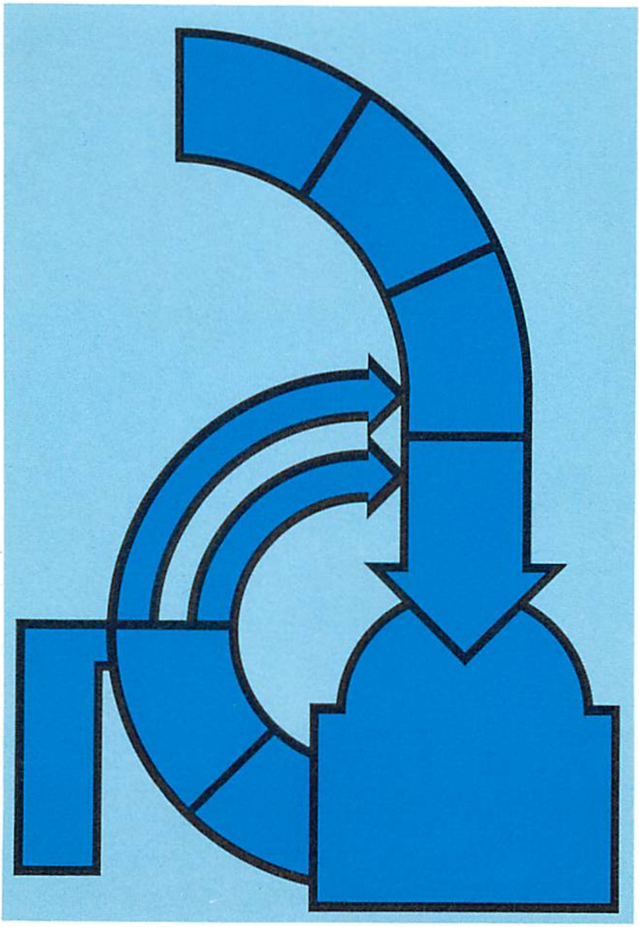
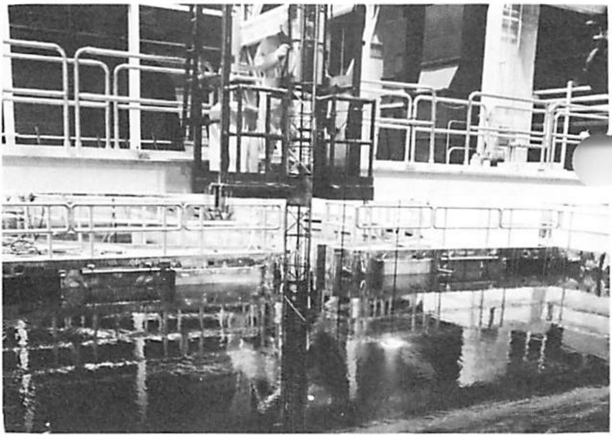
Recycling Nuclear Fuel





Spent fuel stored at reactor pool

Effects examined

Several governmental agencies are now evaluating reprocessing to establish a national policy on implementing this technology. A full range of concerns — safety, economics and possible effect on the spread of nuclear weapons — will be examined.

However, the operating experience of the past 30 years shows that domestic safeguards against theft of weapons material, primarily plutonium, have been effective. Government and commercial reprocessing facilities have accumulated more than 250 plant-years of operation. And during this time there has occurred no known diversion of nuclear material for illicit purposes.

To strengthen existing safeguards, the governm[ent] could assume responsibility for protecting materials in transit, coordinating the emergency response of law enforcement agencies and providing security clearances for employees having access to nuclear materials.

Besides ensuring physical security, industry and government have the responsibility of guarding against possible adverse environmental effects from reprocessing. Again, the record is exceptionally good. The projected routine operation of reprocessing facilities indicates that industry will be able to operate within emission guidelines being prepared by the federal government.

