Decommissioning Strategies: Status, Trends and Issues

This annex summarizes what decommissioning is, alternative decommissioning strategies, the status of decommissioning projects around the world, and the factors that influence choices among decommissioning strategies.

A. Introduction

After a nuclear power reactor is turned off for the last time, the initial steps toward decommissioning are not unfamiliar. The fuel is moved to the spent fuel storage pond where it will cool down for at least a few years, after which it will be moved to away-from-reactor (AFR) storage or sent for reprocessing. During those initial years, the workforce will most likely be relatively unchanged, and the systems to cool the spent fuel storage pond and ensure water quality will operate as before. Systems ranging from the reactor's instrumentation and control to heating and ventilation will all be kept running.

Subsequent steps will depend on the choice that has been made among the decommissioning strategies described in this annex. But the initial steps of powering down the reactor, disconnecting the turbine, and removing spent fuel will be familiar from maintenance and refuelling shutdowns experienced during the reactor's operating life.

While the spent fuel is cooling, the reactor's cooling fluids will be removed from the primary and secondary cooling loops, and the loops may be cleaned by running cleaning fluids through them. At this point, the reactor is in a state of 'cold shutdown', but many systems will continue running, including ventilation and radiation monitoring.

If the selected strategy is immediate dismantling, removal of the spent fuel away from the reactor building is a significant milestone. The reactor workforce can then be reduced and dismantling can begin. Dismantling will likely start with the turbine and other relatively uncontaminated components. Many components, such as pumps, valves and pipes, may have been replaced or removed for maintenance during the reactor's lifetime, and their removal for the final time will not be very different. The contamination level of each component will have to be measured and carefully recorded, but this again is not new. All dismantling will be done inside temporary tents or other containment structures to ensure that contamination is not spread.

As components are dismantled, they may be either stored on-site or shipped to their final disposal site. The sort of final disposal sites that are available will also determine whether large components are cut up or disposed of intact. Steam generators and even reactor pressure vessels have been disposed of intact. They are in fact containers, designed to high containment standards, that are uncontaminated on the outside and can therefore be transported, if they are not cut up, without special additional containers. Most of the dismantled components and rubble, however, must be transported in special containers. Most will be classified as low level waste (LLW) or very low level waste (VLLW). Some, like the reactor internals, will be intermediate level waste (ILW).

The strategy to dismantle and remove everything from the site can take 5–10 years (FIG. IV-1). The vacant site may then be valuable as a potential site for a new reactor since, other things being equal, building on a site that already has been licensed for such use will be easier than starting with a new site. Or, if no future special use is foreseen for the site, once final surveys have confirmed that all contamination has been removed, the nuclear licence can be terminated.

There are many variations on this basic outline of the decommissioning process. No two decommissioning projects are identical. This annex summarizes these variations and the reasons for such variation.

B. Decommissioning status of nuclear power reactors around the world

At the end of 2009, 123 power reactors had been shut down. Of these, 15 reactors had been fully dismantled, 51 were in the process of being dismantled, 48 were being kept in a safe enclosure mode, 3 were entombed, and, for 6 more, decommissioning strategies had not yet been specified (see Table IV-1). The following section explains what these terms mean and outlines the reasons why different strategies are chosen for different reactors.

FIG. IV-1: Maine Yankee being dismantled

C. Overview of decommissioning projects and strategies worldwide

There are three basic decommissioning options: immediate dismantling, long term safe enclosure followed by dismantling, and entombment, which is also called on-site or in-situ disposal [IV-1, IV-2]. Entombment has generally been limited to small installations. A variation on immediate dismantling called incremental or sequential decommissioning has also emerged recently in which dismantling is as immediate as possible subject to restricted year-by-year cash flows. This necessarily takes longer than immediate dismantling, where all funding is immediately available, and is more difficult to plan.

The choice between the two main strategies, immediate dismantling and long term safe enclosure followed by dismantling, depends on many factors. This section presents examples from around the world to illustrate the variety of ways in which these factors can interact in practice in different decommissioning projects. The next section discusses each of the important factors in more detail.

