to a design that is preapproved. There would be a number of duplicate plants, which is what the nuclear industry needs and which we don't have now.

Q: It's certainly what France has done.

Wolfe: That's exactly right. It's what France has done and what, in effect, Japan has done. France is really the outstanding country in terms of this standardization, but Japan does the same thing, getting the plant prelicensed before they start construction. I think that, first, standardization is required. Second, even after we develop the system, we are going to need a demonstration that it works. The utilities have been so burnt that they're going to be hesitant. It will be a challenge to construct the first one or two plants to show that the system really works. Third is timely demonstration of actual need; the predicted need for the next decade is 100 to 200 gigawatts (GW), and I think that these are reasonable, realistic numbers, but we're going to have to show that there is a need for the power. . . .

Q: What could the nuclear industry do differently?
Wolfe: There are two things: First, the industry is doing what I think should be done, getting new plant designs, which correct past problems and provide more economical, improved performance. The ABWR is moving as is the System 80 Plus, and we [General Electric] and Westinghouse are starting on the AP600 and the SBWR [Simplified Boiling Water Reactor, 600 MWe]. What we need are designs which take advantage of the 30 years of nuclear experience, and we're moving on that.

The second thing the industry has to do is to decide how to build these plants. In the past there have been four manufacturers and eight or ten architect-engineers working in various combinations on each plant. I think that's too many participants, especially for the kind of market we see in the next decade or so. Probably there's going to be some partnerships on these new plants, and getting these arrangements set up is going to be another task in the next few years.

In other words, I think utilities are going to want to know that a plant can be built on a certain schedule, at a certain cost. Arrangements are going to have to be made for repetitive production, which probably means fewer architect-engineers and probably means partnerships between a manufacturer and an architect engineer so that plants can be built repetitively. Perhaps, as I understand Westinghouse has proposed, these plants can be built by a combine of a manufacturer, an architect-engineer, and a utility.

Q: Where is Westinghouse planning to do this?
Wolfe: They haven't gotten an order, but they indicated that they would be willing to be a participant in these kind of partnerships. What I'm saying is that there's apt to be a change in the structure of the way nuclear plants are ordered and built. I doubt that they're going to be built as before, where a utility buys a steam supply system from the manufacturer and then reimburses an architect-engineer for construction costs incurred. I think the utilities have found that leaves them a little helpless in terms of the final costs, but without standardization, they had no choice.

As I see it, first we've got to show that standardization works, with a prelicensed plant and a prelicensed site, and then we have to develop project arrangements so that we can build these plants repetitively on a predictable basis.

Incidentally, on the licensing issue, it may take the government to provide guarantees that its regulatory system will work, so that a utility doesn't get into a situation where it starts a project, and then in the middle of the project someone sues, delaying the project for years. Even if the person or organization which sues loses the case, it will have a tremendous cost impact on the project. It may well be that there has to be a government demonstration program that shows that the licensing system works. . . .

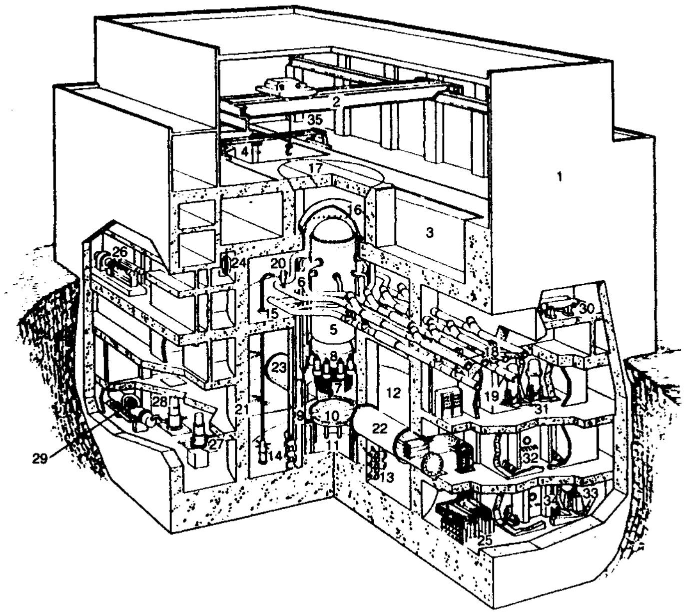
Q: The Asian-Pacific nations want to go nuclear as does Eastern Europe, which has a devastated ecology as a result of burning lignite all these years. That's a market for us. Were the United States to have the kind of attitude the West Germans, the French, and the Japanese have, we would be in there aggressively trying to get a piece of that market and export nuclear plants.
Wolfe: Well, I think that's true. Let me give you the other side though. I think that market hasn't developed yet. This is the time to get into it. If you look at those Third World, and even Eastern European nations, and you say "there's a market," well, there's a need there, that's clear, but where are they going to get the financing? And where the market is and how it's going to develop are still questions. But certainly on a worldwide basis, there's going to be a big need in the future.

