US Nuclear Fuel Cycle

(Updated November 2010)

- **The USA is expanding its nuclear fuel production capacity with up to three new enrichment plants likely to begin operation before 2020.**
- **Currently, almost all the uranium used in US commercial reactors is imported, with about half of it coming from Russian weapons-grade uranium downblended to low enriched uranium in Russia. After reaching a peak in 1980, domestic mining now accounts for only 5% of the fuel used in US reactors.**
- **Between 1977 and 2005, government policy did not allow reprocessing of used fuel for commercial reactors. Recent legislation, however, calls for stepped-up R&D in advanced fuel technology and advanced reactors to recover the energy value of used fuel and reduce the volume of nuclear waste.**

Uranium resources and mining

The USA ranks sixth in the world for known uranium resources in the category up to $130/kgU ($50/lb U_3O_8), with 339,000 tU (reasonably assured plus inferred resources, 2007).

In the 1950s, the USA had a great deal of uranium mining, promoted by federal subsidies. Peak production since 1970 was 16,800 tU in 1980, when there were over 250 mines in operation. This abruptly dropped to 50 in 1984 when 5,700 tU was produced, and then there was steady decline to 2003, by which time there were only two small operations producing a total of under 1,000 tU/y, or about 5% of the uranium consumed by US nuclear plants. So, for the first step in the nuclear fuel cycle, the US must rely on imports of uranium from countries such as Canada and Australia, or downblended weapons-grade uranium from Russia (see section on Military surplus and other government stocks below).

As the price of uranium has increased in recent years, there has been a revival in exploration and plans to reopen old mines. Exploration expenditures doubled between 2006 and 2007 to $50.3 million, and this level was maintained in 2008. A number of companies have announced plans to refurbish and restart mines in Wyoming, Colorado, Utah, Arizona and New Mexico. There are now operating mines in Texas, Wyoming, Colorado, southern Utah, and Wyoming (see US Nuclear Fuel Cycle Appendix 1: US Uranium Mining and Exploration).

Most US production has been from New Mexico and Wyoming. Known resources are 167,000 t U_3O_8 in Wyoming, 155,000 t in New Mexico, 2,000 t in Texas and around 50,000 t in Utah, Colorado and Arizona (all to $50/lb). Production potential is about 45% in situ leach (ISL), 55% conventional mining.

Uranium production from one mill (White Mesa, Utah) and five ISL operations totaled 1,583 tU (1,866 t U_3O_8) in 2006 and 1,748 tU (2,061 t U_3O_8) in 2007. In 2008, Rosita became a sixth ISL production site before being shut down and a total of ten underground mines (four more than during 2007) produced uranium. In total, 1,503 tU (1,774 t U_3O_8) was produced in 2008.[1]

In mid-2009, the Nuclear Regulatory Commission (NRC) issued a generic environmental impact statement (EIS) on ISL (or in situ recovery, ISR) mining in the western USA. This will streamline but not eliminate the requirement for a supplementary EIS for each new mine. The NRC expects 17

applications for ISL facilities in the next couple of years, with each taking two years to process, including public participation.

Details of US uranium mining are in US Nuclear Fuel Cycle Appendix 1: US Uranium Mining and Exploration.

Conversion

The large Honeywell Metropolis Works plant (MTW) in southern Illinois converts uranium oxide, U_3O_8, to uranium hexafluoride, UF_6, which then goes to USEC's Paducah enrichment operation just across the Ohio River as well as to customers abroad. MTW is the only conversion plant in the USA. The facility was built in the 1950s under government contract to meet military conversion requirements, and began providing UF_6 for civilian use in the late 1960s. Capacity has expanded from 9,000 tU as UF_6 per year to 17,600 tU as UF_6 today, and is expected to increase to 23,000 tU by 2020.[a] The next level of planned expansion at MTW is to 18,000 tU as UF_6 by 2012, depending on market conditions. ConverDyn, a partnership between affiliates of Honeywell and General Atomics, is the exclusive agent for conversion sales from Honeywell-MTW.

Deconversion

Deconversion of the depleted uranium (DU) that remains as a byproduct after enrichment has not so far been undertaken on a large scale in the USA,and in fact for legal reasons DU is, in the USA, sometimes considered as a 'waste'.

Uranium Disposition Services (UDS), a joint venture of Areva, Duratek/ EnergySolutions, and Burns & Roe, was awarded a $558 million contract by the DOE in 2002 to build and operate deconversion plants at Portsmouth, Ohio and Paducah, Kentucky. The contract ran to August 2010. The plants use a process developed by Areva which it employs at Richland, Washington and Lingen, Germany. The 13,500 t/yr Portsmouth plant started up in mid-2010 and the 18,000 t/yr Paducah one is due to do so in December 2010. At Portsmouth about 250,000 t depleted UF_6 is stored, with another 75,000 t expected from Oak Ridge, and at Paducah some 440,000 t depleted UF_6 is stored. Aqueous HF will be a commercial by-product.

Babcock & Wilcox Conversion Services won a five-year $428 million contract from DOE in December 2010 for uranium deconversion operations at both Portsmouth and Paducah, using these plants. B&W Conversion Services is a joint venture of B&W Technical Services Group and URS in which B&W is majority partner.

In December 2009, International Isotopes (INIS) applied for a licence to build and operate a 6,500 t/y deconversion plant and fluorine extraction facility near Hobbes, New Mexico, 50 km from the Urenco USA enrichment plant at Eunice. In April 2010, INIS signed a five-year agreement to provide toll deconversion services for DU tails from Urenco, from 2014.

INIS hopes to start production in 2013, subject to raising $75 million capital. Initial capacity is for about 300 cylinders, containing 3600 tonnes of UF_6 per year, increasing to about 575 (6950 t) in 2016. Some 1,300 to 2,300 tonnes of anhydrous hydrofluoric acid (HF) with 450 tonnes of fluoride gas will be produced per year for sale by INIS, and the depleted uranium belonging to the enrichment companies will be stored as more stable U_3O_8. In-mid 2010, the first part of a $65 million loan guarantee application by INIS was approved by the US Department of Energy (DOE), and the company has been invited to submit the second part of its application[2].

Preceding this proposal an agreement was signed in 2005 between LES and Areva to make use of the latter's technology in deconverting LES' DU tails. Areva NC has operated a small deconversion plant in association with its Richland fuel fabrication plant in Washington state.