In the USA, the choice of immediate dismantling for a number of reactors has been driven partly by the current availability of disposal facilities and uncertainty about the availability and costs of future disposal facilities. The availability of the necessary commercial disposal sites also allowed for the intact, and therefore less work intensive, removal of large components such as reactor vessels and steam generators (FIG. IV-2).

Électricité de France initially chose partial dismantling of its retired first-generation reactors and postponed final dismantling for 50 years. At the time, this was the most cost-effective strategy. Subsequently, however, reduced dismantling costs due to technological advances, the availability of very low level waste (VLLW) disposal facilities, and a political interest in resolving what public opinion might consider an undesirable nuclear legacy led to the earlier dismantling of old French reactors. In Italy, political considerations also led to the acceleration of decommissioning programmes.

In Germany, fourteen retired reactors are being immediately dismantled while two are being kept in a safe enclosure mode for delayed dismantling. At some sites, for example Greifswald in eastern Germany, the socio-economic benefits of using local industry and labour in an economically depressed region were an important factor in choosing immediate dismantling. The immediate availability of both on-site and off-site storage options for spent fuel and decommissioning waste also influenced the choice of immediate dismantling. In some cases large components have been cut into pieces on-site; at Gundremmingen, for example, steam generators were cut into pieces after being filled with water, frozen and turned into more manageable monoliths. In other cases, large components are being stored intact on-site, for example at Greifswald.

In Sweden, the current lack of disposal facilities for decommissioning waste has led to deferred dismantling of the Barsebäck reactors until such facilities are available.

FIG. IV-2. Removal of the reactor vessel at Maine Yankee

For most reactors in Eastern Europe, current plans are to significantly defer active dismantling, due mainly to the need to build up sufficient funds. Until recently, most Eastern European countries had no financial provisions to cover eventual decommissioning, and the anticipated operating lifetimes of many reactors were insufficient to accumulate the required funds. In some cases, economic and political constraints have made it difficult to collect the required level of decommissioning funds. In most other countries with long established nuclear power programmes, existing decommissioning funds appear to be adequate. However, the long term effects of the global financial crisis that started in late 2008 have yet to be evaluated fully.

D. Factors in selecting a decommissioning strategy

D.1. Legislative and regulatory requirements

Different countries have different regulations governing decommissioning strategies and their timing. For example:

- Japan, to enable further use of reactor sites, requires that facilities begin total dismantling within ten years of shutdown. Facilitating reuse of available sites is an important consideration in a country where such land is at a premium.
- The US Nuclear Regulatory Commission (NRC) limits the safe enclosure period to 60 years.
- UK policy allows dismantling to be delayed for Magnox reactors and for them to be kept in a safe enclosure mode for more than 100 years. Such a long period allows levels of radioactivity to be reduced through radioactive decay so that workers could work on a Magnox reactor without limitation, and also allows the accumulation of decommissioning funds. This policy is, however, being reconsidered.

In the past ten years, nearly all countries with operating reactors have promulgated decommissioning regulations defining operators' responsibilities. A facility's operator has the primary responsibility for all technical and financial measures necessary for decommissioning and the safe handling of all material. There are, however, different approaches to the responsibility for the disposal of radioactive waste, e.g. whether disposal is under the supervision of national regulatory bodies or national agencies. In a few countries, dedicated national agencies are being made legally responsible for decommissioning nuclear facilities, i.e. they become the new licensees/operators (e.g. ENRESA in Spain, or PURAM in Hungary). The new atomic energy acts also codify requirements for initial and continuing decommissioning planning for nuclear facilities.

