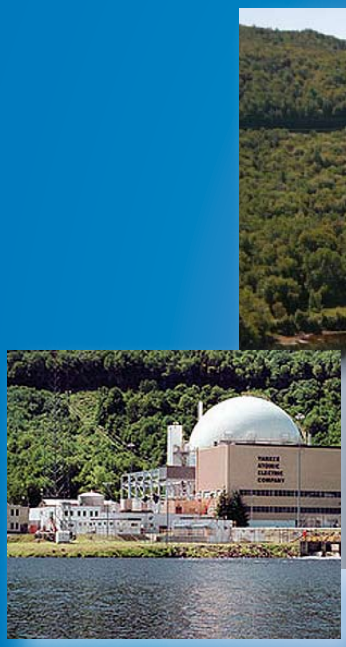
Decommissioning
of Nuclear Facilities



"It can and has been done."

Considerable international experience gained over the last 20 years demonstrates that nuclear facilities can be safely dismantled and decommissioned once a decision is made to cease operations and permanently shut them down. This brochure looks at decommissioning across a spectrum of nuclear facilities and shows worldwide examples of successful projects. Further information can be found in NEA publications and on a number of websites (see the back of this brochure).

Brochure produced by the Working Party on Decommissioning and Dismantling (WPDD) and the Co-operative Programme on Decommissioning (CPD) under the aegis of the OECD/NEA Radioactive Waste Management Committee (RWMC).

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Range of plants needed to generate nuclear energy

The diagram shows the range of plants commonly involved in electricity production by nuclear means. Uranium ore is mined and milled (1) to produce a uranium concentrate for the production of fuel for power plants. The concentrate is refined, converted (2) and in some cases enriched (3) to a form suitable for nuclear fuel. The uranium is then fabricated into fuel elements (4) for use in power plants (5). The used fuel can either be treated as a waste (stored pending disposal) or reprocessed (6). In reprocessing, reusable uranium and plutonium is extracted for further use as fuel (7).

3. Uranium enrichment (Georges Besse, Tricastin, photo courtesy of AREVA).

4. Fuel fabrication (Marcoule, France photo courtesy of CEA).

7. Plutonium fuel fabrication (Tokai-Mura, Japan, photo courtesy of JAEA).

2. Uranium conversion (Korea, photo courtesy of KAERI).

5. Power reactors (Switzerland, photo courtesy of Beznau NPP).

1. Uranium mining and milling (Jouac Mine, France, photo courtesy of AREVA).

6. Reprocessing (Sellafield, UK, photo courtesy of Sellafield Limited).

After decommissioning

In most cases, the bulk of the scrap metal and other materials arising from decommissioning projects is neither irradiated nor radioactively contaminated and can be recycled and reused or disposed of with conventional waste. Radioactive materials are sorted and packaged and sent to radioactive waste disposal facilities (examples: Centre de l'Aube, France, and El Cabril, Spain) or kept in storage where such facilities are not yet available. After decommissioning is complete, the land upon which the facilities were located can be returned for unrestricted use, industrial reuse or nuclear reuse.

Disposal of decommissioning waste

Disposal of low-level radioactive waste (Centre de l'Aube, France, photo: ANDRA).

Disposal of very low-level radioactive waste (El Cabril, Spain, photo: ENRESA).

Examples of completed decommissioning projects

1. Uranium mining and milling

Elliott Lake Uranium Mine Site Reclamation, Canada (Serpent River Watershed)

(Photos reproduced with permission of BHP Billiton)

A number of uranium mines, mills and tailings management facilities were operated in the Serpent River Watershed (Ontario, Canada) between the late 1950s and 1996. The decommissioning of the facilities began in 1985 and was completed in 2000, through a collaborative process involving the mine owners, the provincial government, the Serpent River First Nation and other local communities and interest groups. During the 1990s, most visible structures, including mills, storage tanks and conveyors were removed. Mine entrances were sealed, and the land was recontoured to reflect its natural shape and revegetated.

Before decommissioning.

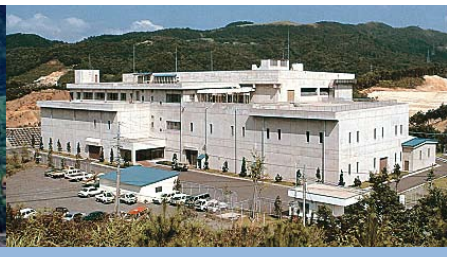
After decommissioning.