Q: The West Germans, in their recent push to develop the market in East Germany and Eastern Europe, cited the billions of dollars of German investment money that now goes to New York and other places, because there is nothing to invest in in West Germany. Karl Otto Poehl, the head of West Germany's central bank, the Bundesbank, has just said himself that money is really not the problem.
Wolfe: That may be, but I was over in China for the American Nuclear Society meeting a few years ago. We met with Li Peng before he became premier, and he took a number of us from the nuclear community out to dinner. His comment was that clearly they needed nuclear power, but that they couldn't afford it. He said that he didn't see nuclear coming until at least the end of the century, although clearly they have a crying need, and clearly coal was hurting their whole country, in terms of environmental effects.

I think that this is the problem. Now, maybe Germany has a special system with West Germany and East Germany being kindred brothers, and maybe they can find financing in some way that makes sense, but the Chinese—at least when Li Peng talked to us—didn't see a way to do it until at least the beginning of the next century. So, financing is a problem. . . .

Q: I'd like to ask you about the economics of mass production of smaller-size reactors. GE is working on an advanced boiling water reactor of 1,000 megawatts, but you noted that you thought that plants of 500-600 megawatts-electric (MWe) would soon be economically advantageous. Has GE done economic studies on the economies of scale versus mass production? From what I have seen, there are many advantages to the modular mass production of smaller-size reactors, including the speed of getting a plant online. I looked at the economic feasibility studies for the modular high-temperature gas-cooled reactor, and I was convinced that for a developing country siting three or four or more smaller reactors makes sense.

Advanced Boiling Water Reactor (1,350 MWe)



1 Reactor building
2 Bridge crane
3 Steam driver and separator storage pool
4 Spent fuel storage pool
5 Reactor pressure vessel
6 Reactor internal pumps
7 Fine motion control rod drives
8 Reactor pedestal
9 Reactor shield wall
10 Lower drywell equipment platform
11 Lower drywell
12 Suppression pool
13 Horizontal vents
14 SRV clenchers
15 Upper drywell
16 Drywell head
17 Shield blocks
18 Main steam lines
19 Feedwater lines
20 Safety/relief valves
21 Primary containment vessel
22 Lower drywell personnel lock
23 Lower drywell equipment hatch
24 Upper drywell equipment hatch
25 Hydraulic control units
26 Diesel generator
27 High power core spray pump
28 Residual heat removal pump
29 Residual heat removal heat exchanger
30 Fuel pool heat exchanger
31 Reactor water clean-up system filter demineralizer
32 Reactor water clean-up system holding pump and operation room
33 Reactor water clean-up system pumps
34 Reactor water and suppression pool clean-up system backwash pump and operation room
35 Refueling platform

This cutaway shows the design of the only advanced light water reactor now under construction. The boiling water reactor, pioneered by General Electric, allows the coolant water to boil in the reactor core. The steam leaving the core is processed and conveyed to the turbine, which then drives a generator to produce electricity. The Tokyo Electric Power Company is constructing two ABWR units scheduled for commercial operation in 1996 and 1997, with GE supplying the nuclear steam supply systems, fuel, and turbine generators.

Wolfe: That's right. The ABWR is big, it's a 1,350 MW plant, and our studies show that there are economic advantages to large size. That's what the French have found; they go in for larger sizes and are now looking at 1,500 MWe plants. There are economies of scale both in building the plant, and in operating it. If you have two 600 MW plants, instead of one 1,200 MW plant, you have a larger number of operators and duplicate systems that have to be maintained as well as security and so on. Thus there are advantages to the big plant.

On the other hand, the basis on which we're developing our SBWR 600, and Westinghouse its AP600, is that, with the small size, you can do some things that maybe you cannot do with the big size. For example, there is inherent safety [if something goes wrong, the plant can cool down without any operator assistance], which is satisfying from the safety standpoint and also cuts down on cost, because fewer pumps, heat exchangers, and other equipment are required. So small size does have some advantages that may help overcome the law of scale.

In the case of the boiling water reactor, we picked 600 MW because, at that size, natural circulation could be used [with the cooling system], thus avoiding the use, complexity, and cost of pumps. What our studies thus far have shown is that, when you get down to 600 MW and if you simplify it—which you can do because it's small—the large plant will still have somewhat better economics. But when I say somewhat better, I'm talking about maybe 10-20%, in mills per kilowatt-hour. Because there are advantages to the smaller plants, you might say, "Okay, I'm willing to pay an extra 20% if I can build a plant at 600 MW, rather than have to wait until I need 1,300 MW.

