BMDO-Funded R&D May Help Reduce The Impact Of Nuclear Waste

Commercial nuclear waste has become an increasingly tough problem for public utilities, both from a business and an environmental perspective. The 109 commercial nuclear power plants operating in the United States, plus 2 that are no longer in operation, have already generated about 27,000 metric tons of spent fuel that must be safely stored.[2] Within the next 15 years, up to 59,000 tons will have to be dealt with.

What do the utilities do with it? Power plants typically store this waste near their reactors in cooling and storage pools. But these storage centers are now nearing maximum capacity and the utilities are looking for new storage or treatment solutions. The answers are not easy. Facing serious cost, liability, regulatory, and transportation issues, the utilities must deal with substances that will remain radioactive for many thousands of years.

Using technology originally developed under BMDO, researchers at Los Alamos National Laboratory, or LANL, (Los Alamos, NM) are finding ways to use particle beam accelerators to reduce the impact of these wastes. They have developed a design concept called accelerator-driven transmutation technology, or ADTT, to destroy long-lived nuclear waste as well as weapons-grade plutonium. Once fully developed, ADTT could reduce the half-lives of radioactive waste to a few centuries, making it easier to design secure storage facilities. And as an added benefit, ADTT can produce thermal power (just as in a nuclear reactor) for generating electricity—while treating the waste.

SCIENTISTS FROM THE FORMER SOVIET UNION AND THE UNITED STATES RECEIVED A $3 MILLION GRANT TO REDUCE THE HAZARDS OF NUCLEAR WASTE USING BMDO-FUNDED R&D.

Receiving international attention, the team has recently been granted $3 million from the International Science and Technology Center (ISTC) to further develop ADTT. ISTC was established in 1992 to support former nuclear weapons scientists from Russia by funding work on civilian projects that reduce the danger of proliferating weapons of mass destruction. Its board of governors includes representatives from the United States, the European Community, and Japan. The Los Alamos project is one of the largest ISTC-funded projects.

Investigating a concept called accelerator-driven transmutation technology (ADTT), researchers at Los Alamos National Laboratory are finding ways to use particle beam accelerators, pictured above, to reduce the impact of nuclear waste.

In the project, Russian researchers will develop hardware, test stands, and databases for accelerator, target, blanket, and separations systems while LANL will provide management support. This effort will provide a new, non-defense mission for more than 200 former weapons scientists from Russia. The scientific fruits of this collaboration should also advance worldwide efforts to reduce the stockpiles of nuclear weapons materials and nuclear wastes.

Commercial spent fuel. One of the two ADTT programs for destroying radioactive material, called accelerator transmutation of waste, or ATW, treats waste from commercial nuclear reactors. ATW uses neutrons to transmute long-lived fission products and actinides in spent commercial reactor fuel, which can remain radioactive for up to a million years. Radioactive isotopes of technetium, iodine, plutonium, neptunium, and americium are among those that could be destroyed by the LANL ATW system.

Weapons-grade plutonium. Accelerator-based conversion, or ABC, is designed to destroy plutonium from weapons and reactor fuel sources. ABC can reduce either weapons-grade plutonium or spent commercial reactor fuel that contains plutonium. In a single cycle, ABC can burn 98 percent of the ^{239}Pu and 90 percent of all plutonium isotopes occurring in weapons-grade plutonium. While this technique does not completely neutralize radioactive material, it does change a significant amount of it into harmless, nonradioactive substances.

[2] Ending the Gridlock on Nuclear Waste Storage…L. Carter; *Issues in Science and Technology,* Fall 1993, p. 74.

Energy production. Researchers at LANL are also finding ways to use accelerator-based concepts for generating electricity, an approach called accelerator-driven energy plants (ADEP). Safer than conventional nuclear power plants, this approach produces significantly less long-lived nuclear waste than conventional nuclear power plants. The laboratory's design concepts rely heavily on particle accelerators. An alternative to conventional nuclear power plants, ADEP transmutes its own long-lived wastes and uses thorium, a more abundant nuclear fuel.

BMDO originally funded neutral particle beam (NPB) R&D at LANL to attack booster or re-entry vehicles. These systems would use an accelerator platform that generates, accelerates, and focuses a beam of ions. The beam is then neutralized and directed at a distant target in space. BMDO chose neutral particle beams because they can propagate for long distances in space without being deflected by the Earth's magnetic field.

About The Technology

LANL has been developing high-performance particle accelerators with BMDO support and under the management of the U.S. Army Space and Strategic Defense Command. The particle beams from these accelerators have a high intensity or brightness and a low emittance. Emittance is a measure of a beam's divergence from its path and relates how little "beam spill" is created. Beam spill is a condition where particles hit the inside of the accelerator, decreasing reliability and operation lifetime, as well as creating radioactive components.

As a spinoff of this technology, ADTT draws heavily on power source technology developed under BMDO-funded NPB research and development. It uses a blanket assembly to produce neutrons that change radioactive nuclear waste and plutonium to either nonradioactive materials or materials with much shorter half-lives.

In the ABC and ATW programs, accelerators bombard a heavy metal target (such as lead) with an 800- to 1,000-million electron volt, high-energy proton beam. When the proton beam hits the target, it produces an energetic spray of neutrons, about 20 to 30 neutrons per atom in the proton beam. A surrounding blanket of molten salt containing graphite and the nuclear material to be transmuted multiplies these neutrons. This blanket also slows the energy level of the neutrons to increase the probability of transmutation reactions. Materials such as plutonium, waste actinides, or long-lived fission products are continuously introduced into the blanket assembly. Remaining radioactive materials can be separated and reintroduced into the system to further reduce their long-lived radioactivity.

Accelerator-based conversion can burn 98 percent of the ^{239}Pu and 90 percent of all plutonium isotopes occurring in plutonium for weapons. Pictured above is part of a BMDO-funded accelerator contributing to this project.

In ADEP, an assembly, which includes a graphite moderator and a fuel such as thorium, surrounds an accelerator-generated source of neutrons. The fuel is embedded in a coolant to obtain the high temperatures and efficiencies needed. The assembly is subcritical and cannot sustain a chain reaction without the accelerator beam.