2. Uranium conversion

Ningyo Toge Refining and Conversion Facilities, Japan (JAEA) (Photos courtesy of JAEA)

Uranium conversion facilities purify and transform uranium ore concentrate for fuel fabrication. The facilities at Ningyo Toge were used for research and development activities from 1981 to 1999, and processed both natural uranium and reprocessed uranium. More than 700 tonnes of enriched uranium were produced over the operating life of the facilities. About 1 500 tonnes of operational radioactive waste, such as neutralised sludge and disused absorbing materials for uranium, were generated. Additional waste will arise from the dismantling activities. Dismantling of the refining and conversion facilities began in 2008 and will be completed by 2012.

Ningyo Toge Environmental Engineering Centre.



Refining and conversion facility.

3. Uranium enrichment

The United States Department of Energy's East Tennessee Technology Park (ETTP)

(Photos courtesy of the US Department of the Environment)

The ETTP at Oak Ridge was originally built as a uranium enrichment facility for defence programmes. The majority of the site facilities have been inactive since uranium enrichment production ceased in 1985. The U-shaped K-25 Building is approximately 1.5 km long and has 18 ha under one roof. The building is near the centre of the ETTP and was built in 1943. The K-27 Building is a rectangular building built in 1945, and has a footprint of approximately 35 000 m^2. Except for the shape and size, the two buildings are very similar in construction and materials. Both buildings contain radioactive contamination and hazardous materials in the building structures, and are scheduled for demolition. This work is nearing completion.

K-25 Building.

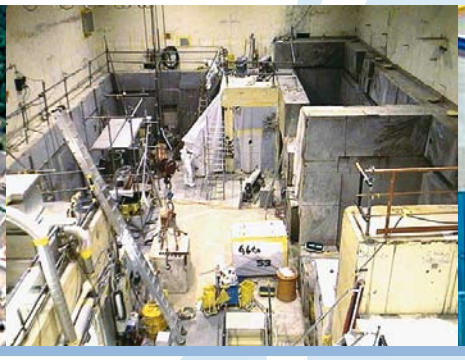
K-25 West Wing demolition.

4. Fuel fabrication

Hanau, Germany (Photos courtesy of Siemens AG)

Hanau was the site of four German fuel fabrication plants, one of which produced uranium fuel elements for light water reactors (1 350 tonnes per year). All four fuel fabrication plants and parts of the site were released from nuclear regulatory control in 2006. A particular challenge during decommissioning was the clean-up of buildings and soil. Uranium and plutonium waste will remain in stores located on the site awaiting disposal.

The facility before decommissioning.



Surface decontamination in progress.

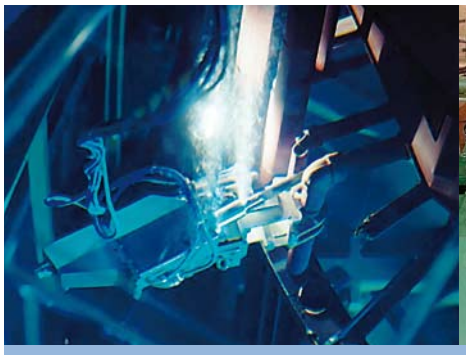
After decommissioning, storage.

5. Power reactors

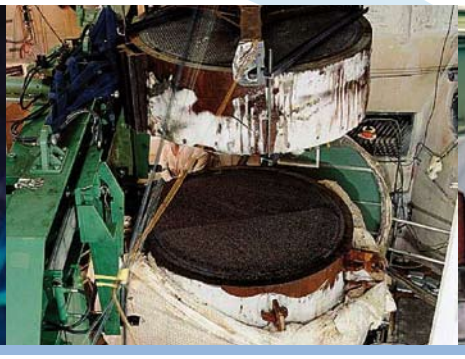
Worldwide, several nuclear power reactors have been fully decommissioned, representing different reactor technologies and ranging in size from small prototype plants to large commercial facilities.

