The New York Times

October 20, 2009

SPECIAL REPORT: ENERGY

Considering an Alternative Fuel for Nuclear Energy

By LISA PHAM

PARIS — For decades, scientists have dreamed about turning thorium — an element that is less radioactive and produces less nuclear waste than uranium — into an alternative fuel for nuclear energy. Recent technological developments may be bringing the dream closer to reality.

As a naturally occurring metal that is substantially more abundant than uranium, its most common isotopic form, thorium-232, can be converted by irradiation to uranium-233, which is suitable for use in nuclear fuels.

The United States is estimated to have 400,000 tons of thorium, Turkey 344,000 tons and India 319,000 tons, according to a 2008 joint report by the Nuclear Energy Agency, a body linked to the Organization for Economic Cooperation and Development, and the International Atomic Energy Agency.

There are no commercial thorium reactors in operation. Instead, nuclear reactors use uranium-235 which must be enriched before it can be used as fuel. Uranium-235 accounts for 0.7 percent of the uranium now being mined.

Rajendran Raja, a physicist at Fermilab — the U.S. Department of Energy's Fermi National Accelerator Laboratory in Batavia, Illinois — said by telephone that the benefit of adding thorium to the fuel mix would be to create much more fuel using existing abundant resources and to reduce waste.

This could be done by building a high-intensity proton accelerator with the capacity to produce fast neutrons that could convert nuclear waste, thorium-232 and uranium-238 into fuel, he said. But to accomplish this, a proton accelerator would need to be 10 times more power-intense than anything that has been produced to date.

The concept of an accelerator-driven subcritical system, known as ADS, has been around since the 1990s. It differs from conventional reactors which operate at criticality, which is the point at which a nuclear reaction can be self-sustaining. But if a chain reaction gets out of control, accidents like those at Chernobyl could occur, and high levels of radioactive material could be released into the atmosphere.

Subcritical reactors, however, would use neutrons provided by the accelerator to continue the fission. This means that criticality could be avoided by switching off the accelerator, which in turn would switch off the neutrons. This type of reactor has not been built because an accelerator with sufficient power does not exist, Dr. Raja said.

But experts in the United States and elsewhere are taking steps in that direction.

In September, a U.S. Department of Energy facility successfully completed a test of the first U.S.-built superconducting radio frequency niobium cavity intended to become part of the prototype accelerator at Fermilab. The niobium cavity, which is more efficient than the more common copper cavities, can be used to build a particle accelerator producing 10 megawatts of beam power, which in turn could convert thorium into nuclear fuel.

“This is a safer form of nuclear energy which produces more fuel and less waste,” Dr. Raja said.

India has been making advances in the field of thorium-based fuels, working to design and develop a prototype for an atomic reactor using thorium and low-enriched uranium.

The country has a long-term objective goal of becoming energy-independent based on its vast thorium resources, Anil Kakodkar, chairman of the Indian Atomic Energy Commission, said in a speech in Vienna in September.

Dr. Raja said that India’s new thorium reactor does not use an accelerator. Instead, it is a fast-breeder reactor and neutrons are produced by a plutonium core rather than an accelerator.

“The advantage of using an accelerator is that if something goes wrong, we can switch it off,” Dr. Raja said. Accelerator-based systems operate at subcriticality, which means they can produce fission without achieving a self-sustaining nuclear reaction.

As of late last year, Australia had identified an estimated 489,000 tons of thorium resources, recoverable at less than $176 a pound, according to Geoscience Australia, a government agency.

But the Australian government is opposed to the development of a nuclear power industry, even with thorium-based systems.

John Boldeman, a specialist in nuclear science and engineering, and his colleagues at the University of Sydney have been interested in accelerator-driven systems for more than 15 years.

He acknowledged that creating any thorium systems would be a long process that could take decades before finding success. “Our programs in Australia are at this stage very limited,” Mr. Boldeman said in an e-mail message, “although we continue to apply for funding.”

The U.S. energy secretary, Steven Chu, announced $1.2 billion in new science financing in March, including research efforts and support for fields like superconductivity.

Dr. Raja estimated that a high-intensity proton accelerator prototype would cost roughly $1 billion, including research, development and overhead. After that, each mass-produced machine could be built for approximately $300 million.

The World Nuclear Association, an international organization in London that promotes nuclear energy, believes that uranium is a safer bet. “The uranium fuel cycle is 50 years old, world proven, thoroughly mature and the costs are well known,” said Ian Hore-Lacy, a spokesman for the group.

“People are naturally inclined to stick with what they know,” he added. Thorium as an alternative source of energy might be commercially viable one day, he said, “but I’m not holding my breath.”

Environmental advocates, including Greenpeace International, also dismiss thorium-based systems as a distant dream — and a distraction from the fast implementation of renewable energy and efficiency technologies.

“While thorium partially addresses some of the downsides of current commercial reactors based on uranium fuel,” Jan Beranek, nuclear energy project leader of Greenpeace International, said in an e-mail message from Amsterdam, “from what we know it still has significant issues related to fuel mining and fabrication, reactor safety, production of dangerous waste, and hazards of proliferation.”

Mr. Beranek said that there might also be other problems, as yet undetected, given the still undeveloped and highly experimental state of the technology.

The need to reduce carbon emissions was urgent, he said. “We need to act now, and not wait several decades to see whether thorium power can deliver or not,” he said.