Enrichment

The USA currently has one operating enrichment plant, USEC's Paducah, Kentucky facility built by the government in the early 1950s to provide fuel for military reactors. This large gaseous diffusion plant, commissioned in 1952 for military use, began providing enriched uranium for civilian reactors in the 1960s. Originally government-owned, USEC became a private sector corporation in 1998, and leased two large enrichment plants from the DOE. In 2001, it consolidated its enrichment operations at the Paducah site after closing the older Portsmouth facility at Piketon, Ohio[b]. Both plants were very energy-intensive and costly to run. The Paducah plant has a capacity of 8 million SWU/yr, compared with the 12.7 million SWU/yr required by the 104 operational US reactors. It is expected to close down once the new US capacity comes on line.

Three new enrichment plants, being built by other companies, are expected to begin operation before 2020. In addition, USEC had started building its own enrichment plant, the American Centrifuge Plant in Piketon, Ohio, which had been due to begin operation in 2010, but the project was put on hold in July 2009.

From 2009, Russia's Tenex has signed a number of contracts with US utilities to supply enrichment services and enriched uranium product. To mid-2010 the contracts totaled some $3 billion, covering supplies to 2020.

This Russian supply is in addition to that of 4.4% low-enriched uranium supplied through USEC having been blended down from Russian weapons material (see section below on Military surplus and other government stocks). This supplies about half of US annual needs, and runs to 2013.

Urenco USA (formerly National Enrichment Facility)

Urenco USA has a major centrifuge enrichment plant at Eunice, New Mexico. It uses 6th generation Urenco technology from Europe, and was planned by the Louisiana Energy Services (LES) partnership – comprising Urenco, Exelon, Duke Power, Entergy, and Westinghouse. Construction of the $1.5 billion plant was licensed by the Nuclear Regulatory Commission (NRC) in mid-2006 when as agreed the three utilities then passed their share to Urenco, and the company is now a subsidiary of Urenco USA. Utility support for the venture – initially amounting to $3.15 billion in orders – was crucial in persuading the NRC that further US enrichment capacity was required beyond that provided and envisaged by USEC.

NRC approval to begin commercial operation was obtained in mid-2010, with full phase 1 capacity of 3.3 million SWU/yr to be reached in 2013. The new plant is a major step forward in underwriting new US nuclear generating capacity and in ensuring security of fuel supply, with flexibility of operation enabling more energy input to produce more fuel from the same natural uranium feed if required. LES has confirmed phase 2 plans to increase the capacity to 5.9 million SWU/yr over 2014-17, with total investment reaching $4 billion. A new centrifuge design may be used in the expansion. The incremental capacity will require NRC approval.

Eagle Rock Enrichment Facility

In mid-2007, Areva announced that it proposed to build a 3.3 million SWU/yr $2 billion centrifuge plant in the USA to supply domestic enrichment services. It submitted a licence application to the Nuclear Regulatory Commission (NRC) for this Eagle Rock Enrichment Facility in December 2008 with a view to licence approval in mid-2011 and operation early in 2014, ramping up to full capacity in 2019. It would be similar to Areva's new French plant (Georges Besse II) and would be built at Idaho Falls, near the Department of Energy's Idaho National Laboratory. It will be owned an operated by Areva Enrichment Services LLC. In 2009, Areva notified a planned doubling in capacity to 6.6 million SWU/yr, with the first stage being 3 million SWU/yr. In May 2010, DOE granted it a $2 billion loan guarantee.

American Centrifuge Plant

In April 2007, the Nuclear Regulatory Commission licensed construction and operation of USEC's American Centrifuge Plant in Piketon, Ohio. The American Centrifuge technology has been developed over many years by USEC, based on work by the Department of Energy (DOE) in 1970s and 1980s. The plant was being constructed on the same Portsmouth site where the DOE's experimental plant operated in the 1980s, involving 1,300 centrifuges as the culmination of a very major R&D program. It is also the site of USEC's large Portsmouth diffusion plant which is now closed. The prototype lead cascade started operation in September 2007 and the test program with it to April 2010 refined the design of the AC100 centrifuge machines (which are much larger than the European Urenco centrifuges). An AC100 lead cascade started operation in March 2010 with "approximately two dozen" machines which USEC plans to increase to 40-50 in operation later in 2010. The original AC100 design was superseded in 2009 by the "value-engineered AC100 machine", or AC100 Mod 1, which is intended to be deployed in the commercial plant, and is expected to deliver 350 SWU/yr per machine. The most recent cost estimate was around $4.5 billion, excluding finance, and utilizing existing infrastructure. By mid 2010, the company had spent $1.8 billion and required "additional capital beyond the $2 billion in Department of Energy loan guarantee program funding that it has applied for and USEC's internally generated cash flow." In mid-2010, USEC said that another $2.8 billion was required going forward from "financial closing of a loan guarantee", initial commercial operations would be 18 to 24 months from then, and completion would be 30 to 36 months later.

The plant would use only 5% of the power of the old diffusion plant it replaces. The licence authorises 7 million SWU/yr enrichment up to 10% U-235, though normal levels today are only up to 5%, which is becoming a serious constraint as reactor fuel burnup increases. In March 2009, USEC said that it had commitments for $3.3 billion of services from ten customers including leading utilities in the USA, Europe and Asia, and amounting to more than half of the initial sales from the plant.

The full plant was expected to commence commercial operation by the end of first quarter 2010, reach 1 million SWU capacity a year later and achieve full 3.8 million SWU annual capacity at the end of 2012. However, early in 2009 the whole project was slowed pending funding through the DOE loan guarantee program, and in July 2009 it was suspended due to the DOE refusing to award a $2 billion loan guarantee, and asking USEC to withdraw its application. USEC refused to do this, and early in 2010 said that completion of the project depended on "a timely commitment and funding for a loan guarantee from DOE". In July 2010, it resubmitted its loan guarantee application to the DOE, pointing out that $200 million investment by Toshiba and Babcock & Wilcox in May 2010 to support the ACP also strengthened its credentials[3].

Global Laser Enrichment

In 2006 Silex Systems in Australia and GE Energy received US government approval for development in the USA of the SILEX (Separation of Isotopes by Laser Excitation) uranium enrichment process using laser technology. This approval cleared the way for development and eventual full commercial production under a licence agreement with Silex. GE (now GE-Hitachi, GEH) is funding the development and making a series of payments to Silex. It will then pay a royalty on revenues from commercial production. GE said that "commercialisation of the SILEX enrichment technology is a crucial part of GE's long-term growth strategy for the nuclear business." SILEX was rebadged as Global Laser Enrichment (GLE).

In October 2007, the two largest US nuclear utilities, Exelon and Entergy, signed letters of intent to contract for uranium enrichment services from GEH. The utilities may also provide GEH with facility licensing and public acceptance support if needed for development of a commercial-scale GLE plant. In August 2010, Tennessee Valley Authority agreed to buy $400 million of enrichment services from GLE if the project proceeds.