D.2. National waste management strategies

Dismantling any radioactive facility generates different categories of radioactive waste. How much waste is generated in each category depends on the timing of dismantling operations. Deferment may reduce the amounts of intermediate level waste (ILW) and increase amounts of low level waste (LLW) or rubble and other waste that can be cleared from regulatory control. This will influence disposal arrangements and costs. Within the past ten years, several countries have introduced the category of very low level waste (VLLW), which is intended to accommodate most decommissioning waste at a disposal cost (per cubic metre) that is an order of magnitude less than the cost of LLW disposal. A VLLW repository opened at Morvilliers, France in 2003 and reached full operation in 2004. Spain opened a VLLW repository in 2008 (FIG. IV-3). VLLW disposal sites are not too different from conventional landfill sites, and all phases of conditioning, packaging, transporting and disposing of the waste are greatly simplified compared to LLW. The availability of the VLLW category allows inexpensive disposal of most decommissioning waste and adds an incentive for immediate dismantling [IV-3].

Although disposal facilities now exist in many countries (Table IV-2), they do not exist everywhere. If no suitable disposal facilities for the amounts and categories of waste are available, then there are two options: maintain the facility in safe enclosure mode or dismantle the facility, condition the waste and store it on-site in appropriate temporary facilities.

FIG. IV-3. El Cabril, Spain: VLLW disposal facility

All countries that do not have waste disposal sites have policies of long term safe enclosure for their shutdown facilities. Even countries with some waste disposal options may not have disposal options for all types of decommissioning waste. For example, the reactor building of the Vandellos nuclear power plant in Spain is being kept in safe enclosure mode partly because of the unavailability of a graphite disposal facility. The Vandellos graphite is kept in segregated vaults inside the reactor building. At Germany's Greifswald site, all wastes resulting from reactor decommissioning are being stored in large warehouses on-site pending future availability of a disposal site.

The most important regulatory requirements are related to clearance criteria. International recommendations for exemption and clearance have been issued by the IAEA [IV-4] and the European Commission [IV-5]. These specify radiological concentrations (typically, mass or surface concentrations) below which material can be considered to be non-radioactive and released from regulatory control. Such criteria are now established in many countries. In some cases they are part of the legislative framework (e.g. Germany, UK and USA), and in others they have been established for specific projects (e.g. Italy).

Materials removed from a decommissioned facility fall into four classes:

- those that can be cleared for unrestricted reuse or disposal;
- those that are authorized for reuse within the nuclear industry (e.g. a plant's cooling water equipment);
- those that can be released for a specific restricted use outside the nuclear industry (e.g. as the foundation for an airport runway); and

- those that are to be stored or disposed of under radiologically controlled and monitored conditions.

The criteria defining these classes vary among countries. Where national regulations are lacking, regulators decide on a case-by-case basis.

D.3. National spent fuel management strategies

Experience shows that spent fuel management strategies can strongly affect the selection of a decommissioning strategy. In particular, facilities to store, dispose of or reprocess spent fuel may not be readily available, and the fuel must therefore remain in the reactor facility. The lack of a transfer route for spent fuel may force a licensee into a safe enclosure strategy with spent fuel in the facility. In general, it is desirable to remove spent fuel off-site or to an on-site facility separate from the power plant within five years. This is the most common strategy in the USA. Several US nuclear power plants have been fully dismantled with spent fuel stored at nearby independent facilities (FIG. IV-4). Some water cooled water moderated power reactor (WWER) operators (e.g. at Paks, Dukovany and Mochovce) have built on-site wet and dry interim storage facilities.

FIG. IV-4: The independent spent fuel storage installation at Maine Yankee

An example of off-site storage is the transfer in the past decade of large amounts of spent fuel from Central and Eastern Europe reactors to the Russian Federation for eventual reprocessing. This paved the way for smoother and more timely decommissioning of those reactors.

D.4. Planned use of the site

The choice of a decommissioning strategy may also depend on the planned future use of the site. For example:

- The owner may have a shortage of sites for new plant construction and may be forced to re-use a site for a new plant. In that case, immediate dismantling may be chosen. In Japan, for example, land is at a premium, and nuclear sites are relatively scarce.
- If the plant to be decommissioned is co-located with other operating facilities that will continue to be in service, safe enclosure may be the preferred choice. The necessary security, surveillance and maintenance for the shutdown facility could be provided by the remaining

operating facilities. Most European and US sites are large enough to accommodate new reactors next to the old ones, so that the old ones would not have to be dismantled to allow new build.