Q: Did your economic studies take into account the cost of the tremendous delays that have plagued U.S. plant construction?

Wolfe: Our assumption is that in the United States there is no natural law preventing one from building an 1,100 MW plant in four years, the way they do it in Japan. So, the assumption in the economics is that we are going to clean up the licensing mess that we have and be able to build a plant in four years.

On the 600 MW plant, we think we can build it in maybe three years, 36 to 40 months, so we will get an advantage there. The point I'm making is that on the small plants you have to look for every advantage in order to keep the economics reasonably competitive with the larger plants. And the small plants, by themselves, as you say, have their advantages. If you're a country with a small power grid, you cannot afford to build a large plant because it has too much effect on the grid when it is shut down for refueling, or if it has a scram [emergency shutdown]. You need small plants.

Q: Is there a limit on the size that can easily be mass produced? Can you mass produce a 600 MW plant?
Wolfe: I think the smaller plants are easier, in principle, to mass produce, but even with the big plants, we're looking at whether we can mass produce components so that we can take advantage of mass production. And this, it seems to me, is really the advantage of standardized plants in general. Because you know the design, you can set up vendors—factories—that will turn out parts on a mass production basis, whether they are for small plants or for large plants. Now, when you get to very small plants, like our liquid metal reactor, the Prism, you can build a whole steam supply system in a factory and ship it to the site. . . .

In the Prism design, the vessel is about 20 feet in diameter, and we think we can build that in a factory and ship that with the components installed. In effect, we would mass produce the components and just repetitively build those modules at the site.

The SBWR is again a 20-foot-diameter vessel, but it's a high-pressure vessel. This makes mass production a little harder to do, but even there we're looking for ways to repetitively produce these reactors at a factory and then ship them to the site. The other thing is, when you build plants repetitively, you would have crews move from site to site, so you would have, in effect, mass production at various sites as well for the installation and the preparation of the site.

Q: Where does your design for the modular breeder reactor, Prism, stand?
Wolfe: From the technical standpoint, let me say, it stands pretty well. The design is continually being refined; we've been working on it for seven or eight years now. The Prism design won the competition in this country two years ago as to what kind of breeder we should employ. We formed a team with Westinghouse, Burns and Roe, Bechtel, and others on the basis that the Department of Energy (DOE) would fund it appropriately—the agreed-upon funding when we won the competition in January 1989 was $14 million a year. In fact, DOE was able only to fund it for $5 million a year. So, we haven't made the progress in the past two years that was anticipated. We're just trying to hold our own, with the hope that in the next year we will get back onto a reasonable funding level where we can make significant progress. . . .

I think that the DOE is looking at the breeder more realistically in terms of two factors: 1) its leadership in the world; and 2) the fact that we now see that the breeder may have a major impact on waste management. With the liquid metal breeder, one can recycle the long-lived actinides, the long-lived radioactive products, so that the waste problem becomes not a million-year problem, but really a problem of just a few hundred years.

In other words, we would take the long-lived products and put them in the breeder and transmute them; the fuel cycle being worked on by Argonne National Laboratory would allow us to do that. The Prism plant, which we think has very big advantages, would allow one, in principle, to develop the breeder reactor in a finite time-scale and with reasonable costs. The problem with breeder development, in which General Electric was the major leader, was the way we were going, as exemplified by the French.

The French built the Phénix breeder reactor, and then the Super-Phénix—both multibillion-dollar projects. The 300 MW Phénix was just an invitation to build the $5 billion, 1,100 MW Super-Phénix, which is now an invitation to build another $5 billion or more Super-Phénix II, which may be an invitation to build the next one. It's not clear that that process converges. In other words, these plants at the large size are so expensive, take so much time and money to build, and have to be built so carefully that by the time you build one you've got a decade or two gone before the next one comes along. In a sense you develop a bureaucracy, rather than a pioneering effort to get things done.

The idea with the Prism is to build a plant in a small size, 150 MWe, so if you wanted a 450-MW plant, you'd put three of these modules together. The thought is that you can design a steam supply system for well under a billion dollars, you take it out, you build it, you test it, you modify it, you change it, you redesign it, and you still are talking about a couple of billion, not tens of billions of dollars. When you're all done, you have the module that you want to build, and then you replicate these module units in units of three and build them using mass production.

What this does is allow you to develop these plants for what appears to be reasonable costs and a reasonable time scale. Phénix works; the problem is that it is not economical. We've got to get one that works and that is economical, so that we can build others that are economical; that's the name of the game.

Q: What is the time-scale on getting the DOE to give you more funding?
Wolfe: If we get DOE back on a reasonable program in the next year, our hope is that by the end of the century, we will be able to demonstrate a module that works. Then we could start building breeders in the year 2010 or so, and from there on out. The timing on the need for the breeder is not clear. As I mentioned, the waste problem is something the breeder can help on, and that could be a big impetus.