Gundremmingen-A, 250 MWe (gross) boiling water reactor (Photos courtesy of RWE Power AG)

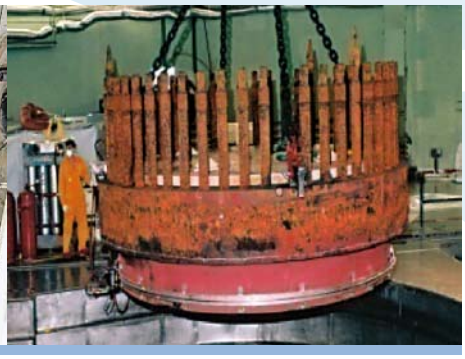
The Gundremmingen Nuclear Power Plant (NPP) Unit A was shut down in 1977 after an incident. Decommissioning started in 1983 and is far advanced. All activated structures have been removed and final work is focused on decontaminating the reactor building. After the dismantling work has been completed, the remaining structures will be reused for a technology centre at the site.



Dismantling of RPV internals using contact arc metal cutting.



Dismantling of a steam generator using an "ice sawing" technique.



Dismantling of the RPV – transporting the flange.

Niederaichbach, 106 MWe (gross) heavy water reactor (Photos courtesy of Babcock Noell GmbH)

Decommissioning was completed in 1995 and the NPP was released from nuclear regulatory control. The Niederaichbach NPP was the first large-capacity nuclear power plant in the world to be completely decommissioned. The site was decontaminated to a "greenfield" state, and thus no restrictions have been placed on its future use.

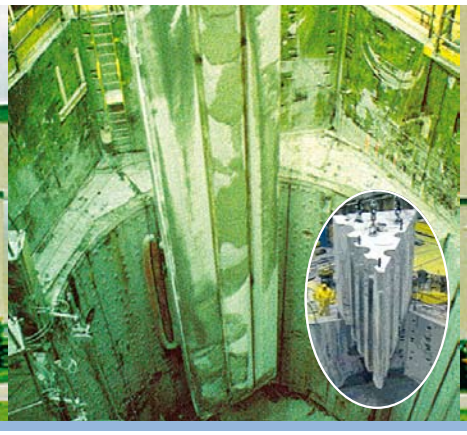
Dismantling of the biological shield.

Greenfield state.

Fort St Vrain, 330 MWe high-temperature gas-cooled reactor (Photos courtesy of FSVFolks.org)

Decommissioning was completed in 1992. The former reactor building now contains a gas turbine plant.

Before.



During.

After: same as before but now a gas turbine plant.

Connecticut Yankee, 600 MWe pressurised water reactor

(Photos courtesy of Connecticut Yankee Atomic Power Company)

Decommissioning was completed in 2007. Other uses for the site are now being sought.

The facility before decommissioning.

Concrete decontamination in progress.

After decommissioning.

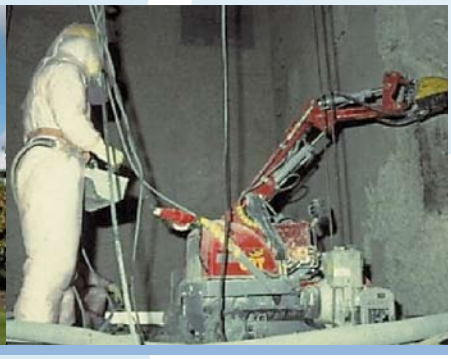
6. Reprocessing

Eurochemic, Belgium (Photos courtesy of Belgoprocess)

The Eurochemic reprocessing plant operated from 1966 to 1974 to process fuel from power and research reactors. The main building was a large concrete structure, comprising a surface area of 55 000 m^2, a concrete volume of 12 500 m^3 and 1 500 tonnes of metal components. After decontamination, more than half of the concrete material has been unconditionally released from the site, as well as almost 70% of the metals. A significant part of the structure (the eastern part) was demolished in 2008 and decommissioning will be completed in 2012.

Before.

Demolition under way (August 2008).



Concrete decontamination.