- The site re-developer may wish to consider the re-use of some of the plant facilities, for example, the cooling water equipment, the infrastructure, and some of the plant process systems, for purposes other than those for which they were originally intended or as part of a new or modified plant.

Originally, nuclear decommissioning management assumed that the goal was the final disposal of waste and restoration of the site to almost pristine 'greenfield' conditions. Today, the focus is on redevelopment and re-use. Decommissioning doesn't need to be seen as the endpoint of an existing facility or site, but rather as the starting phase of redeveloping or reusing the facility or site. Rising expectations about the expansion of nuclear power are starting to create pressure for the redevelopment and reuse of existing nuclear sites and 'brownfields'.

In addition to re-using sites for new nuclear build, there are several recent examples of non-nuclear redevelopment or re-use. The turbine building of a decommissioned nuclear power plant was reused for a fossil fired power plant at Fort St. Vrain, USA. The Chinon-1 nuclear power plant in France was converted into a museum. Part of the Greifswald nuclear power plant in Germany is being converted into a biodiesel production facility (FIG. IV-5).

Decommissioning plans should include the securing of facilities and sites after decommissioning until successful redevelopment and re-use, and they should identify structurally sound buildings and other property that should not be demolished. Early identification of redevelopment and re-use options can also help ensure uninterrupted employment where this is a priority [IV-6].

FIG. IV-5: Biodiesel plant construction at the Greifswald nuclear power plant, Germany.

D.5. Radiological factors

The removal of the fuel, process fluids, and operational waste from a reactor and, if practicable, from the site removes the main radiological risk presented by that facility. The remaining residual radioactivity, however, will present a smaller, but still important, risk to workers, the public and the environment during decommissioning. One argument for delayed dismantling in the past has been that a prolonged period of safe enclosure between the initial and final phases of decommissioning allowed radioactive decay which both reduced local dose rates to workers and allowed the re-categorization of some radioactive wastes.

In practice, however, technological progress over the past 10–15 years due to major breakthroughs in electronics, robotics and remote handling, has considerably reduced the need for manned access to more highly contaminated areas. This has reduced the importance of radiological factors in choosing a decommissioning strategy.

D.6. Availability of technology and other resources

Although decommissioning technologies will continue to improve (FIG. IV-6), decommissioning is a mature industry. Large R&D programmes prevailed through the 1990s (e.g. at the Japan Power Demonstration Reactor (JPDR), BR-3, Gundremmingen, and nuclear fuel cycle facilities run by the US Department of Energy) but came to an end around 2000.

Decommissioning technology is generally more available in countries with more experience and larger nuclear power programmes. Such countries have significant experience and expertise related to their nuclear programmes and are likely to have decommissioning 'markets' with many companies offering a variety of products or services. The situation might be different in countries with less experience and smaller programmes.

FIG. IV-6: Decommissioning technologies: a new waste monitor (left) and cold testing a remote manipulator (right).

Although the basic technology for decommissioning is well known and tested, special problems may be identified during the planning stages that may require special equipment, for example because of poor accessibility or high radiation levels. In such cases it may be necessary to develop special tools or methods for remote operation or handling. However, generally speaking, except in extremely difficult circumstances such as Windscale or Chernobyl, technology is not a limiting factor constraining dismantling.

D.7. Stakeholder considerations

Radioactive waste management institutions have become progressively more aware that technical expertise and technical confidence are insufficient, on their own, either to justify waste management solutions to a wider audience or to see them through to successful implementation. Because of generally heightened public sensitivity to environmental protection, any waste management or decommissioning decision will typically require thorough public examination and the involvement of many stakeholders. Stakeholders include, but are not limited to, waste management agencies, safety authorities, local communities, elected representatives, and technical intermediaries between the general public and decision makers. Decommissioning also includes aspects beyond waste management that are of interest to a wider range of stakeholders. The way in which local communities and the public in general are engaged in dialogue about decommissioning is likely to become an increasingly important issue.

