Alternative Uses For Nuclear Waste

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Backup

<html> <p>Nuclear power is great if you want to generate a lot of electricity without releasing lots of CO2 and other harmful pollutants. However, the major bugbear of the technology has always been the problem of waste. Many of the byproducts from the operation of nuclear plants are radioactive, and remain so for thousands of years. Storing this waste in a safe and economical fashion continues to be a problem.</p> <p>Alternative methods to deal with this waste stream continue to be an active area of research. So what are some of the ways this waste can be diverted or reused?</p> <h2>Fast Breeders Want To Close The Fuel Cycle</h2> <figure id=„attachment_395506“ aria-describedby=„caption-attachment-395506“ class=„wp-caption alignright c1“><figcaption id=„caption-attachment-395506“ class=„wp-caption-text“>The Superphénix reactor in France is one of a handful of operational fast-neutron reactor designs.</figcaption></figure><p>One of the primary forms of waste from a typical nuclear light water reactor (LWR) is the spent fuel from the fission reaction. These consist of roughly 3% waste isotopes, 1% plutonium isotopes, and 96% uranium isotopes. This waste is high in transuranic elements, which have half-lives measured in many thousands of years. These pose the biggest problems for storage, as they must be securely kept in a safe location for lengths of time far exceeding the life of any one human society.</p> <p>The proposed solution to this problem is to instead use fast-neutron reactors, which “breed” non-fissile uranium-238 into plutonium-239 and plutonium-240, which can then be used as fresh fuel. Advanced designs also have the ability to process out other actinides, also using them as fuel in the fission process. These reactors have the benefit of being able to use almost all the energy content in uranium fuel, reducing fuel use by 60 to 100 times compared to conventional methods.</p> <p>Unfortunately, fast breeder technology has largely been held back by economics. The discovery of more abundant uranium resources in the 1970s has meant it’s cheaper to simply dig up more fuel than to reprocess waste. Additionally, concerns about the ability of fast breeder reactors to create weapons-suitable nuclear material have also stymied development. While

the technology is promising, major developments in this area are likely decades away.</p> <h2>Processing Waste Into Nuclear Batteries</h2> <figure id=„attachment_395503“ aria-describedby=„caption-attachment-395503“ class=„wp-caption alignright c1“><figcaption id=„caption-attachment-395503“ class=„wp-caption-text“>A radioisotope thermoelectric generator from the Cassini mission is inspected by a NASA technician.</figcaption></figure><p>For spacecraft traveling into the deep beyond, solar power doesn’t always cut it. Past Mars, there simply isn’t that much light coming in from the Sun to make solar panels a viable option for power supply. In these cases, spacecraft often use radioisotope thermoelectric generators (RTGs), which pack radioactive materials into a case with thermocouples. The heat of the decaying material generates electricity through the thermocouple array, which is used to run the spacecraft. An additional benefit is that the heat provided helps keep systems on board the craft at a suitable operational temperature.</p> <p>Historically, these have been used by Russia and the United States, but the European Space Agency is keen to get their hands on the technology. The plan involves extracting americium-241 from British waste stocks of plutonium from nuclear fuel reprocessing. While it’s unlikely to be a major project in terms of cleaning up waste, it could serve as a useful source for RTG materials. This is particularly relevant as US stocks are running down, as the plutonium-238 previously used was only available from reactors used to produce nuclear weapons, which have since been shut down. The race is on to produce more, but in the meantime, this opens the door for the British project.</p> <p>An alternative idea in this space is that of the betavoltaic battery. This works by using a semiconductor material which captures electrons released by the beta-decay of radioactive material. The University of Bristol is working to develop the “diamond battery”, which uses radioactive carbon-14 from waste graphite moderator blocks used in British nuclear facilities. The blocks have their outer layers scraped off, where most of the carbon-14 resides, and this is used to create man-made diamonds that release electrons as they decay. These are then encased in a shell of non-radioactive carbon-12, to prevent the radiation escaping to the atmosphere. The electrons released in beta-decay are of low energy, so only minor shielding is needed. It’s estimated that such batteries could provide on the order of 100uW for thousands of years.</p> <h2>Uses for Depleted Uranium</h2> <figure id=„attachment_395505“ aria-describedby=„caption-attachment-395505“ class=„wp-caption alignright c2“><figcaption id=„caption-attachment-395505“ class=„wp-caption-text“>A cutaway drawing of a typical depleted uranium anti-tank munition.</figcaption></figure><p>Another major byproduct of the nuclear power industry is depleted uranium. This is the uranium left over after the enrichment process necessary to prepare fuel for use in reactors. It consists mostly of non-fissionable uranium-238, and is still somewhat radioactive, though less so due to most of the uranium-235 being removed during the enrichment process.</p> <p>Depleted uranium has several properties that make it highly attractive for military applications. It’s high density means that it makes a good warhead for anti-tank munitions. Depleted uranium munitions have excellent penetration ability, and are able to pierce heavy tank armor. This is also aided by their self-sharpening nature. When a depleted uranium warhead hits a target, it fractures in a way that causes it to remain sharp, while the heat of the impact helps ignite the resulting cloud of depleted uranium particles. This makes such rounds highly effective in such roles, often replacing other high-density materials like tungsten.</p> <h2>Chemical Processing of Depleted Uranium</h2> <figure id=„attachment_395504“ aria-describedby=„caption-attachment-395504“ class=„wp-caption alignleft c1“><img data-attachment-id=„395504“ data-permalink=„https://hackaday.com/2020/01/29/alternative-uses-for-nuclear-waste/nuclearwaste-chemi/“ data-orig-file=„https://hackaday.com/wp-content/uploads/2020/01/nuclearwaste-chemi.gif“ data-orig-size=„500,305“ data-comments-opened=„1“ data-image-meta=„{"aperture":"0","credit":"","camera":"","caption":"","created_timestamp":"0","copyright":"","focal_length":"0","iso":"0","shutter_speed":"0","title":"","orientation":"0"}“ data-image-title=„nuclearwaste chemi“ data-image-description=„“ data-medium-file=„https://hackaday.com/wp-content/uploads/2020/01/nuclearwaste-chemi.gif?w=400“