The amount of radioactivity released to the environment during reprocessing accounts for about one-quarter of the dose expected from the nuclear power industry through the end of the century. But this exposure is small compared to those we already receive from natural and other man-made sources. In fact, the total body dose expected for an individual standing at the boundary of a reprocessing plant site for a full year — about 7.5 millirem — is less than six per cent of the dose from natural background radiation. Of course most people won't be that close to reprocessing plants. Measured in person-rem (individual radiation exposure multiplied by population), the total off-site dose for the entire United States from fuel reprocessing will be 0.17 per cent of that from background radiation through the year 2000.

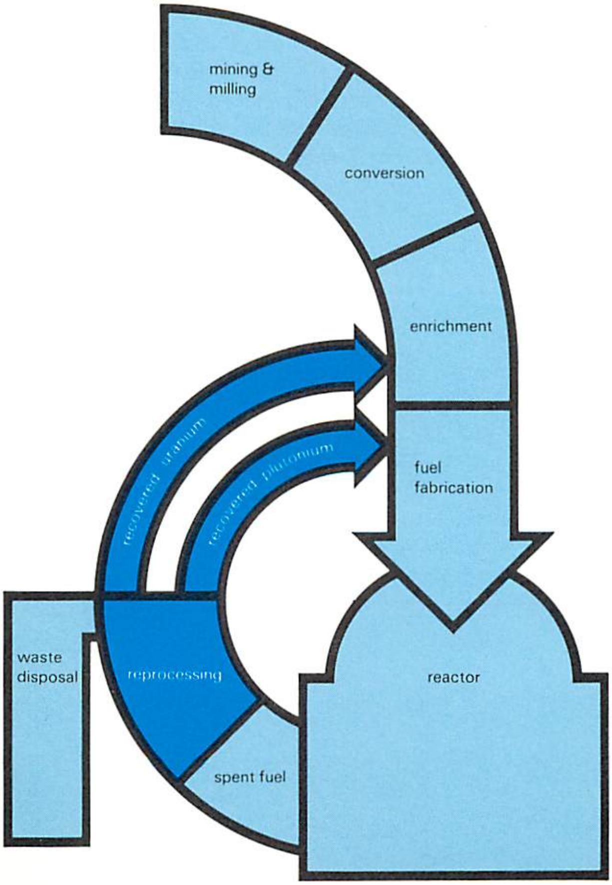
And radiation received from the entire fuel cycle, including recycle of both uranium and plutonium, equals only 0.65 per cent of natural radiation over the same period.

Reprocessing technician operates mechanical arms

Then, under strict control and with careful handling, the rods are loaded into rugged spent fuel shipping casks, to be taken by truck or rail to a reprocessing plant. Here the casks are opened under water and the fuel rods removed and stored in pools, just as they were at the power plant.

Later the rods will be sheared into many short pieces in a concrete-walled work area. The walls of these "hot cells" are several feet thick to protect plant workers from any radiation given off by the fuel. For additional safety, the fuel will be handled entirely by remote controlled machinery.

Next, the rod segments are dropped into nitric acid to leach the spent fuel from the cut up pieces. A chemical extraction process separates the uranium and plutonium from the acid solution which retains over 99 per cent of the waste fission products.



These wastes will be concentrated through evaporation and stored as liquid in underground double-walled stainless steel tanks for up to five years. Then the liquid waste will be solidified and managed in a manner to be prescribed by the federal government.

Another chemical process divides the uranium and plutonium into separate streams of dilute acid solutions, essentially free of fission-product contamination. About 99 per cent of the available uranium and plutonium can be recovered and then converted into forms suitable for shipping, processing and fabrication into new fuel for a power plant reactor.

There are two alternative methods for using this recycled uranium and plutonium:

- manufacturing uranium dioxide pellets, today's standard reactor fuel, from the recovered uranium and storing the plutonium for future use in "fast breeder" reactors,
- combining the uranium and plutonium into a "mixed oxide" fuel to be fissioned in current reactors in much the same manner as uranium dioxide.

Breeder reactors will convert large quantities of the non-fissionable form of uranium into fissionable plutonium. Eventually more fissionable material is produced than consumed in generating electricity, thus extending our nuclear fuel resources for centuries.