But the other major reason for breeders is the fuel problem, the uranium availability. Now whether you believe in the greenhouse effect or not, with the coal effluent problems, with the fossil fuel problems in general, there may be a reason to expand on nuclear. If, in fact, the greenhouse effect is real, and one wanted to use nuclear to reduce the carbon dioxide generation by a factor of 2 in the next 30 or 40 years, then one would be talking about several thousand nuclear reactors worldwide. This is the case in which you would worry about uranium availability, and where you would really need the breeder.

Our view is that we shouldn't do what we did with the light-water reactors, wait until the need was upon us, which meant that we developed light water reactors maybe not in as systematic a way as we should have. We ought to be developing the breeder now in a systematic way, so we can do the right things and when the need really arises we can move ahead reasonably.

Q: Ten years ago we were talking about having the first fusion reactors come on line in 2010, and here we are without the second generation of nuclear fission reactors. It's a sad story, especially when you look at the Japanese, who have been keeping to their schedule.
Wolfe: The Japanese schedule is to have economical breeders in the year 2037. . . . They've set their targets; they set reasonable targets, and they moved. We've had a program which made sense on the breeder here. We went through several years of competing to make sure we had the best concept and after we chose it, as I noted before, we went from the planned $15 million yearly program to a budget of $5 million. That just keeps you going, but you don't get very far.

Q: How do you think we can compete with the Japanese and the Europeans, who are moving so much more aggressively to develop nuclear technologies for domestic use and export?
Wolfe: I think we've got to clean up the licensing system, so that it's predictable, and I think we've got to demonstrate that the system works and that we can build plants economically. And there's no doubt with the right system we can do it. If we do that, I think our national energy requirements can be met.

After all, the Europeans and the Japanese are using our technology. In fact, the latest Japanese plant, the ABWR, which they just licensed (the technical review was just finished by MITI), was developed with General Electric as the leader working with Hitachi and Toshiba over the past decade. We've managed to keep the technology up to date, and it's really a matter of showing that institutionally we can meet the needs of the country and the world. We pioneered these technologies and then did not really develop them here. If we continue doing this, we could end up importing Japanese standardized reactors. . . .

On fusion I know your organization has been more optimistic than I am. I think fusion has quite a ways to go still. It's got the technical problem of demonstrating breakeven, but also I think the real problem we're going to have, when breakeven is reached, is the economics. It's going to be very difficult to get fusion into an economical form.

Q: I think the problem is the way this country looks at things like this, which are really an investment in our future. When you develop a new technology—an advanced nuclear plant or the fusion-fission hybrid, for example—its purpose is also as a bridge to the next step. Now if you start cutting out that process and saying it's too expensive, you totally lose sight of your future.
Wolfe: You have to evaluate the future and decide on a long-term basis, because these are long-term programs. That's one thing that we seem to have a problem doing in this country, but which the Japanese do very well. They have a longer timespan—vision on which they act.

Q: In thinking about what has happened over the past 10 years: It occurred to me that what I knew from ancient history—that societies die and go out of existence—could happen here.
Wolfe: Well, I have some hope and confidence. One thing about our country is that it's resilient. When real problems show up, we work to solve them. The problem we have is that we don't look ahead. We think things are going well; we wait for the real crisis, and then we're magnificent in solving it—at least I hope we are. But things would be a lot better if we would plan more in the future and avoid the crisis.

Q: In the best of situations, how fast do you think we could gear up? On the Prism breeder, I think GE estimated a couple of years back that you could do it in 36 months.
Wolfe: I think if this country really saw an urgent need, we would do things; we have a history of doing amazing things. People forget that the first reactors that were built at Hanford [Washington], were built in a couple of years. The reprocessing plant at Hanford—which today would take us a decade or a decade and a half to build—as I recall was built in three years. The first boiling water reactor and the first pressurized water reactors were built from scratch starting in 1955 and going on line in 1959. So, I think that if we really had a national purpose, we could find the United States approving nuclear plants very quickly and building these plants. Not overnight, but in a matter of a few years, you could start seeing that upturn in production. My feeling is that the American public and the American government have to recognize the need. If they recognize this need, I think we have the capability to bring nuclear plants on line in large quantities in less than a decade. . . .

What we need is the understanding that we should have the capability, that we're not going to solve our energy problems with magic. We may hope that conservation and solar power will do wonderful things, but there's a reality that says that if we want to live decently, we're going to need more power to meet our needs, and there aren't many alternatives: We've got coal and we've got nuclear. We may need both, but I think it's clear that nuclear is the superior technology that we need to have available.