



Nuclear Fuel Cycle

What is the Nuclear Fuel Cycle?

Uranium, the fuel used by nuclear power plants to produce electricity, is a naturally occurring element in the earth's crust. The process of extracting uranium and using it to generate electricity is called the nuclear fuel cycle.

There are two forms of the nuclear fuel cycle at work in different parts of the world — the once-through cycle and the closed-loop cycle. In the United States, we currently use the once through cycle, meaning that the fuel is used one time in the reactor and then stored. In other countries the fuel cycle is closer to a closed loop, and used fuel is recycled.

How Does the Fuel Cycle Work?

The uranium goes through a series of steps from being mined as a raw material through its life as a useful source of energy and beyond. Both forms of the fuel cycle start with the same steps. First, uranium ore is mined and milled. Then, the concentrations of desirable isotopes are increased in a series of steps called enrichment.

Once enriched, fuel is formed into ceramic fuel pellets. These pellets are loaded into sealed metal tubes and cages called "bundles" or "assemblies" to hold them in place inside the reactor. Each fuel assembly spends 5 to 6 years in the reactor before it must be removed and replaced

with fresh fuel. Once removed from the reactor, the fuel assemblies are moved to a storage pool to cool.

At this point, the two fuel cycles diverge. In the once-through cycle, the cooled assemblies are prepared for dry storage on-site and then indefinite storage in a deep geologic repository. In the closed-loop cycle, the fuel is sent to a recycling facility, where the assemblies are broken down and the uranium pellets recycled. The pellets are processed to remove the unwanted byproducts of fission, which produce less heat and have much shorter half-lives than the isotopes which can be used as fuel. The fuel isotopes are then made into new fuel pellets for another turn in the reactor. Only the byproducts are sent to long term storage.

Once-Through Cycle

Throw-Away of Used Nuclear Fuel

The natural form of uranium in the earth's crust is uranium-308 (U308), which must be enriched by increasing the composition of uranium-235 (U235) in order to be used in a nuclear reactor. The U308 is converted to uranium hexafluoride (UF6), a gas, before it can be enriched.

Mining and milling of uranium ore to produce "yellow cake" (U308).

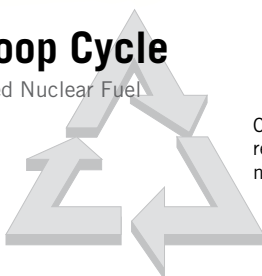
The U235 isotope in UF6 is enriched via centrifuge/diffusion/laser isotope enrichment. This enrichment process raises the concentration of U235 to 3-6% to make the fuel work in the nuclear reactor. U235 is the only nuclide existing in nature that is fissile with thermal neutrons.

The gaseous, enriched UF6 product is processed to form uranium dioxide (UO2), which is pressed and sintered into a ceramic pellet. The ceramic pellet is designed to wear well in the reactor environment.

Fuel is loaded into reactor. Each fuel assembly spends 5 to 6 years in the reactor before it must be removed and replaced with fresh fuel.

