

## Uranium Enrichment

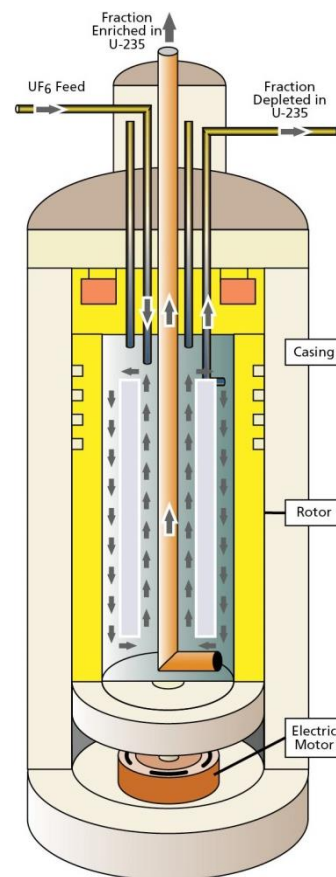
Nuclear power plants use uranium for fuel. One type of uranium atom – uranium-235 ( $U^{235}$ ) – is easily split to produce energy.  $U^{235}$  makes up less than 1 percent of natural uranium. To make fuel for reactors, this natural uranium is “enriched” to increase the  $U^{235}$  to between 3 and 5 percent.

The fuel cycle begins by [mining and milling](#) uranium ore into a powder. This powder is converted into a gas called uranium hexafluoride, or  $UF_6$ . (In the United States, [conversion](#) is done at a Honeywell plant in Metropolis, Ill.) The  $UF_6$  contains both  $U^{235}$  and the more plentiful  $U^{238}$ , which is heavier. This difference in weight allows the uranium to be [enriched](#). In this process, the gas is separated into two streams—one with more  $U^{235}$  than before and the other with less. Today this is done by gas centrifuge. Until recently, gaseous diffusion was also used. A third method – laser enrichment – has been proposed for use in the United States.

### Gas Centrifuge

The gas centrifuge process has been used in Europe for about 35 years. It uses many rotating cylinders (centrifuges) that are connected in long lines.  $UF_6$  gas is placed in the cylinder, which spins at high speed, creating a strong centrifugal force. Heavier  $U^{238}$  gas molecules move to the cylinder wall, while lighter  $U^{235}$  collects near the center. The stream slightly enriched in  $U^{235}$  is fed into the next cylinder. The depleted stream is recycled back into the previous cylinder.

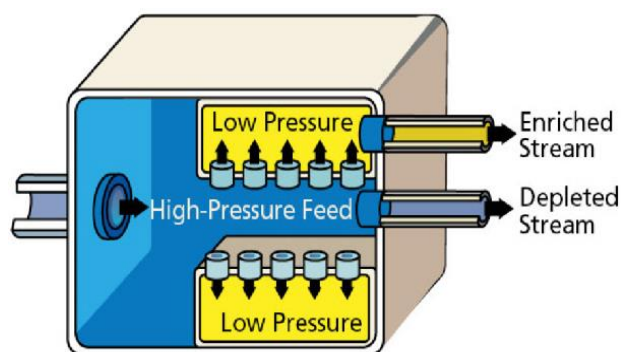
The NRC has licensed three gas centrifuge plants. In 2006, Louisiana Energy Services (also known as Urenco USA) received a license to construct and operate the National Enrichment Facility in Eunice, N.M. This plant opened in 2010. In 2004, the NRC licensed the United States Enrichment Corporation (USEC) to construct and operate a demonstration and test facility known as the Lead Cascade in Piketon, Ohio. This test facility has been operating since 2007. The NRC also licensed USEC in 2007 to build and operate the American Centrifuge Plant at Piketon. (USEC now operates as Centrus.) And in 2011, the NRC issued a license to Areva Enrichment Services to construct and operate the Eagle Rock plant near Idaho Falls. This project is on hold.



Schematic of a centrifuge

## Gaseous Diffusion

A gaseous diffusion plant processes  $\text{UF}_6$  in a vessel with small holes in its walls. A  $\text{U}^{235}$  molecule will travel faster and strike the walls more often than a molecule of  $\text{U}^{238}$ , so more  $\text{U}^{235}$  flows through the walls. The gas that passes through the walls is enriched in the lighter isotope. The Department of Energy (DOE) built two of these plants that came to be used commercially—in Piketon, Ohio, and Paducah, Ky. DOE turned the plants over to USEC, which Congress created as a government corporation in 1992 and privatized in 1996. The Ohio plant closed in 2001, the Kentucky plant in 2013.



Schematic of the gaseous diffusion process

## Laser Enrichment

$\text{U}^{235}$  can also be separated using specially-tuned lasers. Lasers can increase the energy in the electrons of a specific isotope, changing its properties and allowing it to be separated. Laser enrichment is more technically complicated but consumes less power and is more efficient. Two laser enrichment methods have been developed, but neither has been used commercially. DOE developed Atomic Vapor Laser Isotope Separation, or AVLIS, in the 1980s and 1990s. An Australian technology called SILEX, for Separation of Isotopes by Laser Excitation, is being developed by GE-Hitachi for potential use in the United States. The NRC licensed GE-Hitachi to construct and operate a test facility in Wilmington, N.C., in 2008 and a full commercial laser enrichment plant there in 2012.

## NRC Responsibilities

Under the Atomic Energy Act, the NRC licenses and inspects uranium enrichment plants. Before issuing a license to construct and operate a plant, the NRC prepares an Environmental Impact Statement (EIS) and a Safety Evaluation Report (SER). The NRC gets public input on the issues to be addressed in the EIS through a process known as “scoping.” Then the NRC prepares for public comment a draft EIS assessing what impact the facility might have on public health and the environment. Meanwhile, NRC experts review the application to make sure the proposed facility would meet the regulations. They document their findings in an SER. An independent licensing board examines the staff’s work in a hearing. People who may be affected by the facility can raise safety or environmental concerns, which may be considered in a separate hearing.

No enrichment plant can operate until the NRC verifies through rigorous inspections that it has been constructed as required by the license. Throughout construction, NRC inspectors make sure the design, construction, installation and tests of the features that are important to safety comply with the license and NRC regulations. Inspectors also review policies and procedures to make sure the plant will be operated safely and securely.

As construction winds down, the NRC reviews the most safety-significant features. These include chemical safety, fire protection, radiation control, emergency preparedness, training and criticality safety. The NRC will only allow  $\text{UF}_6$  to be introduced after these inspections are completed. The inspections are conducted by experts from NRC headquarters in Maryland and the Region II office in Atlanta, which oversees fuel cycle facilities.