# A Fourth-Generation Technology

*By Eric Loewen, GE Hitachi Nuclear Energy.*

## Eric Loewen

*Since 2006, Dr. Loewen has guided GEH's technical efforts for deployment of the PRISM integral fast reactor. His US Navy service included Instructor at Nuclear Power School, and Quality Control Officer and Senior Reactor Operator in USS Long Beach (CGN-9). As Science and Technology Advisor to the Congress and aide to then-Senator Chuck Hagel, he integrated nuclear power into the U.S. Energy Policy Act 2005. From June 2011-June 2012 Eric served as President of the American Nuclear Society (ANS).*

*Responses to questions by Newal Agnihotri, Editor of Nuclear Plant Journal.*

1. *What is the evaluation status of PRISM by NDA?*

PRISM (Power Reactor Inherently Safe Module) is a high energy, sodium-cooled reactor that uses proven, safe and advanced technologies to create an innovative solution to harness the remaining energy potential of used nuclear fuel and surplus plutonium.

In January 2014, following a two-year review process, the UK Nuclear Decommissioning Authority (NDA) declared that PRISM's fourth generation nuclear power technology is a "credible option" for managing the UK's plutonium stockpile.

We continue to work with the NDA to further develop their understanding of the technology as a credible option.

2. *What are the past and current applications of PRISM?*

PRISM is based on the successful EBR II reactor that began operating in 1964. GE started to work on PRISM technology in 1981 and in 1984 the U.S. government, through the U.S. Department of Energy funded the Advanced Liquid Metal Reactor program at the Argonne National Laboratory. The goal of the physicists and engineers who worked on this program was to mitigate concerns associated with nuclear power including waste, economics, proliferation and fuel supply. The 10-year program was unique in that it involved U.S.-owned companies, including GE, all working with the national laboratories to come up with an advanced nuclear reactor design that would lead to a new, safer and more secure approach to nuclear energy. After 30 years of development, the technology utilized by PRISM is ready to be commercialized and can be made operational within a time period that is competitive with other potential plutonium reuse options.

Recycling used nuclear fuel with PRISM is calculated to make approximately 95 percent more energy available from uranium than current conventional reactors. At the same time, extracting this energy makes used nuclear fuel easier to dispose of and safer over the longer term. Finally, PRISM is uniquely suited to the disposition of plutonium stockpiles thereby making the world more secure from nuclear proliferation concerns. A single nuclear power plant technology, PRISM, can concurrently increase the world's supply of low-carbon electricity, address the nuclear waste issue and improve nuclear security.

3. *What are its abilities to be used for (e.g. power generation, hydrogen generation, desalination plant, district heating, any other applications)?*

PRISM is designed to have many applications including plutonium disposition and electricity generation. PRISM has a rated thermal power of 840 MW and an electrical output of 311 MW. Two PRISM reactors make up a power block that combined produce 622 MW of electrical output. Of course low cost electricity opens the door to many other possible applications.

4. *Is there any collaboration with international Gen IV effort?*

GE Hitachi encourages industry involvement of US companies in government-led international programs that promote advanced nuclear technology such as the Gen IV effort.

5. *Has PRISM been proposed for any applications at Fukushima Daiichi nuclear power plant?*

Our joint venture partner Hitachi continues to assist TEPCO. We believe the fuel technologies associated with the PRISM reactor design would be ideal to treat damaged oxide cores initially cooled with seawater by stabilizing the radioactivity in a robust ceramic and metallic waste form.

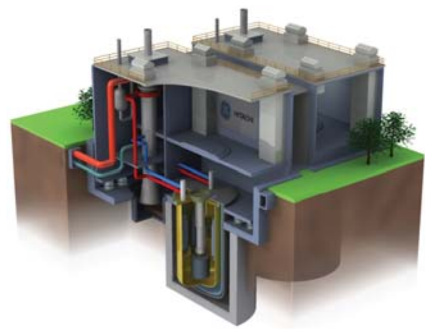
6. *Who are the vendors collaborating for engineering, construction and manufacturing in the United Kingdom? Who is supplying the digital equipment, including the control room?*

In April 2012 we conducted a supplier conference and met face-to-face with a number of talented and experienced employees from nuclear sector suppliers at ENERGUS Convention Center in West Cumbria, U. K. We were supported in planning and conducting the conference by Britain's Energy Coast Business Cluster. And we have a Memorandum of Understanding in place with engineering firms Costain, Arup and Pöyry. In addition, we met with several supply chain representatives during an event in November 2011 at the Church House Conference Center in Westminster, London and we have a memorandum of understanding with National Nuclear Laboratory Ltd. (NNL) and the University of Manchester for expert technical input to the deployment of PRISM. We continue to work with potential UK suppliers for the project and are committed to the greatest extent possible to utilizing UK companies and workers for this effort.

