Used Fuel is Not an Obstacle to Nuclear Power

Sustainable Used Fuel Management Working Group
World Nuclear Association

The management of used nuclear fuel[1], including any ultimate waste arising from it, is a mature industrial activity that has been carried out safely and responsibly since the inception of the civil nuclear industry in the 1950s. Plans for the deployment of any power generation technology, including new nuclear or the extension of an existing nuclear energy programme, should consider its full life-cycle and supply chain. This should cover the long-term management of used fuel and associated waste. While there is ongoing research and development in this area to continuously improve technologies and processes, current and prospective nuclear power generators are able to effectively manage used nuclear fuel using existing practices.

Current situation

Historically, two basic management paths have been implemented by governments and industries to manage used nuclear fuel. These are:

- Interim storage of the used nuclear fuel, either at the reactor site or at an offsite storage facility, pending future disposal in a deep geological repository (DGR) disposal facility or reprocessing.
- Reprocessing of the used nuclear fuel to recycle useful nuclear materials into fresh fuel, while conditioning in a durable glass matrix the remaining non-useful high-level waste for future emplacement in a DGR.

An additional practice, currently limited to research reactors, is the return of the used fuel to the country of origin for recycling or conditioning for disposal; this has largely been applied to research reactors deployed by the USA and Russia.

High-level waste must be conditioned so that it is in a suitable form for its subsequent management, transport, storage, and final disposal in a deep geological facility. Used nuclear fuel declared as high-level waste is placed into specially designed canisters; waste separated from reprocessing is vitrified and sealed in stainless steel containers. Although final disposal of used nuclear fuel and/or high-level waste from reprocessing is not yet in operation, licensing and construction activities are under way in several countries, including Finland, France, Sweden .

Various national regulators and global nuclear service companies have proven competence in all these solutions.

Interim storage

There are several storage technologies available for used nuclear fuel, whether using spent fuel pools or dry storage technologies. Many competing technologies are available at reactor sites or at offsite storage facilities, the selection of which depends on the specific context and policies of the individual operator and country.

Reprocessing and recycling

Reprocessing and recycling have been widely deployed to extract the uranium and plutonium contained in used nuclear fuel to provide fresh fuel for existing and future nuclear power plants. Other valuable materials can also be extracted for non-power uses, for example for nuclear medicine.

Many countries, including Belgium, France, Germany, India, Russia, UK and USA, have operated reprocessing facilities for commercial used nuclear fuel. France's La Hague site fulfils its domestic reprocessing needs and offers reprocessing /recycling services to other countries. Russia's RT-1 has been reprocessing commercial used fuel for several decades. The UK carried out reprocessing of domestic and foreign used nuclear fuel mainly at Sellafield

[1] Used nuclear fuel, also referred to as spent nuclear fuel (SNF), is nuclear fuel removed from a reactor following irradiation that is no longer usable in its present form because of depletion of fissile material, poison buildup or radiation damage, it is either considered as an asset – as it contains valuable materials – or as a waste

World Nuclear Association
Tower House 10 Southampton Street
London WC2E 7HA United Kingdom

Tel: +44 (0)20 7451 1520
Fax: +44 (0)20 7839 1501

info@world-nuclear.org
www.world-nuclear.org

Incorporated in England No1215741
VAT Reg No GB 340 2373 93

but ceased operation of all reprocessing activities in 2022. In Japan, a reprocessing plant has been built at Rokkasho but has not yet started commercial operations. China and India also operate reprocessing plants for domestic needs though not yet on a commercial basis.

Final disposal

The science and technology of engineered underground repositories, often referred to as deep geological repositories (DGRs), is well-understood and some countries are progressing towards their operation. Many geologies are suitable for final geological disposal of used fuel or vitrified high-level waste. Some countries (including Finland, France and Sweden) have gained societal acceptance for DGR sites, whereas other countries are finding the siting process to be challenging. In the USA, the Waste Isolation Pilot Plant (WIPP) deep geological disposal facility for defence-related transuranic waste has been in operation since 1999.

Although the cost of reprocessing and recycling could be considered relatively high in comparison to the historic costs for mined uranium, this might change depending on the level of demand for nuclear fuel in the future. This together with the social, environmental and security of supply advantages of reprocessing/recycling mean that it could become the most attractive option for used nuclear fuel management, particularly for advanced reactors and/or fuel cycle systems.

Some countries, including Canada, Finland, Spain, Sweden, Switzerland and the USA, have decided to directly dispose of their used nuclear fuel in a DGR. In some cases, this is a political decision but in others it has been judged to be economic considering the prevailing market conditions.

Potential future options

The options of either recycling or direct disposal are expected to remain as the fundamental pathways for the management of used nuclear fuel in the future. Moreover, avenues that are being researched and developed to complement these options include:

- Advanced recycling fuel cycle options such as multi-recycling of valuable materials, uranium and plutonium in conventional light water reactors and/or transitioning to closed fuel cycles with fast neutron reactors that fully utilize natural uranium resources are close to full scale demonstration. Both options, which can be implemented sequentially, minimize waste quantities and toxicity thus alleviating some requirements for the design and operation of the deep geological repository.
- Additional advanced options such as the transmutation of minor actinides are at the early stages of research and development and require significant efforts to reach commercialization. These solutions have the potential to significantly further reduce both nuclear waste generation and the decay time of the remaining waste.
- Deep borehole disposal technologies have been studied for a long time in various countries. However, R&D programmes are still necessary to advance the development of the deep borehole repository concept and to reach maturity both in terms of component technologies and in supporting safety cases.
- Further develop the use of multinational/regional infrastructures, including but not limited to repositories, particularly for countries with small nuclear programmes. For multinational deep geological repositories, these will require significant development as well as long-term intergovernmental agreements.
- The used fuel return schemes currently deployed for research reactors may be adapted for larger quantities of used fuel arising from commercial activities, with shared reprocessing/recycling and/or disposal infrastructures. This would require the development of innovative commercial terms between national governments, the nuclear fuel cycle industry, reactor vendors and utilities.
- A longer-term, more ambitious prospective pathway could be for nuclear power users to not own the fuel at all. Fuel could be leased from a vendor or just the energy contained in the fuel could be purchased, with the used fuel being returned to the supplier. However, besides the need to deploy innovative commercial arrangements, this would require long-term intergovernmental agreements to address fuel security of supply aspects. There are legal, regulatory and ethical implications associated with allowing waste generated in one country to be disposed of in another.

The development of small and advanced modular reactors providing electricity as well as energy for process heat, desalination, remote industries such as mining, and potential other non-electricity generation purposes, will be secured with similar used nuclear fuel management options as those listed above. Nevertheless, various novel reactor technologies have different challenges for the management of used nuclear fuel, with different life-time costs which should be factored in when considering new technologies.

Conclusion

Used nuclear fuel management considerations should be included as part of the assessment process for establishing new nuclear power programmes or expanding existing ones. The generation of used nuclear fuel, by-products of the operation of nuclear reactors, should not be a barrier to the deployment of new nuclear projects, as solutions for its sustainable management currently exist and innovative options for the future are being developed.