From studies of stakeholder involvement in past decommissioning decisions, the one generality that can be drawn is that each decision is unique. The diversity of relevant social, political, economic, and cultural environments makes it difficult to develop guidance that is universally applicable. However, those planning new decommissioning projects may find in the experiences of others useful analogies that they can adapt to their own situations. On this basis, the IAEA facilitates the exchange of experiences among Member States, and the joint development and review of specific case studies [IV-7].

D.8. Decommissioning cost and funding

To fully assess the economics of the life cycle of a nuclear plant, it is necessary to clearly understand decommissioning and waste management costs and make the necessary provisions for them. Available cost estimates of completed decommissioning projects for commercial nuclear power reactors range from about $100 million to $700 million. Cost estimates for future activities are necessarily uncertain, given the diversity of influencing factors catalogued in this annex, but growing experience in the decommissioning of large, commercial nuclear facilities is contributing to the improvement of cost estimates. The comparison of decommissioning projects is still difficult due to different approaches in cost breakdowns and reporting requirements, but several international working groups, sponsored by the EU, the IAEA and the OECD/NEA, are currently developing standardized definitions and structures for decommissioning cost estimates. Commercial firms now also offer proprietary strategic advice and cost estimation services for decommissioning projects, based upon experience gained from commercial decommissioning projects.

Whatever choices and decisions are made, it is the responsibility of the owner of the plant to make financial provisions sufficient to cover the costs of all stages of decommissioning, up to and including total dismantling and removal of the waste, in accordance with pertinent national legislation and funding requirements. If a long period of safe enclosure is envisaged, the forecasting of funding requirements may be uncertain because of variations in the costs of regulatory, social and industrial influences. On the other hand, deferment of dismantling may improve the financial situation by allowing time to accrue additional funds.

Over the past few decades most Member States have established legal provisions to collect and build up decommissioning funds. Most decommissioning funds for nuclear power plants are accumulated based on electricity surcharges. However, there is still little experience on how these accumulated funds will work in the long term [IV-8].

D.9. Knowledge management

The final decommissioning of a nuclear facility should be considered from the earliest stage of its life cycle, and emphasis should be given to the acquisition and maintenance of all relevant records. One important lesson from decommissioning projects to date is that more attention needs to be given to managing and organizing records for decommissioning purposes, not just for operating and regulatory purposes. During detailed planning for the permanent shutdown of a facility, a dedicated effort is needed to develop a strategy for selecting and managing key records. Experience shows that insufficient attention to record keeping can be expensive (e.g. due to the need to reconstruct missing information) and may present safety problems (e.g. by making it necessary to work with unknowns).

When there are significant delays between permanent shutdown and the completion of dismantling, arrangements must be put into place to ensure that the necessary information is preserved. This refers not only to the physical preservation of information, but also to the skills needed to understand what it means and to assure timely actions [IV-9, IV-10].

E. Conclusions

Technologically, decommissioning is a mature industry. Many of the steps in the process are similar to maintenance, storage or transport procedures experienced during a plant's operating lifetime. There is more uncertainty in the areas of knowledge management, funding, the availability of disposal sites and the potential reuse of decommissioned sites and facilities. Decommissioning experience is continually growing. Although no two decommissioning projects are identical, there is much to be gained from sharing experiences and, in areas like knowledge management, specific techniques that have proven to be successful. Even in the area of stakeholder involvement, where local situations can be diverse, those planning new decommissioning projects may find in the experiences of others useful analogies that they can adapt to their own situations.

Table IV-1: Decommissioning status of shutdown power reactors (NO = no data available on selected strategy; UD = being dismantled or planned for near term dismantling; SE = in safe enclosure; FD = fully dismantled; ISD = in-situ disposal (entombed))

