Traveling Wave Reactors: Sodium-cooled Gold at the End of a Nuclear Rainbow?

Bill Gates on the wrong path with traveling wave reactors: despite $100 billion invested globally, sodium-cooled reactors plagued by leaks, accidents, and low reliability

Report: TWRs Will Likely Be Economically Obsolete Before They Are Commercialized

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WASHINGTON, D.C. – September 4, 2013 – Bill Gates's heart is in the right place on climate: we do need to get to a very low carbon emissions energy system. But, when it comes to the traveling wave reactor, his money is not.

A new report from the nonprofit Institute for Energy and Environmental Research (IEER) think tank finds that the "traveling wave reactor" (TWR) concept championed by TerraPower, in which Bill Gates, of Microsoft fame, is a key investor, is likely to be a commercial failure. $100 billion already has been invested by over half a dozen countries over more than six decades in an unsuccessful commercialization effort. There has been essentially no demonstrable learning curve: the most recent sodium-cooled demonstration reactors in France and Japan have among the worst reliability records.

The "traveling wave reactor," first conceived in 1958, has been intensively investigated only since about 2006. It is a sodium-cooled "fast" reactor design in which neutrons are not slowed down and the heat created by fission is carried away by liquid sodium, which is used to boil water. In turn, the steam is used to drive a turbine-generator set to generate electricity. A TWR has never been built. However, the TWR is a type of the sodium-cooled fast reactors that have been pursued with little success over several decades in several countries.

Titled ***"Traveling Wave Reactor: Sodium-cooled Gold at the End of a Nuclear Rainbow?,"*** the report concludes:

- **The sodium-cooled reactor experience does *not* bode well for TWRs.** "Sodium-cooled fast reactors have a checkered history. Some have operated well, while others have done poorly. The most recent commercial demonstration reactors belong in the latter category. The French demonstration reactor, Superphénix, operated at an average capacity factor of less than 7 percent over 11 years before being shut in 1996….The Japanese Monju reactor, commissioned in 1994, and connected to the grid in 1995, had a sodium leak and fire in 1995. It was closed until May 2010, when it was restarted for testing, but suffered another accident in August 2010. It has not been restarted since…."
- **Power produced by TWRs would *not* be affordable or competitive.** "Even apart from the poor reliability in many cases, sodium-cooled breeder reactor capital costs have been very variable and have not decreased over time. Fermi I, built in the 1960s, cost about $4,000 per kilowatt, while the

> Fast Flux Test Facility, operational in 1980, cost over $10,000 per kilowatt. Superphénix cost, commissioned in 1986, about $4,800 per kilowatt, but Monju, commissioned nearly a decade later, cost over $20,000 per kilowatt [all in 1996 dollars]. Proponents of sodium-cooled reactors, including traveling wave reactors, tend not to focus on how they plan to overcome the problematic parts of the sodium-cooled design history, centered in large part on sodium-related problems, but rather tend to focus on the vast available raw material to produce a large amount of power for the indefinite future. Overall, it is expected that costs of sodium-cooled breeders will be significantly higher than current reactors, despite the fact that about $100 billion have been spent worldwide (2007 dollars) on the attempt to commercialize sodium-cooled breeder reactors, so far without success."

Arjun Makhijani, Ph.D., nuclear engineer and president, Institute for Energy and Environmental Research, and author of the TWR report, said:

> "By focusing on the uranium resource issue, which is an economic non-problem for the foreseeable future, TWR proponents have lost sight of the practical problems that have prevented commercialization of sodium-cooled breeders despite immense effort and expense. Contrary to the claims of proponents, supplying most of the world's electricity with TWRs would create significant proliferation risks, with or without reprocessing, were they to be used as a mainstay of global power generation. Moreover, given the reactor development that remains, it is highly unlikely that such reactors could help significantly alleviate the problem of fossil fuel generation in the next few decades, when it must be solved. TWRs are likely to be economically obsolete before there are commercialized."

Dr. Makhijani, who is principal author of the first ever study of energy efficiency potential of the U.S. economy (1971), said he will send Mr. Gates his book, Carbon-Free and Nuclear-Free: A Roadmap for U.S. Energy Policy, and invite him to debate the path to a low carbon-emissions economy.

Report reviewer M.V. Ramana, Ph.D., Nuclear Futures Laboratory and Program on Science and Global Security, Woodrow Wilson School of Public and International Affairs, Princeton University, said:

> "Sodium cooled fast neutron reactors have been pursued by several countries around the world. The lesson from the many decades of such pursuit has been that these reactors are expensive, are prone to operational problems and sodium leaks, and are susceptible to severe accidents under some circumstances. There is no evidence that the Traveling Wave Reactor will overcome any of these. It is not convincing even on paper."

Other Key Findings

- **Promised delivery dates for TWRs are wildly unrealistic.** "TWR proponents aim to have a demonstration reactor operating by 2022 and the first commercial reactor by the late 2020s. This is an impossible schedule, at least for the United States. The TWR design, like other sodium-cooled reactors, is so different from presently licensed reactors that the Nuclear Regulatory Commission will have to write regulations specifically tailored for them. For instance,

accident mechanisms in sodium-cooled breeders are different than in light water reactors. It will take years for the Nuclear Regulatory Commission to staff up and acquire the necessary data and expertise to write the rules and do the safety and risk evaluations. As a result, certification and licensing of a demonstration reactor design is likely to take much longer than proponents have allowed for so far. Perhaps that is why TerraPower is reportedly exploring agreements with China and India even though China has little experience with sodium-cooled breeder reactors and India's record so far hardly inspires confidence, having been plagued by leaks and accidents."

- **Even if reducing the cost of uranium were possible with TWRs, it would not make nuclear power cheaper.** "The main argument that has been made for TWRs is that they can greatly expand the use of the uranium resource without reprocessing. But a paucity of uranium resources is not holding back nuclear power – it is the capital cost of the reactors. Reducing the cost of uranium resources significantly will do almost nothing to alleviate this problem, since the cost of mined uranium in existing power plants is roughly two percent of the overall cost of nuclear power."
- **TWRs may be prone to radioactive leaks and core meltdowns.** "… leaks have been a common problem in sodium-cooled breeder programs, including in France, the UK, India, Russia, and Japan. Core meltdown accidents can also occur: two of the U.S. sodium-cooled breeders have had partial core meltdowns. Sodium-cooled reactors have some safety advantages relative to present-day light water reactors, such as operation at low pressure, in contrast to light water reactors. But they also have safety disadvantages, including the potential for the reactor to continue to sustain a chain reaction in the event of coolant loss."

See the full report at http://www.ieer.org.

About IEER

The nonprofit Institute for Energy and Environmental Research provides interested parties with understandable and accurate scientific and technical information on energy and environmental issues. IEER's aim is to bring scientific excellence to public policy issues in order to promote the democratization of science and a safer, healthier environment.

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