GEH is now operating the GLE test loop at Global Nuclear Fuel's (GNF's) Wilmington, North Carolina fuel fabrication facility. [GNF is a partnership of GE, Toshiba, and Hitachi, while GLE comprises GE (51%), Hitachi (25%) and Cameco (24%).] In April 2010, GLE announced successful completion of the first phase of the test loop program and that technology validation would continue through 2010 as designs for the commercial facility evolved and economic feasibility was verified. A decision on proceeding with a full-scale commercial enrichment facility, and if so, its schedule, would then be made. In mid-2009, GEH submitted the last part of its licence application for this GLE plant, which is expected to take the NRC 30 months to process. If construction proceeds, the GLE commercial production facility at Wilmington, North Carolina would have a target annual capacity of 3.5 to 6 million separative work units (SWU).

New US enrichment capacity

	Type	Status	Capacity (million SWU/yr)	Start-up	Full production
Urenco/LES	Urenco centrifuge	Operating	5.9	Mid-2010	2015
USEC	American Centrifuge	Construction	3.8	2010 planned, but now on hold	2012 planned
Areva	Urenco centrifuge	Planned	3.3 then 6.6	2014	2019
GEH/GLE	Laser	Proposed	3.5 - 6.0	Possibly 2013	

Fuel fabrication

The USA has five fuel fabrication facilities to convert enriched uranium oxide into solid pellets for fuel rods. Areva, Westinghouse, Babcock & Wilcox and General Electric operate fabrication facilities in Virginia, Washington state, North Carolina and South Carolina.

In addition, Shaw-Areva MOX Services (30% Areva) is constructing a mixed oxide (MOX) fuel fabrication facility at the US Department of Energy's Savannah River Site in South Carolina. Under current plans, the plant, which will be owned by the government's National Nuclear Security Administration (NNSA), will dispose of at least 34 tonnes of weapons-grade plutonium and convert it into useable fuel.

In 2009, Areva's 35-year-old Richland, Washington fuel fabrication plant was the first to receive a 40-year licence extension from the NRC.

Military surplus and other government stocks

Almost half of the uranium used in US nuclear power plants currently comes from Russian weapons-grade military uranium, downblended in Russia. Under this program, by mid 2009, 367 tonnes of high-enriched uranium (HEU) had been downblended into some 10,600 tonnes of low-enriched uranium (LEU) for reactor fuel, representing 65 million SWU of enrichment and over 14,500 warheads, at a cost of $5.5 billion (paid by electricity consumers).

On the US side, 174 tonnes of military high-enriched uranium has been declared to be surplus and available for civil power generation. A start has been made on downblending this by Nuclear Fuel Services in Tennessee, and the first fuel fabricated from it has been shipped to Tennessee Valley Authority (TVA) power plants.

In 2005, the Department of Energy's (DOE's) National Nuclear Security Administration (NNSA) announced that it was committing 40 tonnes of off-specification HEU in the US to its Blended Low Enriched Uranium (BLEU) program, with the fuel produced going to TVA power plants.

In June 2007, the Department of Energy's (DOE's) National Nuclear Security Administration (NNSA) awarded contracts to Wesdyne International and Nuclear Fuel Services (NFS) to downblend 17.4 tonnes of HEU from dismantled warheads to be part of a new international Reliable Fuel Supply program.[c] In June 2009, NNSA awarded a further contract ($209 million) to NFS and Wesdyne for 12.1 tonnes of HEU, which will yield some 220 tonnes of LEU by 2012. This batch of LEU is to provide fuel supply assurance for utilities which participate in the DOE's mixed-oxide fuel program utilising surplus plutonium from US weapons. To cover the cost of the project, Wesdyne will sell a small part of the LEU on the market over a three- to four-year period. (The scheme is consistent with international concerns to limit the spread of enrichment technology to countries without well-established nuclear fuel cycles. Russia has agreed to join the initiative.)

In March 2008, the DOE announced a policy for dealing with uranium which was surplus to defence needs. The inventory, totaling nearly 59,000 tonnes of natural uranium equivalent, was as follows:

	tonnes U		Natural U equivalent
US high-enriched U from unwanted weapons	67.6	HEU	12,485
US natural U	5,156	Natural U as UF_6	5,156
Russian natural U*	12,440	Natural U as UF_6	12,440
Off-spec non UF_6	4,459	DU / Natural U / LEU	2,900
Depleted U > 0.35% U from historic DOE enrichment	73,500	DU	29,950
Total			**58,931**

** Natural uranium exchanged under the 1993 agreement whereby Russian blended-down uranium is supplied to US utilities – effectively Russian-origin stocks*

The DOE plan shows a total of 22,700 tonnes of its uranium entering global markets before the end of FY2017, but with no more than 10% of US annual requirements being delivered to the market in any one year – apart from an allocation for the first cores of newly built US reactors.[d] In 2009 the DOE is reported to have transferred about 617 t to the market, and in 2010 it plans to transfer up to 1337 t of excess uranium to the domestic market, including that which will go to USEC in payment for the clean-up of the Portsmouth enrichment plant.

The DOE will maintain a uranium reserve of 670 tonnes U – equivalent to about 20 power reactor reloads – for energy security reasons. This will be kept as low-enriched uranium stored either at the

DOE's Portsmouth or Paducah sites, or may be kept as part of a commercial entity's working inventory.

See also information page on Military Warheads as a Source of Nuclear Fuel.

Plutonium disposition

In addition to the HEU surplus, the US government has declared 61.5 tonnes of weapons-grade plutonium to be excess to the needs of the US defence program. Of this, the government agreed under the 2000 US-Russia Plutonium Management and Disposition Agreement to dispose of 34 tonnes by 2014, incorporating it (with depleted uranium) into mixed oxide (MOX) fuel.

Construction of a MOX fuel fabrication plant at the DOE Savannah River site in South Carolina was authorised by NRC early in 2005 and began in August 2007 when funding became available. The MOX Fuel Fabrication Facility (MFFF) is being built by Shaw Areva MOX Services under a $2.7 billion contract to the DOE's National Nuclear Security Administration (NNSA), which will own the plant. (Most MOX plants use fresh reactor-grade plutonium comprising about one-third non-fissile plutonium isotopes; this uses weapons plutonium with more than 90% fissile isotopes.) The plant is expected to be in operation in 2016, eventually producing 1,700 MOX fuel assemblies from the 34 tonnes of weapons-grade plutonium – or more, should the government decide to dispose of some or all of the balance of the 61.5 tonnes surplus plutonium in this way.

In February 2010, the NNSA signed an agreement with TVA to evaluate the use of this MOX in its Sequoyah and Browns Ferry power plants.