7. *What is the planned timeline for design, construction and operation of PRISM in the United Kingdom after receiving the go-ahead?*

While no formal commercial contract arrangements have been developed, we estimate the schedule for the first irradiation of plutonium in a PRISM reactor to be comparable to other options. Licensing is always significant for new nuclear plants because safety is of the utmost importance, but multiple reviews including one performed by the U.S. NRC have concluded that there are no fundamental impediments to PRISM licensing. The technology is proven and PRISM's simplified reactor design should speed construction.

PRISM represents a multi-billion pound investment in the UK, regional and local economy. This will be a much needed boost to the UK business community, particularly as the economy continues to emerge out of recession. Based upon preliminary investment plans and current thinking, it is estimated that the construction of a PRISM reactor could create a peak of several thousand jobs in the local economy, with 900 of these being permanent operational jobs at Sellafield. In addition to jobs directly associated with the project and plant, further jobs would be created in the local economy, for example from suppliers to the plant and in the local retail sector. The engineering and research work to support PRISM will undoubtedly have a direct and significant impact on jobs and skills in West Cumbria, bolstering the UK's nuclear research capability in many areas pre and post-construction phase.



**PRISM Cutaway Illustration.**

8. *When was the prototype for PRISM tested to ensure its operation after deployment?*

The basis of PRISM technology comes from the 30-year operation of EBR II from 1964-1994. In addition, PRISM leveraged the testing and demonstration done during the Clinch River breeder reactor program from 1972-1983 as well as large component testing during the Advanced Liquid Metal Reactor program from 1984-1994. Many of these tests were done at the U.S. Department of Energy's Energy Technology Engineering Center in California.

9. *How does PRISM coolant temperature compare with ESBWR and an ABWR under normal conditions and under accident conditions?*

The normal operating temperature for sodium cooled reactors is about 500° Celsius whereas the normal operating temperature for water cooled reactors like the ESBWR and ABWR is about 300° Celsius. In addition, PRISM is designed to operate at much lower pressure than either boiling or pressurized water reactors.

10. *Describe the safety aspects of PRISM reactor under a Beyond Design Basis Event.*

Various safety features of the PRISM design are specifically intended to prevent a loss of coolant accident. These safety features make PRISM robust for coping with beyond design basis events. For example, PRISM is the only nuclear facility designed to sit on seismic isolation bearings. The seismic isolation system reduces horizontal seismic accelerations that are transmitted to the reactor module by a factor of three. Another example is that the control room, reactor plant and steam plant are separated and don't impact each other. Yet another example is that PRISM has the ability to remove decay heat passively without any operator action.

In the event of a worst-case-scenario accident, the metallic core is designed to expand as the temperature rises so that its density decreases, thereby slowing the fission reaction. The reactor simply shuts itself down. PRISM's very conductive metal fuel and metal coolant then readily dissipates excess heat without damaging any of its components. Passive safety is a design feature that relies upon the laws of physics, instead of human, electronic or mechanical intervention, to mitigate the risk of an accident.

11. *Describe any other important features.*

The manufacture of PRISM metallic fuel will incorporate more forgiving dimensional tolerances than plutonium oxide fuel. Because PRISM's fuel can accommodate a larger relative proportion of plutonium than other reactor options being considered by the UK, this is highly likely to mean lower fuel manufacturing cost, less fuel handling and less used fuel to dispose. Plant electrical output is designed to permit tailoring to operator needs through the modular addition of power blocks. This modularity is expected to allow expansion from one power block to as many as desired on one side. Factory fabrication of the modules is aimed at providing improved quality, reduced cost and shortened construction times.

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