Country	Unit	Type	Const. Date	Shutdown Date	Strategy	MW(e)
AM	ARMENIA-1	PWR	1969-07-01	1989-02-25	NO	376
BE	BR-3	PWR	1957-11-01	1987-06-30	UD	10
BG	KOZLODUY-1	PWR	1970-04-01	2002-12-31	UD	408
BG	KOZLODUY-2	PWR	1970-04-01	2002-12-31	UD	408
BG	KOZLODUY-3	PWR	1973-10-01	2006-12-31	UD	408
BG	KOZLODUY-4	PWR	1973-10-01	2006-12-31	UD	408
CA	DOUGLAS POINT	PHWR	1960-02-01	1984-05-04	SE	206
CA	GENTILLY-1	HWLWR	1966-09-01	1977-06-01	SE	250
CA	ROLPHTON NPD	PHWR	1958-01-01	1987-08-01	SE	22
DE	AVR JUELICH (AVR)	HTGR	1961-08-01	1988-12-31	UD	13
DE	GREIFSWALD-1 (KGR 1)	PWR	1970-03-01	1990-02-14	UD	408
DE	GREIFSWALD-2 (KGR 2)	PWR	1970-03-01	1990-02-14	UD	408
DE	GREIFSWALD-3 (KGR 3)	PWR	1972-04-01	1990-02-28	UD	408
DE	GREIFSWALD-4 (KGR 4)	PWR	1972-04-01	1990-07-22	UD	408
DE	GREIFSWALD-5 (KGR 5)	PWR	1976-12-01	1989-11-24	UD	408
DE	GUNDREMMINGEN-A (KRB A)	BWR	1962-12-12	1977-01-13	UD	237
DE	HDR GROSSWELZHEIM	BWR	1965-01-01	1971-04-20	FD	25
DE	KNK II	FBR	1974-09-01	1991-08-23	UD	17
DE	LINGEN (KWL)	BWR	1964-10-01	1979-01-05	SE	183
DE	MUELHEIM-KAERLICH (KMK)	PWR	1975-01-15	1988-09-09	UD	1219
DE	MZFR	PHWR	1961-12-01	1984-05-03	UD	52
DE	NIEDERAICHBACH (KKN)	HWGCR	1966-06-01	1974-07-21	FD	100
DE	OBRIGHEIM (KWO)	PWR	1965-03-15	2005-05-11	UD	340
DE	RHEINSBERG (KKR)	PWR	1960-01-01	1990-06-01	UD	62
DE	STADE (KKS)	PWR	1967-12-01	2003-11-14	UD	640
DE	THTR-300	HTGR	1971-05-01	1988-04-20	SE	296
DE	VAK KAHL	BWR	1958-07-01	1985-11-25	FD	15
DE	WUERGASSEN (KWW)	BWR	1968-01-26	1994-08-26	UD	640
ES	JOSE CABRERA-1 (ZORITA)	PWR	1964-06-24	2006-04-30	UD	141
ES	VANDELLOS-1	GCR	1968-06-21	1990-07-31	SE	480
FR	BUGEY-1	GCR	1965-12-01	1994-05-27	UD	540
FR	CHINON-A1	GCR	1957-02-01	1973-04-16	UD	80
FR	CHINON-A2	GCR	1959-08-01	1985-06-14	UD	180
FR	CHINON-A3	GCR	1961-03-01	1990-06-15	UD	360
FR	CHOOZ-A (ARDENNES)	PWR	1962-01-01	1991-10-30	UD	305
FR	EL-4 (MONTS D'ARREE)	HWGCR	1962-07-01	1985-07-31	UD	70
FR	G-2 (MARCOULE)	GCR	1955-03-01	1980-02-02	SE	39

