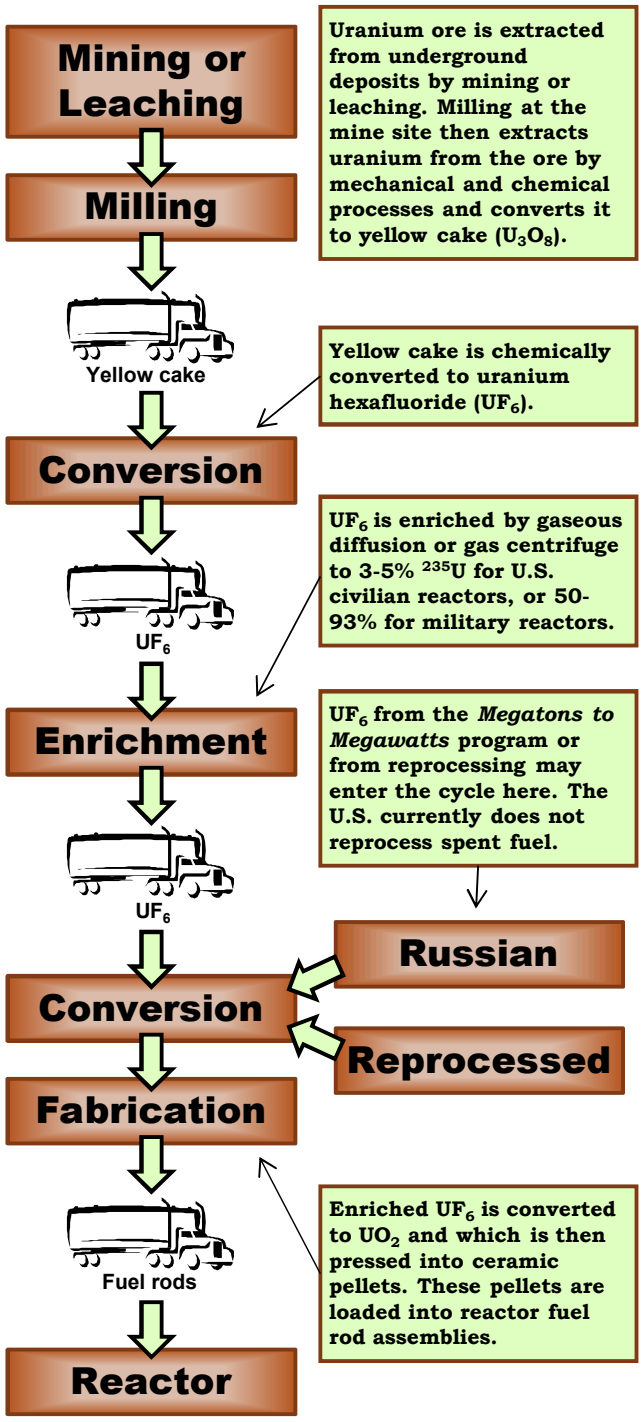
THE FUEL CYCLE



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TRANSPORTATION

The U.S. Department of Transportation (**DOT**), U.S. Department of Energy (**DOE**), U.S. Nuclear Regulatory Commission (**NRC**), and (outside the U.S.) the International Atomic Energy Agency (**IAEA**) regulate the transportation of radioactive nuclear fuel cycle items.

UF_6 is transported in special 12 MT, 48" dia. steel cylinders like the one shown in this Department of Energy photo.

The DOE **Transportation Emergency Preparedness Program** (TEPP) ensures that federal, state, tribal, and local responders are well trained to respond to transportation accidents involving DOE-owned radioactive materials. See http://www.em.doe.gov/TEPPPages/TEPPHome.aspx for details.

TRANSCOM is an unclassified DOE web-based system available to authorized users in state, local, and tribal governments that provides information on "high visibility" shipments including bills of lading, routes, and current positions. See http://tcc.doeal.gov/ for details.

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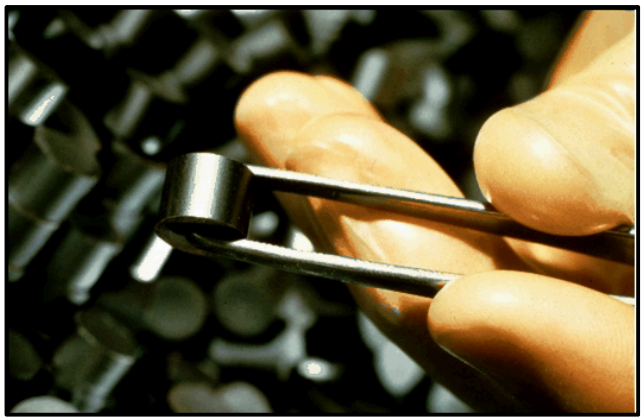
SAND2010-1925P

A Guide to the Nuclear Fuel Cycle

Developed by the
DHS Secondary Reachback Program
March 2010

This tri-fold addresses the production of new **nuclear fuel** for civilian and military reactors in the United States and Canada. This "front end" of the fuel cycle includes mining, milling, chemical processing, enriching, and the formation of fuel pellets and rods. A companion tri-fold discusses the "back end," that is the handling of used fuel and other **nuclear waste**.



Uranium fuel pellet; fuel pellets are stacked into long rods which are then bundled into a reactor fuel element.
Source: U.S. Energy Information Administration (Oct 2008).