Duke Energy has used four mixed oxide test fuel assemblies incorporating this weapons-grade plutonium (fabricated in France) at its Catawba 1 nuclear power reactor. This was to prepare for possible use of MOX for 20-40% of the cores of the Catawba and McGuire reactors from about 2010, using the fuel fabricated at MFFF.

Weapons-grade plutonium in MOX test assemblies has been burned at the Saxton prototype reactor in the mid-1960s, and some MOX was burned in other US plants before 1977.

See also information page on Military Warheads as a Source of Nuclear Fuel.

Reprocessing used fuel

In 1977, the US government called a halt to the reprocessing of used fuel from commercial reactors as part of its stance against nuclear non-proliferation. The country has some experience with reprocessing oxide fuels as part of its military program, and has also built three civil reprocessing plants. The first, a 300 t/y plant at West Valley, New York, was operated successfully from 1966-72. However, escalating regulation required plant modifications which were deemed uneconomic, and the plant was shut down. The second was a 300 t/y plant built at Morris, Illinois, incorporating new technology which, although proven on a pilot-scale, failed to work successfully in the production plant. It was declared inoperable in 1974. The third was a 1500 t/y plant at Barnwell, South Carolina was built but not commissioned due to the changed government policy. It is now demolished. In all, the USA has over 250 plant-years of reprocessing operational experience, the vast majority being at government-operated defence plants.

One of these is the H-Canyon plant[e] at the DOE Savannah River site in South Carolina. This facility

is the last such US plant able to treat used HEU fuel and similar materials still operational. From 2011 it will treat used HEU fuel from the USA and overseas research reactors which have been converted to LEU or shut down under the Global Threat Reduction Initiative.

Several shifts in energy policy beginning in 2002, however, increased the likelihood of a resumption in reprocessing. In June 2005, the report accompanying the $31 billion energy and water funding bill approved by the Senate Appropriations Committee emphasised the need for new nuclear energy technologies. The DOE's Advanced Fuel Cycle Initiative (AFCI) would receive $85 million to develop fuel cycle technologies for Generation IV reactors including reprocessing and using fast neutron reactors to destroy long-lived components of wastes. A major driver for reprocessing was the reduction in the volume of high-level wastes, possibly obviating the need for any expansion of the planned repository at Yucca Mountain. In July 2005, with passage of the Energy Policy Act of 2005, the "recovery of the energy value from spent commercial fuel" became an explicit objective of the AFCI.

The shift on reprocessing was given further impetus by the government and industry commitment to develop of advanced nuclear reactors. In late 2005, the American Nuclear Society issued a position paper stating that "the development and deployment of advanced nuclear reactors based on fast-neutron fission technology is important to the sustainability, reliability, and security of the world's long-term energy supply."[4] An initial $50 million for "integrated spent fuel recycling facilities" focused largely on fast reactors was committed by the US Congress in 2006. The US industry body, the Nuclear Energy Institute, has said that the US nuclear industry needs to plan for recycling used fuel to reduce the long-lived radioactivity arising from it so that in a relatively short time high-level wastes become no more toxic than the original uranium ore. This means recycling and burning all the long-lived actinides, which is most efficiently done in fast neutron reactors.

The development of new reprocessing technology became a central element in the government's 2006 proposal for a Global Nuclear Energy Partnership (GNEP) to reduce the risk of nuclear proliferation (see information page on Global Nuclear Energy Partnership). Under this proposal, the US and other developed countries would develop proliferation-resistant recycling technologies and provide nuclear fuel to developing countries that promised not to engage in enrichment and reprocessing activities. GNEP has attracted criticism, but has brought increased attention to the possibilities of reprocessing, an issue once thought to be decided. However, financial support for GNEP has been decreasing and, by 2009, under Barack Obama's Democratic administration, the DOE removed its GNEP website and did not refer to the program in its budget request for FY 2010.[5] In June 2009, the DOE cancelled the programmatic environmental impact statement for GNEP "because it is no longer pursuing domestic commercial reprocessing, which was the primary focus of the prior Administration's domestic GNEP program."[6]

Despite the lack of US government support for GNEP as such, research activities under AFCI have continued. A DOE-funded demonstration project involving several versions of the UREX+ process for spent fuel is underway at the Argonne National Laboratory. The DOE is also exploring reprocessing technologies such as AREVA's COEX, which is based on processes already used in France, the UK, Russia and Japan, as well as a number of other technologies that would require the widespread use of fast neutron reactors. (See information page on Processing of Used Nuclear Fuel.)

Areva has costed plans for a major recycling complex in the USA, including reprocessing plant and MOX fuel fabrication plant, at $25 billion. It would have annual input capacity of 2500 tonnes, and is expected to take 12-15 years to licence and build. The reprocessing cost is expected to be less

than the 0.1 ¢/kWh fee now charged for the nuclear waste fund.

A possible site for an initial reprocessing plant is at Morris, Illinois, which is the only licensed away-from-reactor wet used fuel storage facility in USA. It is adjacent to the Dresden nuclear power plant and currently stores about 700 tonnes. It was the site of GE's Midwest Fuel Recovery Plant, a small reprocessing plant built in the early 1970s but not operated.

Decommissioning reactors

Nearly 30 civil prototype and commercial reactors have been decommissioned in the USA. Twelve have been totally dismantled (*Decon* option[f]) so that the site is released for unrestricted use, notably Fort St Vrain, Big Rock Point and Shoreham. Ten are in various stages of dismantling, or *Safstor*[f].

The Nuclear Energy Institute reported in 2006 that of the total $32 billion estimated to decommission all eligible nuclear plants at an average cost of $300 million, about two-thirds has already been funded. The remainder will be funded over the next 20 years[g].

Nuclear wastes

US policy since 1977 has been to forbid reprocessing of used fuel and to treat it all as high-level waste, which the government is responsible for finally disposing of in a deep geological repository.

The Nuclear Waste Policy Act of 1982 established federal responsibility for all civil used fuel, including a timetable and procedures for the building of two repositories, funded by fees from utilities, with the federal government taking delivery of the spent fuel by 1998 along with responsibility for its disposal. The Act was amended in 1987 to designate Yucca Mountain in Nevada as the sole initial repository for 70,000 tonnes of high-level wastes[h].

Despite several delays to the program[i], in June 2008 a construction licence application was eventually submitted to the Nuclear Regulatory Commission (NRC) by the Department of Energy (DOE).

Following the 2009 presidential elections, the Barack Obama administration attempted to abort the Yucca Mountain project[j], and a high-level committee was appointed to come up with alternative proposals by the end of 2011[k].

Before budget cuts and policy announcements by the Obama administration, DOE estimates of when Yucca Mountain repository might be operational was about 2021,[9] with some expansion of the original 70,000 tonne capacity[10]. The total cost in mid-2008 was put at about $96 billion (in 2007 dollars) for its construction, operation for 110 years, decommissioning from 2133 and the transport of used fuel to it[11].

