Nuclear power needs a fuel recycle reactor

BY LEONARD J. KOCH

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THERE IS INCREASING recognition that it may be necessary to increase the amount of electricity that is generated by nuclear power. Some of the projections predict *huge* increases, as well as requirements for other applications, such as water desalination and hydrogen production. These projections also reflect concerns about the availability and acceptability of fossil fuels and the environmental impact resulting from their use.

The nuclear energy industry's "Vision 2020," calling for 50 000 MWe of new nuclear energy production by 2020, is a modest response; however, it will replace only about half of the present capacity when the latter is retired. Our preparations must be much more aggressive. They must recognize that much more than 1 percent of the energy contained in fissionable material must be recovered to respond effectively.

This can be done. The potential capability to recover virtually 100 percent of this energy was recognized by Enrico Fermi and his colleagues more than 50 years ago. It requires that nuclear fuel be recycled in a fast-neutron spectrum nuclear reactor. The *science* for doing so is established; the *total technology* is not. Total technology includes the composition and character of the fuel as it proceeds through multiple cycles, including the "transmutation" of plutonium isotopes and other actinides, antiproliferation characteristics, composition of ultimate "real waste," etc.

The original "U.S. Vision" for nuclear power included the development of this technology. EBR-I and EBR-II resulted from this vision, verified the science, and developed some of the technology, but not all that is needed. What is needed now is a second, parallel, "Vision 2020" that does not involve the planned 50 000 MWe of new nuclear power capacity, but involves only a single 200- or 300-MW Fuel Recycle Reactor (FRR), which by 2020 could be developing and demonstrating this essential technology.

EBR-II was the first FRR. Its primary objective was to demonstrate integrated nuclear power operation with recycled fuel produced by a pyrometallurgical refining process. This concept was consistent with the basic objectives that had been established at that very early stage of fast breeder reactor (FBR) development, including high-density metal alloy fuel, onsite fuel reprocessing, fabrication of highly radioactive fuel, and electric power generation.

Only a small part of this program had been completed (five core loadings of relatively low-burnup fuel had been recycled) when the Atomic Energy Commission shifted the program emphasis from fuel recycle to first-cycle fuel performance. The EBR-II fuel recycle program was terminated. The lasting and continuing contribution of the EBR-II experience will only be achieved by the demonstration of total integrated nuclear power operation on a much larger scale for a much longer duration.

The new FRR program can logically pick up where EBR-II left off. The FRR needs only to be about 10 or 15 times the size of EBR-II. Much of the EBR-II technology can be expanded to this size, and other technology can be incorporated. The dominant requirement for the FRR is that it be capable of operation with recycled fuel and that it do so with the variety of fuels that may be produced by fuel refining processes.

This program should be the cornerstone of the U.S. advanced nuclear technology development program. It should have the top priority for resources allocated to future advanced nuclear power development. It should be number one on the Generation IV list (not number three or four). The capability of operating nuclear power plants with recycled fuel is far more important than the capability of operating nuclear power plants at higher temperatures. The benefits of increasing thermal efficiency are minuscule when compared to the benefits of increasing nuclear fuel efficiency.

In my book *EBR-II* (See Recently Published section, p. 11), I expand on this message and describe my concept of an FRR that would exploit and extend this technology (I refer to it as EBR-III in Appendix D). We must develop and demonstrate all the technology required by the reactor, the fuel cycle, the power cycle, and the environment.

The primary deterrent to proceeding logically with the development of this technology appears to be a concern that recycling nuclear fuel may enhance nuclear weapons proliferation. Therefore, a significant objective of this program must include the demonstration that this is not a valid conclusion.

This recycled fuel, by its natural composition, will be far inferior to the relatively "clean" material produced by "once-through" operation of any nuclear reactor (power or other application). At equilibrium, this recycled fuel will consist of a mix of plutonium isotopes and other actinides. Even after the first cycle, with the burnup that was routinely achieved in EBR-II, this fuel will contain much too high of a concentration of higher isotopes of plutonium and other actinides to be attractive for weapons.

The technology and the experience are urgently needed. The urgency exists because this will be a slow process. It will take many years to recycle fuel enough times to approach equilibrium composition and to learn how to deal with this changing composition. That is why it is imperative to start now. It should have started 25 years ago.

In addition, the transition period when both thermal and fast reactors are in use (probably a period of at least 50 years) will present an opportunity to employ a variety of operational options to enhance the total capability of nuclear power—for example, the use of fast reactors to produce uranium-233 from thorium in the blanket while "burning" plutonium and other actinides in the core. The FRR will contribute to establishing such technologies and to the utilization of the huge inventories of spent fuel and depleted uranium.

Using the other 99 percent of the energy contained in nuclear fuel will also be a slow process. It will take hundreds of years to use the stockpiles of spent fuel and depleted uranium. But when that stage is reached, there will be no urgency. Energy will be produced from a virtually inexhaustible fuel supply, and concerns about fossil fuel supply and the environmental consequences of their use will have been addressed.

That will fulfill the Vision of the founders of nuclear power and of those who stood on their shoulders. NN

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