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Author

Seaborg, B.T.

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G.T. Seaborg

April 1989

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NEW DIRECTIONS IN THE DEVELOPMENT OF NUCLEAR POWER

by Glenn T. Seaborg

Nuclear Science Division
Lawrence Berkeley Laboratory
1 Cyclotron Road
Berkeley, California 94720

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NEW DIRECTIONS IN THE DEVELOPMENT OF NUCLEAR POWER

Remarks by Glenn T. Seaborg
2nd International Symposium on Aneutronic Power
Washington, D.C.

April 28, 1989

Today there is a strong movement in the direction of developing nuclear power that is more acceptable to the general public. As many of you know, I have had a front seat in the development of the water-cooled reactors that are producing nearly 20% of the electrical energy being developed in the United States. I believe that these reactors are relatively safe compared to other methods of producing electricity today--in fact, they probably represent the safest method of producing electricity. However, that is not the topic of my opening remarks this morning, which will be devoted to new developments in the production of nuclear electric power.

I shall say a few words about these new directions in the development of nuclear fission power and then go on to talk about nuclear fusion power--the topic for discussion at this conference here today.

Presently, in the United States there is an aggressive program to develop nuclear fission reactors with passive safety features. There are some four types of such nuclear power systems under development--two types of advanced passive light water reactor (APLWR), the liquid metal reactor (LMR), and modular high temperature gas-cooled reactor (MHTGR). Passive safety features can be thought of as characteristics of a reactor which, without intervention of the human operator, will tend to shut a reactor down, keep it in a safe configuration, or prevent release of radiation to the public. These features fall into two broad categories--features which are designed to prevent accidents from taking place and those which mitigate the effects of potential

accidents if they do happen. Although there are significant differences in how passive safety is achieved between the four types of passive reactors, I do not see significant differences in overall safety between the systems.

The most developed is the Advanced Passive Light Water Reactor (APLWR), of which two designs are being developed. These two reactors are similar in that they are both 600 MWe in size, run at lower temperatures and with larger water inventories than current light water reactors, and have passive emergency core-cooling systems which utilize gravity, thus, eliminating the necessity for the large electrically driven emergency pumps common to the current generation light water reactors. They both use passive natural circulation for the removal of decay heat from the core and rejection of it to containment, and passive containment cooling systems to cool the containment, which would otherwise be heated as a result of the rejected decay heat in a post-accident situation. The two current designs are the AP-600 (Advanced Passive 600 MWe), a pressurized water reactor, and the SBWR (Simplified Boiling Water Reactor).

The Liquid Metal Reactor (LMR), passive design, is the PRISM (Power Reactor Inherently Safe Module) concept. The PRISM concept utilizes nine identical reactor modules arranged in three 465 MWe power blocks for an overall net electric rating of 1395 MWe. The reactor itself is a pool-type sodium-cooled reactor with an intermediate heat transport system to isolate the steam generators from the reactor in the event of a steam generator leak in subsequent metal/water reaction. No containment cooling is thought to be necessary because the designers believe that overall reactor safety may be met without the necessity for containment. The other concept of the family of passive reactors under development is the Modular High Temperature Gas-cooled

Reactor (MHTGR). The MHTGR is a helium-cooled graphite-moderated reactor system. This concept has four reactors feeding two turbines to make up a 540 MWe power block. Like PRISM, this reactor does not have a conventional containment.

The largest hurdle for all three of these systems appears to lie in their ability to meet the as-of-yet unspecified NRC requirements for severe accident. Meeting these requirements for either the MHTGR or the PRISM will require a new regulatory approach to licensing because of their use of a confinement--as opposed to a conventional--containment system. These planned passive reactors, have the advantage, as do the present conventional fission reactors and the fusion reactor that I will describe in a moment, that they circumvent some of the problems accruing from fossil-fueled electricity generating plants--acid rain, the greenhouse effect, the tremendous health toll on coal miners, and so forth.

Now I turn to the role of nuclear fusion reactors. As you know, the present types can be developed for economic operation, if this should prove possible at all, on an unfortunately long time scale--that is, the magnetic confinement and the inertial confinement fusion reactors. Although such reactors do not have the fission product waste disposal problem attendant with fission reactors, they are accompanied by neutron emission leading to large quantities of radioactive by-products, and they are also plagued by the difficult problem of converting this neutronic energy into electric power. Required here are extremely high plasma temperatures or difficult laser implosion techniques that have defied the ingenuity of investigators for many decades, with the prospects that such hurdles may not be overcome for many decades to come, if ever.