In the meantime, storage space at some operating nuclear reactors has run out and at 40 of the 65 nuclear sites pool storage is being supplemented with dry cask storage. Of the total inventory of 58,000 tonnes of used fuel[l], 10,700 tonnes was in dry cask storage as of early 2008. By 2017, it is anticipated that practically all nuclear power plant sites will need dry storage which will then hold

22,300 tonnes of used fuel. A number of utilities have sued the federal government for not meeting its obligation under the 1982 Nuclear Waste Policy Act to begin taking waste by 1998 and have been awarded about $1 billion by the courts[m]. By the beginning of 2010, utilities had contributed over $31 billion (including interest) into the Nuclear Waste Fund, with $24 billion remaining after funding disbursements for the Yucca Mountain program[n].

As well as the DOE Yucca Mountain enterprise, Private Fuel Storage LLC (PFS) planned to store used fuel on a site in Utah for up to 40 years pending disposal. PFS is a consortium of eight utilities impatient with the DOE. In February 2006, the NRC issued a 20-year licence for a 40,000 tonne centralised surface dry storage facility on land owned by the Skull Valley band of the Goshute Indians[o]. But ongoing state government opposition led to the Department of Interior then disapproving the Goshute-PFS lease and the use of public land as a transport corridor to the planned facility. This decision was appealed, and in July 2010 the "arbitrary and capricious" 2006 Department of Interior ruling was overturned by a District Court ruling (which was not challenged).

In the light of the 2006 Utah setback, the Nuclear Energy Institute started a search for communities willing to host interim storage sites for used fuel. It received several offers and by mid-2008 had reduced the possibilities to two, and discussions are proceeding. A commercially-operated facility on a 400 ha site is envisaged for each location, with the DOE paying rent for casks stored there.

Under new standard contracts with DOE, proponents of new reactor construction must undertake to store used fuel on site indefinitely, so that the DOE does not become liable for delays. The contracts specify that the DOE will begin removing used fuel within 20 years of the first refueling. As of January 2009, 19 such contracts had been signed under the Nuclear Regulatory Commission's (NRC's) Waste Confidence Rule. They are a prerequisite for new reactor licensing and for licence renewals, and reflect the degree to which the NRC is confident that used fuel from US power reactors can be safely managed. The rule states that the NRC is confident that a repository (not necessarily Yucca Mountain) will be available 50 to 60 years after a reactor operating licence expires.

Low-level waste

For low-level waste (LLW)[p], there are a number of specialist US facilities – otherwise LLW storage is at reactor sites:

1. EnergySolutions at Barnwell, South Carolina, for Class A-C LLW from that state, New Jersey and Connecticut.
2. EnergySolutions facility at Clive, Utah, which accepts class A LLW (about 90% of all LLW) from all over the USA.
3. EnergySolutions at Oak Ridge, Tennessee which claims to be the largest licensed commercial US LLW facility with innovative technologies for radioactive material volume reduction (compaction, melting, incineration) and nearby capacity for recycling depleted uranium.
4. U.S. Ecology at Richland, Washington accepts Classes A-C waste from the Northwest and Rocky Mountain compacts.
5. Waste Control Specialists in Texas, whose facility was licensed in 2009 for class A, B & C LLW, to operate from late 2010 and also take Vermont's and DOE LLW. The company is

also seeking to take LLW from other states.

Further Information

Notes

a. Actual annual production at the Metropolis conversion plant is currently around 15,000 tU – see Metropolis Expansion Update, ConverDyn press release (18 June 2007) [Back]

b. From the 1960s to 2001, the Portsmouth Gaseous Diffusion Plant worked in tandem with its sister facility in Paducah to enrich uranium for use in power plants. The Paducah plant enriched uranium up to 2.75% U-235 and then shipped it to Portsmouth for further enrichment to some 4-5%. In August 2010, the Department of Energy awarded a $2.1 billion contract to a joint venture between Fluor Corp and Babcock and Wilcox (B&W) for decontamination and decommissioning of the huge (15 sq km) Portsmouth uranium enrichment site. [Back]

c. NFS will dilute the material in Tennessee to yield some 290 tonnes of low-enriched uranium (4.95% U-235) by 2010. Wesdyne, the prime contractor, will then store the LEU at the Westinghouse fuel fabrication plant in South Carolina to be available for the Reliable Fuel Supply program – an international fuel reserve. This batch of LEU will be available for use in civilian reactors by nations in good standing with the International Atomic Energy Agency that have good nonproliferation credentials and are not pursuing uranium enrichment and reprocessing technologies. The fuel – worth some $500 million – would be sold at the current market price. [Back]

d. In line with this, the annual quantity coming from dismantled weapons and re-enriched depleted uranium increases steadily to reach 1,920 tonnes U in 2013 and then continues at that level, totalling 15,000 tonnes U. From 2010 to 2015, another 7,700 tonnes U from Russian-origin stocks is allocated for the first cores of newly-built reactors in the USA. [Back]

e. H-Canyon dates from 1955 and originally recovered uranium, neptunium and plutonium from used military and research reactor HEU fuel. Since 1998 it has recovered HEU from degraded materials and spent fuel, to recycle it as LEU. This program will continue to 2019. [Back]

f. In the USA, the option of immediate decommissioning of nuclear plants is known as the Decon strategy. The second option, where a facility is dismantled after allowing much of the radioactivity to decay, is known as Safstor. The third option, known as Entomb, is to permanently encase radioactive contaminants onsite until the radioactivity has decayed to a level where restricted release of the facility is possible.

US plants with Decon completed are: Big Rock Point, Elk River, Fort St Vrain, Haddam Neck, Maine Yankee, Pathfinder, Rancho Seco, Saxton, Shippingport, Shoreham, Trojan and Yankee Rowe. Decon is in progress at Fermi 1, Humboldt Bay 3 and San Onofre 1. Those plants in Safstor include Dresden 1, Indian Point 1, LaCrosse, Millstone 1, Peach Bottom 1, and Zion 1&2, as well as *NS Savannah*. Three Mile Island 2 is in post-defueling monitored storage. The only US plants subject to the Entomb option are three small experimental ones.