Country	Unit	Type	Const. Date	Shutdown Date	Strategy	MW(e)
FR	G-3 (MARCOULE)	GCR	1956-03-01	1984-06-20	SE	40
FR	ST. LAURENT-A1	GCR	1963-10-01	1990-04-18	UD	390
FR	ST. LAURENT-A2	GCR	1966-01-01	1992-05-27	UD	465
FR	SUPER-PHENIX	FBR	1976-12-13	1998-12-31	UD	1200
GB	BERKELEY 1	GCR	1957-01-01	1989-03-31	SE	138
GB	BERKELEY 2	GCR	1957-01-01	1988-10-26	SE	138
GB	BRADWELL 1	GCR	1957-01-01	2002-03-31	SE	246
GB	BRADWELL 2	GCR	1957-01-01	2002-03-30	SE	150
GB	CALDER HALL 1	GCR	1953-08-01	2003-03-31	SE	198
GB	CALDER HALL 2	GCR	1953-08-01	2003-03-31	SE	35
GB	CALDER HALL 3	GCR	1955-08-01	2003-03-31	SE	35
GB	CALDER HALL 4	GCR	1955-08-01	2003-03-31	SE	198
GB	CHAPELCROSS 1	GCR	1955-10-01	2004-06-29	SE	192
GB	CHAPELCROSS 2	GCR	1955-10-01	2004-06-29	SE	35
GB	CHAPELCROSS 3	GCR	1955-10-01	2004-06-29	SE	35
GB	CHAPELCROSS 4	GCR	1955-10-01	2004-06-29	SE	35
GB	DOUNREAY DFR	FBR	1955-03-01	1977-03-01	UD	11
GB	DOUNREAY PFR	FBR	1966-01-01	1994-03-31	UD	250
GB	DUNGENESS-A1	GCR	1960-07-01	2006-12-31	SE	225
GB	DUNGENESS-A2	GCR	1960-07-01	2006-12-31	SE	225
GB	HINKLEY POINT-A1	GCR	1957-11-01	2000-05-23	SE	470
GB	HINKLEY POINT-A2	GCR	1957-11-01	2000-05-23	SE	250
GB	HUNTERSTON-A1	GCR	1957-10-01	1990-03-30	SE	300
GB	HUNTERSTON-A2	GCR	1957-10-01	1989-12-31	SE	150
GB	SIZEWELL-A1	GCR	1961-04-01	2006-12-31	SE	210
GB	SIZEWELL-A2	GCR	1961-04-01	2006-12-31	SE	210
GB	TRAWSFYNYDD 1	GCR	1959-07-01	1991-02-06	SE	390
GB	TRAWSFYNYDD 2	GCR	1959-07-01	1991-02-04	SE	250
GB	WINDSCALE AGR	GCR	1958-11-01	1981-04-03	UD	24
GB	WINFRITH SGHWR	SGHWR	1963-05-01	1990-09-11	UD	92
IT	CAORSO	BWR	1970-01-01	1990-07-01	UD	860
IT	ENRICO FERMI (TRINO)	PWR	1961-07-01	1990-07-01	UD	260
IT	GARIGLIANO	BWR	1959-11-01	1982-03-01	UD	150
IT	LATINA	GCR	1958-11-01	1987-12-01	UD	153
JP	FUGEN ATR	HWLWR	1972-05-10	2003-03-29	UD	165
JP	HAMAOKA-1	BWR	1971-06-10	2009-01-30	UD	515
JP	HAMAOKA-2	BWR	1974-06-14	2009-01-30	UD	806
JP	JPDR	BWR	1960-12-01	1976-03-18	FD	12
JP	TOKAI-1	GCR	1961-03-01	1998-03-31	UD	137
KZ	BN-350	FBR	1964-10-01	1999-04-22	SE	52