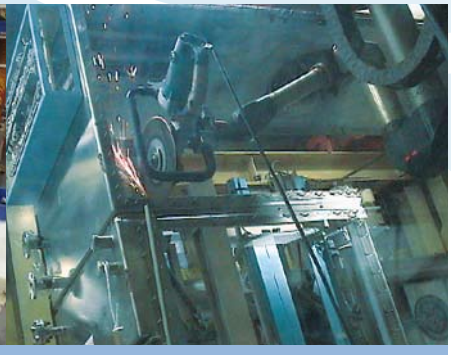
7. Plutonium fuel fabrication

Plutonium Fuel Fabrication Facility, Tokai-Mura, Japan (Photos courtesy of JAEA)

The Plutonium Fuel Fabrication Facility (PFFF) forms part of the Plutonium Fuel Centre at Tokai-Mura, which contains development, production and fabrication facilities for plutonium fuel. The PFFF was constructed in 1972 for the fabrication of fuel for the Joyo Experimental fast reactor; it was shut down in 2003 and is now being decommissioned. An important aspect of the decommissioning project is concerned with dismantling the glove boxes used for the fabrication of MOX pellets. The activity will be undertaken using a combination of manual and remote-controlled cutting devices.

Plutonium Fuel Fabrication Facility.

During dismantling of the glove boxes.

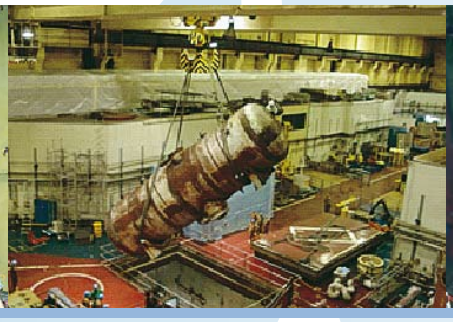


Remote size reduction of metal components.

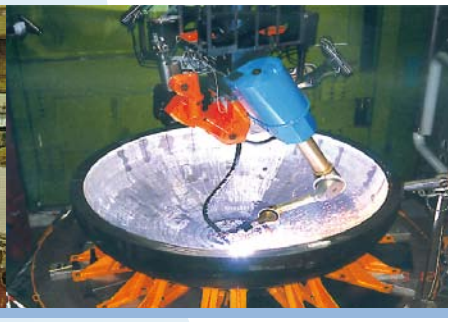
Greifswald NPP, Germany (Photos courtesy of EWN)

Aerial view of the plant.

Removal of a reactor pressure vessel.



Dismantling of a steam generator in unit 4.



Plasma cutting, dry.

Mechanical cutting

Reciprocating/alternative sawing.

Diamond cable wire cutting.

Cutting of a steam generator with a large band saw in the Interim Storage Facility North (ZLN).

Empty turbine hall.

Decommissioning: overview of current status

The term *decommissioning* is used to describe all the management and technical actions associated with ceasing operation of a nuclear installation and its subsequent dismantling to facilitate its removal from regulatory control (delicensing). These actions involve decontamination of structures and components, dismantling of components and demolition of buildings, remediation of any contaminated ground and removal of the resulting waste.

Worldwide, of the more than 560 commercial nuclear power plants that are or have been in operation, about 120 plants have been permanently shut down and are at some stage of decommissioning. About 10% of all shutdown plants have been fully decommissioned, including eight reactors of more than 100 MWe. A larger number of various types of fuel cycle and research facilities have also been shut down and decommissioned, including: facilities for the extraction and enrichment of uranium, facilities for fuel fabrication and reprocessing, laboratories, isotope production facilities and particle accelerators.

Further information on decommissioning

Examples of international websites on decommissioning

- **Publications from the Working Party on Decommissioning and Dismantling (WPDD) and the Co-operative Programme on Decommissioning (CPD):**
  www.nea.fr/html/rwm/wpdd
  www.nea.fr/html/jointproj/decom.html
- **International organisations:**
  www-newmdb.iaea.org
  http://ec.europa.eu/energy/nuclear/decommisioning/decommissioning_en.htm
- **Industry associations:**
  www.world-nuclear.org/how/decommissioning.html
  www.nei.org/
  www.ewn-gmbh.de/

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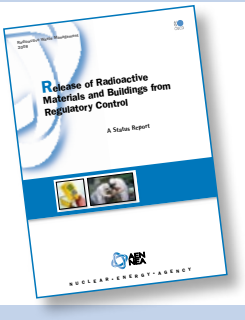

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