See the Fact Sheet on Decommissioning Nuclear Power Plants on the Nuclear Regulatory

Commission's website (www.nrc.gov) for more information. [Back]

g. For further information, see the web page on Sites Undergoing Decommissioning on the Nuclear Regulatory Commission's website (www.nrc.gov); see also the WNA information page on Decommissioning Nuclear Facilities, which has some detail of US plants. [Back]

h. The 70,000 tonne high-level waste repository planned at Yucca Mountain would take 63,000 tonnes of used reactor fuel, 2333 t of naval and Department of Energy used fuel and 4667 t of other high-level wastes, all from 126 sites in 39 US states. Studies by the Electric Power Research Institute show that the repository could hold at least 260,000 tonnes and possibly 570,000 tonnes of used fuel and high-level wastes, rather than the arbitrary 70,000 tonnes set by Congress in 1982.[7] [Back]

i. After several years of failure to get matching bills through both houses of Congress, early in 2000 the House of Representatives finally passed the Nuclear Waste Policy Amendments Act 2000 by 253 votes to 167, matching the earlier Senate passage of the legislation by 64 to 34. However, the President then vetoed it. The Bush Administration sought to make some urgent headway on the matter, and several reports in 2001 suggested no insurmountable scientific or technical problems with the proposed repository site in Nevada. The US Energy Secretary recommended that the site be approved as the nation's permanent repository. This was strongly supported by Congress and signed into law in July 2002. The Department of Energy submitted a licence application to the Nuclear Regulatory Commission in June 2008. Less than a year later, the new Obama administration's FY 2010 Congressional Budget Request confirmed "the Administration's decision to terminate the Yucca Mountain program while developing nuclear waste disposal alternatives." [Back]

j. The first budget from the Obama administration in 2009 cut off most of the money for the Yucca Mountain project[8]. Although the Administration has said it has cancelled the project, the Atomic Safety and Licensing Board of the Nuclear Regulatory Commission ruled in June 2010 that the construction licence application submitted two years earlier may not be withdrawn without consent of Congress. See the Nuclear wastes section in the information page on *US Nuclear Power Policy* for further information. [Back]

k. In January 2010, the DOE announced the formation of a 15-member *Blue Ribbon Commission on America's Nuclear Future* to "provide recommendations for developing a safe, long-term solution to managing the nation's used nuclear fuel and nuclear waste."[12] In a memorandum to energy secretary Steven Chu[13], President Obama said: "The commission should conduct a comprehensive review of policies for managing the back end of the nuclear fuel cycle, including all alternatives for the storage, processing, and disposal of civilian and defence used nuclear fuel and nuclear waste." The commission is to submit an interim report within 18 months and a final report within 24 months. [Back]

l. As of 2008, there was some 58,000 tonnes of civil used fuel awaiting disposal and about 12,800 tonnes of government used fuel and separated high-level wastes. The total increases by about 2,500 tonnes per year. [Back]

m. In 2004, Exelon reached agreement with the US Justice Department on recovering up to $300 million in storage costs for its used fuel to 2010. The agreement covered all of Exelon's 17 nuclear reactors, and the cash came from tax monies, not the Nuclear Waste Fund. In 2006, the US Federal

Court awarded $143 million in damages to three related New England utilities and $40 million to the Sacramento Utility District for the same reason – the former had had to build dry storage facilities. Then $43 million was awarded to Pacific Gas & Electric. In 2007, Duke Energy negotiated $56 million on same basis for three plants, plus ongoing costs. Then Xcel Energy was awarded $116 million for costs associated with three reactors from 1998 to 2004 and Entergy Arkansas was awarded $48.6 million for costs to 2006. Progress Energy was awarded $82.8 million in 2008. Other utilities have been suing the federal government to achieve the same result and billions of dollars are involved. [Back]

n. Congress established a trust fund for waste management in 1982 under the Office of Civilian Radioactive Waste Management (OCRWM), and utilities have supplied over $31 billion (including some $14 billion investment returns) to this Nuclear Waste Fund through a 0.1 cent/kWh levy towards final disposal, so that by the end of January 2010 it had a balance of $24 billion, after development expenses for Yucca Mountain[14]. The fund is growing by about $770 million per year from utility inputs and $1 billion from investment returns. [Back]

o. PFS then offered the facility to the Department of Energy for use from 2008 pending Yucca Mountain repository opening, suggesting that it would be very much cheaper for DOE than leaving the used fuel at reactor sites. While fuel ownership was originally intended to remain with utility customers, the proposal to DOE was that it would take ownership at the reactor site (as was legally required by 1998) and be responsible for moving it to PFS, and ultimately to Yucca Mountain. [Back]

p. Class A low-level waste contains radionuclides with the lowest concentrations and the shortest half-lives; Classes B and C contain greater concentrations of radionuclides with longer half-lives. Class A LLW must be contained for up to 100 years, Class B waste for up to 300 years and Class C waste for up to 500 years. [Back]

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US Uranium Mining and Exploration

US Nuclear Fuel Cycle Appendix 1

(Updated 19 November 2010)

Related page: US Nuclear Fuel Cycle

Uranium mining in the USA today is undertaken by few companies on a relatively small scale. Uranium exploration is undertaken by many companies, often going over areas that were mined in the 1950s-80s.

Uranium production from one mill (White Mesa, Utah) and five in-situ leach (ISL) operations totalled 1,583 tU (1,866 t U_3O_8) in 2006, 1,748 tU (2,061 t U_3O_8) in 2007, and 1,503 tU (1,774 t U_3O_8) in 2008.[1] In 2008, Rosita became a sixth ISL production site before being shut down. In 2009, production was 1445 tU (1704 t U_3O_8) with only the White Mesa mill and three ISL operations (Crow Butte, Smith Ranch-Highland, Alta Mesa) producing at year end and into 2010.

Cameco's US subsidiary Power Resources Inc operates the Smith Ranch-Highland mine in Wyoming's Powder River basin and the Crow Butte mine in Nebraska, both of them ISL operations, and producing nearly 1200 tonnes U between them in 2009 from total reserves of 12,000 tU (15,000 t U_3O_8). The US company is now known as Cameco Resources and is aiming to increase production from these mines and adjacent properties including Reynolds Ranch to 1,770 tU/y by 2011.

Uranium Resources Inc (URI) commenced production from its Vasquez ISL mine in 2004 at about 50 tU/y and from Kingsville Dome in 2006, both in south Texas. Vasquez peaked in 2006 and is now depleted (30 tU in 2007, 9 tU in 2008). Rosita started production in 2008 with oxygen injection but was then closed as uneconomic after 3 tU was recovered.

Kingsville Dome produced 67 tU in 2008 and 19 tU in 2009. It was closed in June 2009 due to low uranium prices, and is being remediated along with Vasquez and Rosita.

Mestena Uranium's Alta Mesa ISL plant in southern Texas is also operational.

Conventional (non-ISL) uranium mining is resuming in the USA after some years (though Cotter Corporation produced 38 tonnes U through its 400 t/day Cañon City mill, Colorado in 2005).