Country	Unit	Type	Const. Date	Shutdown Date	Strategy	MW(e)
LT	IGNALINA-1	LWGR	1977-05-01	2004-12-31	UD	1185
LT	IGNALINA-2	LWGR	1978-01-01	2009-12-31	UD	1185
NL	DODEWAARD	BWR	1965-05-01	1997-03-26	SE	55
RU	APS-1 OBNINSK	LWGR	1951-01-01	2002-04-29	NO	5
RU	BELOYARSKY-1	LWGR	1958-06-01	1983-01-01	NO	102
RU	BELOYARSKY-2	LWGR	1962-01-01	1990-01-01	NO	146
RU	NOVOVORONEZH-1	PWR	1957-07-01	1988-02-16	NO	197
RU	NOVOVORONEZH-2	PWR	1964-06-01	1990-08-29	NO	336
SE	AGESTA	PHWR	1957-12-01	1974-06-02	SE	10
SE	BARSEBACK-1	BWR	1971-02-01	1999-11-30	SE	615
SE	BARSEBACK-2	BWR	1973-01-01	2005-05-31	SE	615
SK	BOHUNICE A1	HWGCR	1958-08-01	1977-02-22	UD	93
SK	BOHUNICE-1	PWR	1972-04-24	2006-12-31	UD	408
SK	BOHUNICE-2	PWR	1972-04-24	2008-12-31	UD	408
UA	CHERNOBYL-1	LWGR	1970-03-01	1996-11-30	SE	740
UA	CHERNOBYL-2	LWGR	1973-02-01	1991-10-11	SE	925
UA	CHERNOBYL-3	LWGR	1976-03-01	2000-12-15	SE	925
UA	CHERNOBYL-4	LWGR	1979-04-01	1986-04-26	SE	925
US	BIG ROCK POINT	BWR	1960-05-01	1997-08-29	FD	67
US	BONUS	BWR	1960-01-01	1968-06-01	ISD	17
US	CVTR	PHWR	1960-01-01	1967-01-01	UD	17
US	DRESDEN-1	BWR	1956-05-01	1978-10-31	SE	197
US	ELK RIVER	BWR	1959-01-01	1968-02-01	FD	22
US	ENRICO FERMI-1	FBR	1956-08-01	1972-11-29	UD	60
US	FORT ST. VRAIN	HTGR	1968-09-01	1989-08-29	FD	330
US	GE VALLECITOS	BWR	1956-01-01	1963-12-09	SE	24
US	HADDAM NECK	PWR	1964-05-01	1996-12-05	FD	560
US	HALLAM	X	1959-01-01	1964-09-01	ISD	75
US	HUMBOLDT BAY	BWR	1960-11-01	1976-07-02	UD	63
US	INDIAN POINT-1	PWR	1956-05-01	1974-10-31	SE	257
US	LACROSSE	BWR	1963-03-01	1987-04-30	SE	48
US	MAINE YANKEE	PWR	1968-10-01	1997-08-01	FD	860
US	MILLSTONE-1	BWR	1966-05-01	1998-07-01	SE	641
US	PATHFINDER	BWR	1959-01-01	1967-10-01	UD	59
US	PEACH BOTTOM-1	HTGR	1962-02-01	1974-11-01	SE	40
US	PIQUA	X	1960-01-01	1966-01-01	ISD	11
US	RANCHO SECO-1	PWR	1969-04-01	1989-06-07	FD	873
US	SAN ONOFRE-1	PWR	1964-05-01	1992-11-30	UD	436
US	SAXTON	PWR	1960-01-01	1972-05-01	FD	3
US	SHIPPINGPORT	PWR	1954-01-01	1982-10-01	FD	60

Country	Unit	Type	Const. Date	Shutdown Date	Strategy	MW(e)
US	SHOREHAM	BWR	1972-11-01	1989-05-01	FD	809
US	THREE MILE ISLAND-2	PWR	1969-11-01	1979-03-28	SE	880
US	TROJAN	PWR	1970-02-01	1992-11-09	FD	1095
US	YANKEE NPS	PWR	1957-11-01	1991-10-01	FD	167
US	ZION-1	PWR	1968-12-01	1998-01-01	SE	1040
US	ZION-2	PWR	1968-12-01	1998-01-01	SE	1040

Table IV-2: Countries that currently have the capability to dispose of decommissioning waste and (in brackets) countries are at various stages of planning, construction and start-up

EUROPE
(Belgium); Bulgaria; Czech R.; Finland; France; (Germany); Hungary; Latvia: Lithuania; Norway; Poland; Romania; Russian F.; Slovakia; (Slovenia); Spain; Sweden; (Switzerland); Ukraine; United Kingdom
AFRICA
(Egypt); South Africa
AMERICAS
(Argentina); (Brazil); (Canada); (Chile); Mexico; (Peru); United States of America
ASIA and the PACIFIC
(Australia); China; India; (Iran); (Iran); Japan; (Jordan); (Korea); (Malaysia); (Pakistan); (Philippines)

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