Joint Analysis Center (JAC)
24-hour Technical Assistance HOTLINE: 877-363-6522
Email : dndo.jac@dhs.gov

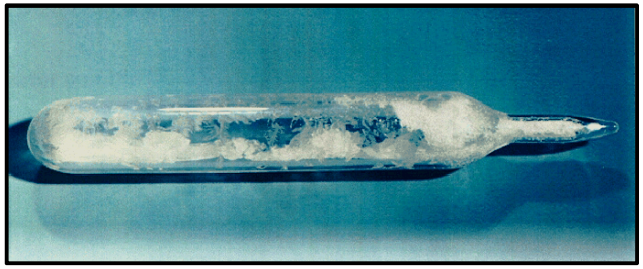
YELLOW CAKE

Yellow cake is produced from uranium ore or leach solutions by mechanical and chemical processing. In spite of the name, yellow cake from modern mills is **brown or black in color**, and has twice the density of water. Chemically it is 70-90% U_3O_8 with some UO_2 and UO_3.

A drum of yellow cake; U.S. Government photo.

URANIUM HEXAFLUORIDE

Uranium hexafluoride – UF_6 – normally is in the form of solid grey crystals, but will sublime to gas above 125° F. It is **very toxic** and is **corrosive** to many metals. UF_6 reacts strongly with water (even humid air) forming UO_2F_2 and HF, both water soluble and toxic.



UF_6 crystals sealed in a glass tube.
U.S. Department of Energy photo.

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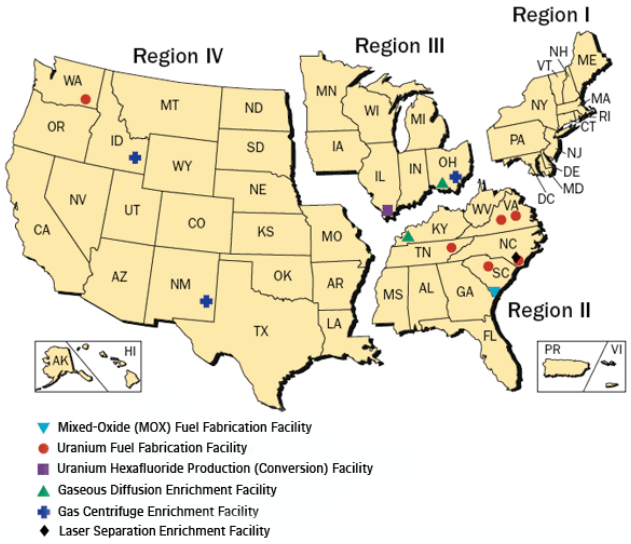
NUCLEAR FUELS

Reactors require a fissionable fuel – typically ^{235}U. Natural uranium is 99.284% ^{238}U (which is not a good reactor fuel) and only 0.711% ^{235}U. CANDU reactors in Canada can use natural uranium as fuel, but U.S. Pressurized and Boiling Water Reactors (PWR and BWR) require a higher percentage of ^{235}U – about 3-5%. Some research reactors require 12-20% enrichment, which is still considered low-enriched uranium (LEU). Highly enriched uranium (HEU) is required for many U.S. Navy reactors, and is also usable as a nuclear weapons material. Other fissionable isotopes such as ^{239}Pu and minor actinides from reprocessed fuel are used in some reactors outside the U.S.

Large quantities of **depleted uranium** (DU), a by-product of enrichment, are stored as UF_6 at facilities near Portsmouth OH and Paducah KY.

FUEL FACILITIES



U.S. Department of Energy nuclear fuel production, fabrication, and enrichment facilities by NRC region.
Source: U.S. Nuclear Regulatory Commission

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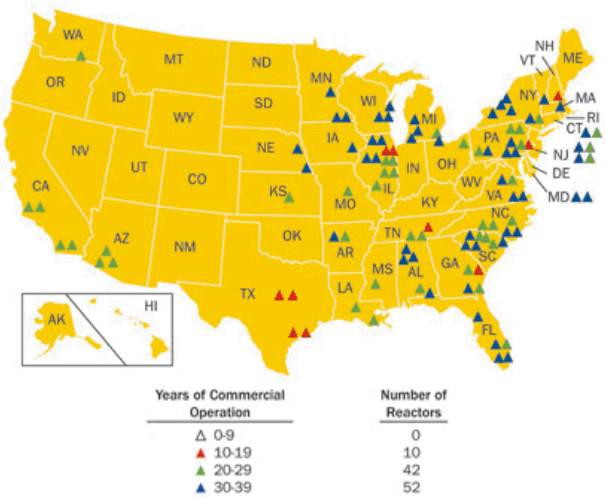
U.S. POWER REACTORS



U.S. commercial nuclear power reactor locations and years of operation. Source: U.S. Nuclear Regulatory Commission

SHIPPING ROUTES

Uranium fuel cycle products are shipped on approved routes between the following locations. Data is from the U.S. Energy Information Administration and is current as of 3Q2009.

- Yellow cake is produced by the White Mesa UT mill and is imported from Canada through ND and MI. Also leaching production is occurring at Crow Butte NE, Alta Mesa TX, and Smith Ranch-Highland WY. Others are in the permitting process.
- UF_6 conversion is at Metropolis IL.
- Enrichment is at Paducah KY and Piketon OH (cold standby). NM, ID, and NC plants are under construction or review.
- Fuel and rod fabrication is at Lynchburg VA, Richland WA, Wilmington NC, Erwin TN, Aiken SC, and Columbia SC.
- Fuel rods ship to reactors (see map above).