But the future of the breeder power reactor depends on reprocessing to produce the plutonium used as its primary fuel.

Reprocessing questioned

Despite the ability to extend the useful life of uranium fuel, some observers of nuclear power feel that reprocessing should not be permitted. They fear that recovered plutonium could be diverted for unlawful purposes.

In their view, the "fuel cycle" — the chain of events making up the life of uranium from mining to eventual disposal — should not be closed: fuel removed annually from a power reactor should be discarded.

Extending resources

Reusing materials is not a new idea.

The growing environmental awareness of the past [illegible]de has made recycling an active part of our way of [illegible]o help preserve precious resources, many Americans have become accustomed to saving glass, paper and metal products and returning them to recycling centers. From here these materials are turned over to industry so that salvageable portions can be separated from the waste and reused in manufacturing.

The fuel discharged from a nuclear power plant also can be saved, reprocessed and reused to generate about 50 per cent more electricity, thereby conserving existing natural resources.

In fact, only a small part of spent fuel is waste; it contains nearly 30 per cent of the original loading of Uranium-235 and a substantial amount of plutonium created during reactor operation. Spent fuel discharged from nuclear reactors through the end of this century will contain as much energy as 24 billion barrels of oil — more than half the domestic reserve.

Since there remain materials that can fission, or split, to produce energy, why is fuel removed from a reactor and what is the waste?

As a reactor operates, the fragments or by-products of fission build up in rods containing the fuel. This accumulation of wastes eventually reduces the efficiency of the nuclear chain reaction by absorbing neutrons that could otherwise cause more fissions.

Approximately once a year, then, from one-fourth to one-third of the fuel rods are removed and replaced w[illegible]fresh fuel. Through the proved technology of re[illegible]cessing, the uranium, plutonium and waste products can all be separated out of spent fuel.

Closing the cycle

When the fuel rods — thin metal tubes about 12-14 feet long, containing hundreds of half-inch uranium dioxide pellets — are removed from the reactor, they are stored in pools of water at the plant site to allow some of the short-lived radioactive fission products to decay. This takes about 120 days and reduces the radioactivity of the spent fuel by over 90 per cent.

The benefits of recycle

Reprocessing and recycling spent fuel will result in substantial savings of money and conservation of uranium resources. Although disposing of spent fuel incurs none of the costs of recycle — reprocessing, mixed oxide fuel fabrication, transportation between these steps and plutonium safeguarding — it also reaps none of the benefits. Further, this "throwaway" option adds substantial costs in developing and operating disposal systems to handle spent fuel entirely as waste; reprocessing reduces the volume of highly radioactive material that must be managed by approximately 80 per cent.

Even more important are the resource savings associated with recycle. The use of mixed oxide fuel could reduce the requirement for uranium by 360,000 tons, or 22.5 per cent, through the end of the century. This can be cut further when breeder reactors come into operation; they require practically no mining at all.

The second largest source of savings from the recycle alternative is in reducing the demand for enrichment services, where the 0.7 per cent concentration of U-235 in natural uranium is increased to about 3 per cent. Some savings are obtained because recycled uranium is slightly more enriched than that occurring in nature. More importantly, recycled plutonium can be directly substituted for U-235 in mixed oxide fuel.

Although estimates of the dollar savings associated with recycle vary, most studies indicate a clear advantage for this option. Based on conservative growth of the nuclear industry, for example, recycle would save about $18.2 billion through the year 2000 ($3.2 billion in 1975 dollars).

Nuclear power is an economical and environmentally acceptable means for generating electricity. Any given quantity of nuclear fuel is capable of producing hundreds of times more power than a like amount of fossil fuels. And since the use of recycled nuclear fuel and breeder reactors can extend our present uranium reserves from decades to centuries, we cannot afford to throw away the valuable uranium and plutonium recoverable from spent fuel. An energy policy that allows usable resources to be treated as waste will only add to the crisis from which we are trying to free ourselves.

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