Closed-Loop Cycle

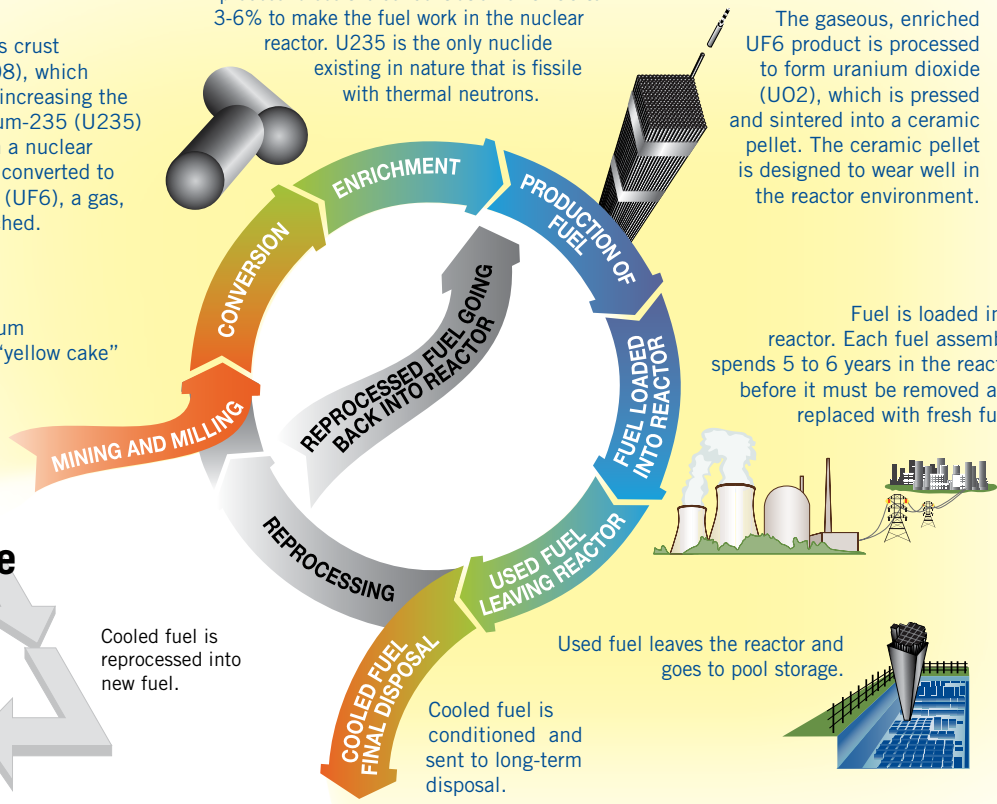
Recycling of Used Nuclear Fuel



Cooled fuel is reprocessed into new fuel.

COOLED FUEL FINAL DISPOSAL
Cooled fuel is conditioned and sent to long-term disposal.

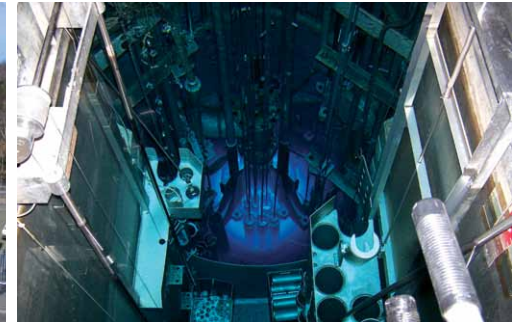
Used fuel leaves the reactor and goes to pool storage.



Why is the Closed Fuel Cycle Important?

Why is the Closed Fuel Cycle Important?

- By recycling the remaining useful fuel, we greatly reduce the amount of material needing long-term disposal.
- The more use we can get out of each gram of uranium, the less mining is required to produce the same amount of electricity.
- Efficient use of our energy resources means we have that energy source available for many more years to come. In the case of nuclear energy, many millennia.
- Closing the fuel cycle avoids the long-term storage of plutonium worldwide.



Source Energy Equivalents

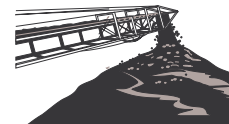
1 Uranium Fuel Pellet, without being reprocessed and recycled, has about as much energy available in today's light water reactor AS...



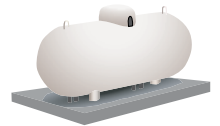
Uranium Fuel Pellet
(actual size)



3 Barrels of Oil
(42 gal. each)



1 Ton of Coal



17,000 Cubic Feet of Natural Gas



American Nuclear Society

Established in 1954, the American Nuclear Society (ANS) is a professional organization of scientists and engineers devoted to the applications of nuclear science and technology.

For more information on nuclear science and technology, please visit NuclearConnect.org, ansnuclearcafe.org, or contact the ANS outreach department at outreach@ans.org.