data-large-file=„https://hackaday.com/wp-content/uploads/2020/01/nuclearwaste-chemi.gif?w=500“ class=„size-medium wp-image-395504“ src=„https://hackaday.com/wp-content/uploads/2020/01/nuclearwaste-chemi.gif?w=400“ alt=„“ width=„400“ height=„244“/><figcaption id=„caption-attachment-395504“ class=„wp-caption-text“>Recently, uranium has proven its ability to be used as a novel catalyst for ethylene to ethane production.</figcaption></figure><p>There are other applications for depleted uranium too, outside of weaponry. Recently, a new application has been found for depleted uranium, in the area of chemical processing. A group of researchers at the University of Sussex have created a catalyst using the material, which helps convert ethylene into ethane. While converting between the two chemicals is nothing new, it’s a novel application for depleted uranium.</p> <p>The storage of large quantities of depleted uranium from the enrichment process is an ongoing problem for governments around the world. Being able to use the material in industrial processes could be a viable alternative to simply storing it at disposal sites or firing it into foreign countries via tanks and warplanes. However, care is needed to ensure the lightly-radioactive material doesn’t cause additional workplace hazards or health issues.</p> <h2>Roadblocks Remain</h2> <p>Unfortunately, there are issues in the way of reuse and reprocessing of nuclear waste. Many of these processes open up the possibility for nuclear material to be stolen or diverted. This poses a risk for the proliferation of nuclear weapons.</p> <p>For example, the amount of plutonium required to create a viable nuclear weapon is measured in the tens of pounds. With reprocessing operating on an industrial scale, the possibility exists for quantities of this material to go missing while remaining undetected. It’s a fraught problem, one that depends on the exact particulars of isotopes and processes. Current nuclear waste from light-water reactors is not a concern, for example, as it is considered too highly radioactive to easily steal. But technologies like fuel reprocessing have the possibility of generating weapons-grade material from spent fuel, which many governments seek to prevent wherever possible.</p> <p>Additionally, some argue that efforts to recycle or reuse nuclear waste take away resources that should be applied to finding a dedicated storage solution for the material. Many countries have dragged their feet on establishing permanent waste dumps, including the USA. With spent fuel from current reactors remaining unsafe for thousands of years, finding a safe long-term storage solution for this existing waste material should be a priority.</p> <h2>Why Do Today What Can Be Put Off To Tomorrow?</h2> <p>Fundamentally, the highly radioactive and dangerous nature of nuclear waste poses many challenges for governments and industries looking to dispose of the material. The current status quo is largely to let it build up while the decades-long struggle continues over what to do with the ever increasing amount of nuclear waste. Ideally, new technology will open up avenues to dealing with the problem in a clean and safe manner, but in the meantime, difficult political decisions will need to be made.</p> </html>