We have all been intrigued by the reports from Utah in recent weeks suggesting that "cold fusion" has been observed in the electrolysis of heavy water, utilizing a palladium electrode. The relative yield of neutrons is reported to be very low, which may not be an advantage, depending on the validity of the experiments. These observations have caught the interest of scientists in some 100 laboratories in this country and abroad with the result that much doubt has been cast on whether this can ever be a practical source of energy or even whether nuclear fusion reactions have actually been observed. I shall not comment further on this today.

Here today we are concerned with a unique approach to nuclear fusion--an approach that could lead to aneutronic power, essentially nonradioactive nuclear energy. You will hear today about the concept of colliding beam fusion, featuring the $D + {}^3\text{He}$ reaction leading to the aneutronic charged particle products $H + {}^4\text{He}$. The energy released in such aneutronic reactions is in the form of charged particles which can be converted directly to electricity with a very high efficiency. No other form of energy has ever come close to this degree of cleanness and efficiency. In all power sources today approximately two-thirds of the energy is in the form of waste heat or heat pollution. We may apparently be at the brink of an energy technology which is compact, safe, and has virtually no residue but the electricity we see fit to create with it. There is virtually no waste at all and none of it dangerous. Most amazing of all, the theory itself demands smallness for the greatest efficiency. It is conceivable that this technology could be miniaturized, revolutionizing electrical transmission distribution and decentralizing energy production.

The greatest energy needs are those of the developing world. There can be no development of industry without a new source of energy. The spread of nuclear energy to the developing world has been prevented by two factors: (1) high capital cost of nuclear reactors and (2) non-proliferation regulations.

How could the American innovative capacity be harnessed to develop a nuclear power system that the world can use? There is a large potential demand for a small modular nuclear power plant (5-100 MW), if it were able to be built with low capital cost, and was inexpensive, mass-produced, proliferation-proof, and radiation-safe.

Neither the industry nor the government has thus far made more than a trivial study of the possibility of developing the power plant that would meet these market demands. The projected aneutronic power plants promise to be small and modular, thus cutting the capital cost; and since they are neutronless, they cannot proliferate. I am not the first to declare that this would "meet the original goal of the fusion program: universally available, inexhaustible, environmentally benign power."

The planet which we inhabit is in the midst of a serious environmental crisis. In large part this has been brought about by our efforts to meet the constantly growing demand for energy. It is now apparent that lack of energy resources is not the problem, but the threat to our environment from the unused residue of energy production. We are in an energy residue crisis, and this is how we must look at energy technology from now on. We cannot allow the unused residue of our energy production--waste heat from thermal conversion, carbon dioxide from fossil fuels, radioactive waste from nuclear fission power--destroy the environment while we accommodate our needs.

Aneutronic power is an answer to the energy residue crisis. In their colliding beam fusion approach, Dr. Bogdan Maglich and the pioneers of this research have advanced this approach to the point where a further experiment could prove that it works, and that a prototype reactor could be built. They reached this point in 1982 without government support. But the recognition of these results came only after elaborate feasibility studies had been carried out in the period 1985-88 with USAF support. The next step is costly, and will require a level of support which can only come from government funding.

This conference has assembled scientists from all over the world. I commend Drs. Maglich and George Miley (Co-Chairmen) and their colleagues H. Berk (U. of Texas), B. Brunelli (ENEA), B. Coppi (MIT), M. Heindler (Graz U. of Tech.), R. Kulsrud (PPPL), L. Lidksy (MIT), and H. Momota (Nagoya) for sharing the results of their work, so that no nation is excluded from participation. The United States has been the leader in this research. In the event the United States government does not support this research, other countries are free to pursue it further. I am sure they will, and we will all benefit. But as an American I would be sorry to see the United States lose its leadership role in nuclear energy.

I was much involved in the development of nuclear fission engineering, and have shared the excitement. I know well what a disappointment it is to experience the difficulties and frustrations in coping with the environmental hazards of fission reactors. But being aware of the enormous challenges we have overcome to get where we are, I am all the more convinced that we must not lose sight of the need to develop clean and safe nuclear power.

It has been only 80 years since the discovery of radioactivity, and 50 years since the discovery of nuclear fission. In historical terms, this is an extremely short time. We may just have begun to explore the world of nuclear energy. We are still pioneers. Nuclear engineering has dared greatly, and encountered great obstacles. But we may be at the beginning, not the end, of the nuclear age.

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