Cotter Corporation, a General Atomics subsidiary, is planning a $200 million rebuild of its Cañon City mill by 2014, when it expects to treat ore from the Mount Taylor mine in New Mexico. (Mount Taylor, which has been on standby since 1989, is owned by another General Atomics subsidiary, Rio Grande Resources Corporation.)

Denison Mines produced 165 tU in the first half of 2009 through its 2000 t/day White Mesa mill in southeastern Utah, from its own and purchased ore (the company is advertising its ore-buying program), as well as doing some toll milling. Production cost for this was $197 per kgU. The mill has a vanadium co-product recovery circuit.

Denison is opening the first of its Uravan Mineral Belt mines on the Colorado Plateau (straddling the Utah-Colorado border) containing 2100 tU in placer deposits plus vanadium co-product (Uravar = uranium + vanadium). Its mines are mainly in the La Sal, Sunday and East Canyon/Rim zones, about 100 km northeat of its White Mesa mill. In 2007, Denison operated four of these mines: Topaz, West Sunday and Sunday/St. Jude in the Sunday group, and Pandora in the La Sal group. Most are mature operating mines with extensive underground workings, while the Topaz mine is relatively new. Two more of these mines reopened in 2008: Rim and Beaver (La Sal group), which required significant refurbishing to produce some 30 tU/y. There are no plans to bring the other mine there, Van 4, into production. In August 2009, the Pandora, West Sunday and Beaver mines were operating, while the Topaz, Rim and Sunday mines were closed pending market improvement.

Denison's Henry Mountains deposits in Utah including Tony M, Southwest and Bullfrog have 4900 tU as indicated resources at over 0.2% and inferred resources of 3100 tU, both NI 43-101 compliant. All these are some 120 km west of the White Mesa mill. Denison began production from the Tony M mine in 2007, but late in 2008 put it on care and maintenance. The company was intending to spend $35 million on the adjacent new Bullfrog mine, but it was put on hold in 2008.

Denison also has four old mines in the Arizona Strip of north central Arizona, along with some new deposits there, though all these are some 500 km south from White Mesa mill and some may be impacted by the Bureau of Land Management decision to stall developments there. It has been working to bring the Arizona 1 underground mine into production.

Toronto-based Uranium One in 2007 bought US Energy's 1,000 t/day Shootaring Canyon mill in southeast Utah and associated properties in four contiguous states for $50 million plus royalties. US Energy had been planning to bring the mill back into production at a cost of $31 million. (Uranium One had also secured the right to buy Rio Tinto's 3,000 t/day Sweetwater uranium mill and associated uranium properties in south-central Wyoming for $110 million, but in January 2007 Rio Tinto cancelled the deal.)

In Wyoming, Uranium One has plans for production from the Irigaray-Christensen Ranch ISL mine in the Powder River Basin from 2011. It acquired 500 tU/yr capacity through the Irigaray central processing plant when it bought those assets for $35 million from Areva in mid-2009, and plans to expand this plant to its licensed 960 tU/yr. (In 2007, it announced a 'toll milling' arrangement with Cameco's Power Resources Inc for recovery of up to 540 tU per year at PRI's Smith Ranch-Highland mill, but that appears to be superseded.) Production from its three small mines (Moore Ranch, Peterson Ranch, Nine Mile) will be from loaded resin trucked to Irigaray starting 2012, initially Moore Ranch. The NRC issued a licence for Moore Ranch in October 2010. Uranium One has some 4,000 tU as measured resources (2,235 t at Moore Ranch) and 23,000 tU as indicated resources in the state. It also had plans for production from Antelope and JAB in the Great Divide Basin, but these were deferred due to endangered species concerns.

In 2009, Titan Uranium Inc bought Uranium Ones's 50% interest in Sheep Mountain so that it now holds that whole deposit with 6200 tU indicated resource at 0.1%U and an existing mine permit. Underground development took place in the 1970s. Titan has undertaken a prefeasibility study on mining by open pit and underground, with heap leaching recovery, to produce 580 tU/yr from 5500 tU probable reserves.

Uranerz is in the process of permitting its Nichols Ranch ISL operation in the Powder River Basin o Wyoming. This will have a number of satellite operations, starting with Hank, with loaded resin

being trucked to Nichols Ranch, which is being licensed for 770 tU/yr. Production is envisaged from 2011. The company has NI 43-101 compliant resources of 6060 tU at about 0.1 %U in seven deposits, including measured & indicated resources of 1,137 tU for Nichols Ranch itself, 860 tU for Hank, 1100 tU for West North-Butte and 1655 tU measured and indicated resources at about half the grades of these - 0.048 %U, at Reno Creek, 30 km east of Nichols Ranch.

Australian-based Peninsula Minerals reports JORC-compliant resources of 9700 tU at about 0.05% for its Lance ISL project in Wyoming's Powder River Basin, including 3550 tU as measured and indicated resources. It is undertaking a feasibility study with a view to bringing this into production.

Energy Fuels Resources Corporation (EFRC, a subsidiary of Energy Fuels Inc of Toronto) has applied to reopen former uranium-vanadium mines in the Uravan Mineral Belt in western Colorado. Whirlwind (including Packrat, Bonanza and La Sal) is a near-term project following Bureau of Land Management approval, but late in 2008 was put on standby. Tenderfoot Mesa is adjacent. It has applied for a licence to build the new Piñon Ridge mill, with construction start possible in 2011. EFRC's nearby Energy Queen mine in Utah was refurbished for 2008 reopening. In August 2008 EFRC announced NI 43-101 compliant indicated resources of 1480 tU and inferred resources of 1,370 tU for its Colorado and Utah properties.

Bayswater Uranium Corporation of Canada has received a pre-feasibility study on mining its newly-acquired Reno Creek and Southwest Reno Creek deposits in Wyoming. These have a NI 43-101 measured and indicated resource of 4220 tU @ 0.066% suitable for ISL, plus inferred and historical resources. The project would have five wellfields and a central processing plant producing about 750 tU/yr. It is 30 km southeast of Christiansen Ranch and 50 km north of Cameco's Smith Ranch, and Bayswater plans to bring it into production about 2014.

In October 2009, Uranium Energy Corporation (UEC) bought the small but recently-refurbished Hobson mill in southern Texas from Uranium One (it had been shut since 1991). UEC plans to make Hobson the basis of its Texas uranium projects. Hobson will have 380 t/yr capacity, and already recovers uranium from loaded resin trucked there from the La Palangana ISL mine, to which will be added loaded resin from satellite plants at Goliard and Nichols. In November 2010, UEC reported that production had commenced at Palangana – the first US ISL operation to start in five years. UEC has been granted preliminary approval to mine its Goliard ISL project in south Texas from 2011. Goliard has 2100 tU and Palangana 410 tU measured and indicated resources which are NI 43-101 compliant, at about 140 m depth. Nichols has 500 tU inferred. Another potential ISL satellite is Salvo, with 580 tU 'historic' resource.

