A Thought on Small Modular Reactors

By Kenichi Matsui*

Prominent nuclear physicist Dr. Alvin Weinberg expressed reservations about the safety of the large light water reactor in 1964 just after its commercial success and the signing of GE to construct the 515 MW BWR nuclear power plant at Oyster Creek in New Jersey. He warned that "The Oyster Creek reactor is just getting under way. It is still possible, I suppose, that some flaw will develop in boiling water reactors after they have operated for a long time."[1] His warning turned out to be true in Fukushima. Pursuance of the up scaling of the light water reactor has required more safety measures which in turn increases costs and demands operators to carry out more severe monitoring and maintenance to ensure safety.

Looking back at the history of nuclear power plant development, there were arguments from the very beginning of the development that commercial reactors should not be large, light water reactors which are dominant today, but should be small reactors including small fast breeder reactors and molten salt reactors. In fact, the first nuclear reactor which generated electricity was a fast breeder reactor, EBR I (Experimental Breeder Reactor Number One) at the Idaho site of Argonne National Laboratory. This reactor came into operation in December 1951 and supplied electricity to the reactor control system as well as the building and a machine shop. This reactor proved the breeding concept and the possibility of an almost unlimited supply of energy and the use of plutonium as generation fuel. Dr. Weinberg believed that "the commercial success of nuclear power would have to await the development of the breeder."[2] This reactor had been operated for around 10 years until replaced by a little larger version, EBR II,in 1962. However, further development of this reactor for commercialization was interrupted by a change in the research policy of the laboratory which favored development of a large fast breeder reactor coping with large light water reactors. While this project to develop a large fast breeder reactor failed, research on EBR II has continued appropriating a small portion of the budget allocated for various projects and items. And in 1984, Argonne National Laboratory started the project to develop an IFR (Integral Fast Reactor) system based on the research on EBR combined with spent fuel pyroprocessing technology. IFR is a complete system composed of a safer, more fool-proof reactor and a new process that allows the recycling of its spent fuel and creates a waste product with a much reduced radiological lifetime. After around 10 years of research, this project was suddenly terminated in September 1994 by President Clinton. He terminated "all advanced reactor development" because "it is unnecessary".

Thus development of the small reactor was interrupted politically. It has also been intentionally ignored by the established nuclear community in order to protect their interests in the large light water reactor. Recently, however, escalating costs, long construction times and growing safety concerns about large light water reactors turned the spotlight on the small modular reactors (SMR) raising their merits of passive safety philosophy, simple structure, easy construction (like prefabricated homes), easy maintenance, operational flexibility, reduced construction time, reduced upfront capital costs and debt loads, lowering the burden of high radioactive waste disposal and proliferation-resistance features, etc.

Recognizing the possible great contribution of SMR for the United States in many aspects, including giving a key competitive edge in the global clean energy race, creating new jobs and business, the Obama administration has committed to speed up their commercialization.

A small version of the current light water reactor will be commercialized around 2020 and will be followed by innovative, small fast reactors. They will dramatically solve the problem of the final treatment of radioactive waste specifically the high radioactive fission materials.

The long history of human beings and energy use tells us that cutting edge science theory and the technology based on that theory has led the development of civilization. The civilization of the 20th century was spurred by technology based on Newtonian physics and that of 21st century will be led by technology based on the theory of Relativity and Quantum Mechanics represented by information technology and nuclear technology. Science and technology has its own dynamism. Countries ignoring or contradicting this dynamism will ultimately pay dearly. Science and technology have two sides; a very large benefit and a very large destructive power. Human beings have coexisted with the development of science and technology whatever the dangers they pose. Human beings are not so wise and have made many mistakes. But human beings are not stupid either. They know where the stupidity should be stopped. I don't make any ethical judgment about the development of science. But in the past, the difficulty caused by technology has been overcome with more advanced technology and it will be repeated in the future. I believe

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there is no other way to live.

Now, I think development of SMR has specific meaning for Japan as a country with almost no fossil fuel resources and as the only country bombed by the atomic bomb. Japan should lead a peaceful use of nuclear energy in the international non-proliferation framework through development and introduction of SMRs not only in Japan but also in the world.

After the Fukushima nuclear power plant accident, safety is the most critical factor for the future of the nuclear power plant. Also, the final treatment of radioactive waste and non-proliferation questions should be addressed. Simple extension of the current nuclear power plant system based on large light water reactors will not be accepted socially and the introduction of SMRs to the current system could be an answer.

In the past, Japan had a good chance to introduce the SMR. In the late 1980's to the beginning of 1990's, several Japanese nuclear researchers and executives of the nuclear industry visited the Argonne Laboratory to learn about the IFR program. Impressed by the project, Japan signed agreements for a joint program on IFR technology with the USDOE. Altogether, these agreements represented an over $100 million contribution from Japan. However these contracts were terminated when the IFR program was terminated by President Clinton. Dr. Charles Till, leader of the IFR program, said in his book "The few years we collaborated with the Japanese utilities were among the highlights of my career. Given the situation with nuclear energy in the U.S. I truly believed that the IFR with pyroprocessing might be first commercialized in Japan"[3]

Japan missed the chance, however, due to the commitment to construct the French type purex processing plant. This plant still doesn't work well after 20 years from its introduction. I think Japan has the technical base to commercialize SMRs including the IFR system. I wish that Japan would reconsider the introduction of SMR including the IFR system and take due action.

If Japan will not move and U.S. will not move fast enough, other countries including Russia, China and Korea will lead the development of these technologies. In the middle of the Shale Gas Revolution, the Nuclear Revolution is creeping. However, with a little encouragement the Nuclear Revolution and the Second Era of Nuclear Energy can come much faster than generally perceived.

References

1. Alvin M. Weinberg, "The First Nuclear Era Life and Times of a Technological Fixer", AIP Press 1994, p.134

2. ditto p.135

3. Charles E. Till and Yoon Il Chang "Plentiful Energy, The Story of the Integral Fast Reactor", 2011 ISBN 978-1466384606 Library of Congress, Control Number 2011918518 p.75