UEC in 2007 bought the New River Uranium Project in Arizona with a historic resource estimate of 5,000 tU in shallow low-grade ore. In 2009, it formed a joint venture with Australia’s Uran Ltd to develop the Grants Ridge project in New Mexico, including nine historic mines which operated from 1970-80s, with average grade 0.20%.

Ur-Energy has approval for ISL mining at its Lost Creek, Wyoming deposit with 4200 tU indicated and inferred resources at 0.05%U. The company claims potential for some 10,000 tU in the immediate area. Mining is planned, and the site is close to Kennecot's Sweetwater mill.

Uranium Resources Inc (URI) in 2007 sought to buy Rio Algom Mining, with uranium properties and a licensed mill site at Ambrosia Lake in New Mexico, where it planned to construct a new mill to serve the Grants mineral belt. However, the deal was aborted in mid-2008. URI subsidiary Hydro

Resources Inc was licensed in 1994 to mine the Crownpoint and Church Rock ISL deposits in New Mexico, and after years of opposition the licence was validated by the Nuclear Regulatory Commission in 2006. URI's future potential is in its Grants district properties in New Mexico which hold 39,000 tU, and from which it hopes to produce 2000-3000 tU/yr from ISL. URI plans to produce 385 tU/yr from Churchrock from mid-2013.

Also in New Mexico, Uranium International Corp (UIC) has announced 1,180 tU measured and indicated resource at Dalton Pass, with ISL potential. It also announced a 1,160 tU measured and indicated resource at Nose Rock, deep in hard rock. Both are NI 43-101 compliant, in the Grants mineral belt and owned by Strathmore Minerals. UIC has the option of earning a 65% share of each.

Neutron Energy Inc has taken full ownership of the Cebolleta Land Grant in New Mexico which has 8000 tU resources after mining took place 1975-81, producing 460 tU.

Yellowcake Mining Corp reports 5,000 tU reserves at its planned Beck mine in the Uravan area of Colorado and agreed in May 2008 to sell a 50% stake in it to Korea Electric Power Corp (KEPCO). However, in February 2009, KEPCO withdrew, leaving the project bereft of funds. The company had joint ventures with Strathmore Minerals for Juniper Ridge and a Gas Hills prospect in Wyoming, but these were terminated in 2008.

Strathmore Minerals is working towards bringing its Gas Hills properties in Wyoming into production, though it has only historical resource figures for most of these.

In New Mexico, Strathmore submitted a mining permit application in October 2009 for Roca Honda (60% owned, with Sumitomo 40%) in the Grants mineral district which has measured & indicated resource of 6,745 tU at 0.195% U and slightly less inferred resources. The company also has other projects in the Grants mineral district, including: another Church Rock prospect with 4570 tU as measured & indicated resource, Marquez with 3500 tU as indicated resource, Dalton Pass with ISL potential and 1000 tU measured & indicated resource, and Nose Rock, deep in hard rock with 1160 tU measured & indicated resource. All the above are NI 43-101 compliant.

Powertech Uranium Corp is proposing to develop two ISL mines: Centennial in northern Colorado, and Dewey-Burdock in South Dakota – in each case very close to the Wyoming border. Centennial has 4,430 tU in 0.08% ore and Dewey-Burdock 2570 tU indicated resources averaging 0.18%U and 1880 tU inferred resources averaging 0.13%, both NI 43-101 compliant. The company has applied to develop Dewey-Burdock.

Bluerock Energy Corporation has shipped the first ore from development of the J-Bird mine in Colorado to Denison's White Mesa mill in Utah.

White Canyon Uranium based in Perth, Australia, commenced production from its Daneros deposit in southeastern Utah in December 2009. Ore is trucked 100 km to Denison's White Mesa mill for treatment and recovery of U_3O_8 product. Ore produced during the development phase was sold to Denison, and from there a 3-year toll treatment agreement came into effect, from January 2010, for up to 55,000 tonnes of ore per year. JORC-compliant resource figures of 447 tU in 0.22%U ore were quoted in August 2010, and production is planned to be 227 tU/yr.

US uranium mines and other production facilities

	ISL mine	Hard rock mine	Mill	Status	Annual capacity
Uranium One	Christiansen Ranch, WY		Irigaray, WY	Being refurbished and expanded	960 tU
	Antelope, WY			Under construction	900 tU
Uranerz	Nichols Ranch, Hank, Jane Dough, WY		Nichols Ranch, WY	Permitting	770 tU
Power Resources Inc (Cameco)	Smith Ranch - Highland, WY		Smith Ranch - Highland, WY	Operating	2100 tU
Cameco Corporation	Crow Butte, NE			Operating	385 tU
Uranium Resources Inc	Vasquez, TX Rosita, TX			Operating in 2008, but now closed	0
	Kingsville Dome, TX			Operating in 2008, but closed mid-2009	0
Mestena Uranium	Alta Mesa, TX			Operating	385 tU
Uranium Energy Corp	La Palangana, Goliard, TX		Hobson, TX	Palangana operating, Goliard licensed, Hobson mill licensed	Mill: 380 tU
Hydro Resources Inc (URI subsidiary)	Church Rock, NM			Under construction*	385 tU
	Crownpoint, NM			Under construction*	385 tU
White Canyon Uranium		Daneros, UT	White Mesa, UT (toll)	Operating	227 tU
Cotter Corp			Canon City, CO	Standby, refurbish plan for 2014 start	
Denison		Uravan, CO-UT, Tony M, UT, Arizona 1, AZ	White Mesa, UT	Some operating	
Kennecott			Sweetwater, WY	Standby	
Uranium One			Shootaring Canyon, UT	Operational in 2008?	
Energy Fuels Resource Corp		Uravan mines	Pinon Ridge, CO	Developing, maybe operate 2011	

** Partially permitted and licensed*

There was a considerable legacy of pollution from abandoned uranium mines and treatment plants, most dating from the 1940s and 1950s, and which was addressed in the 1980s. For instance, the Uravan mill site on the San Miguel River in Colorado was designated a Superfund site and was cleaned up between 1987 and 2007 at a cost of over $120 million. Historic mining and milling at Uravan included the production of radium, vanadium and uranium, leaving radioactive residues from the early 1900s through to the mid-1980s. From the time Uravan mill began operating in the 1920s until it was shut down, it processed over ten million tonnes of uranium-vanadium ore, giving rise to a similar amount of uncontained tailings, and 1,440 megalitres of liquid wastes were treated in the site rehabilitation program.

Further Information

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US Nuclear Fuel Cycle

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