Opportunities to Reuse and Recycle Redundant Radioisotopes – 16023

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ABSTRACT

Sixty plus years of nuclear research and operation in the UK has produced significant quantities of nuclear material. To those involved in decommissioning a site or facility, this material represents a liability that needs to be managed and eventually disposed of. However to those in the wider nuclear industry and supply chain, the radioisotopes represent a potential resource of valuable, and in some cases irreplaceable material for future work. There is therefore an opportunity to create a win-win by identifying material that could be recycled or reused, removing it from being a liability and creating value from what is considered a waste.

The UK is currently focused on the clean up of nuclear sites and the safe disposal of legacy nuclear material. Whilst the bulk of legacy material on these sites is mixed wastes in various solid and liquid forms, some of it consists of material produced for research purposes in the form of radioisotopes or exotic fuels. This has resulted in a plethora of unirradiated and irradiated materials in store across the UK including:

- Depleted and natural Uranium
- Enriched Uranium
- Mixed U/Pu oxides
- Uranium carbide and mixed U/Pu carbides
- Thorium as metal and oxides
- Research radioisotopes

The material exists in almost every conceivable state from pure metal and oxides to solutions. Some material is well characterised and free from extraneous debris, other material is poorly characterised and contaminated with chemicals, experimental residues and sweepings. In addition, to reduce the risk and potential hazard across the UK there has also been a period of consolidation of obsolete radioactive sources from a wide variety of industrial or medical facilities to secure storage within a licenced site.

The waste hierarchy is an established principle for the management of wastes, radioactive or otherwise. Its principles are set out and it gives top priority to prevention in the first place. Where waste is produced, it gives priority to preparation for re-use, then recycling before consideration for disposal as a last resort. The term wastes may only be applicable to the owner of the material where they may view the material as unwanted, unusable, or a by-product. It does not necessarily follow that the material is a waste to all potential owners. Therefore it is important to consider the potential value of material before it is considered for disposal since there is a significant and growing market for radioisotopes across the world.

This paper will outline some of the opportunities in the UK for the recycle of surplus radioisotopes and orphan material.

INTRODUCTION

The UK is currently focused on the clean up of nuclear sites and the safe disposal of legacy nuclear material. Whilst the bulk of legacy material on these sites is mixed wastes in various solid and liquid forms, some of it consists of material produced for research purposes in the form of radioisotopes or exotic fuels. To reduce the risk and potential hazard across the UK there has also been a period of consolidation of obsolete radioactive sources from a wide variety of industrial or medical facilities to secure storage within a licenced site.

To those involved in decommissioning a site or facility, this material represents a liability that needs to be managed and eventually disposed of. However to those in the wider nuclear industry and supply chain, the radioisotopes represent a potential resource of valuable, and in some cases irreplaceable material for future work. There is therefore an opportunity to create a win-win by identifying material that could be recycled or reused, removing it from being a liability and creating value from what is considered a waste.

SOURCES OF RADIOISOTOPES

Sixty plus years of nuclear research and operation in the UK has produced significant quantities of nuclear material. Figure 1 shows the nuclear regulated sites across the UK. These have been or are the major radioactive waste producers and are therefore potential locations for usable radioisotopes. Many ‘small users’ of radioactive materials such as hospitals and industrial, educational and research establishments also use radioisotopes; their sites are not shown on the figure.

The UK nuclear industry has produced a significant quantity of materials and samples resulting from R&D, operations and plant commissioning programmes. There is a plethora of unirradiated and irradiated materials in store across the UK including:

- Depleted and natural Uranium
- Enriched Uranium
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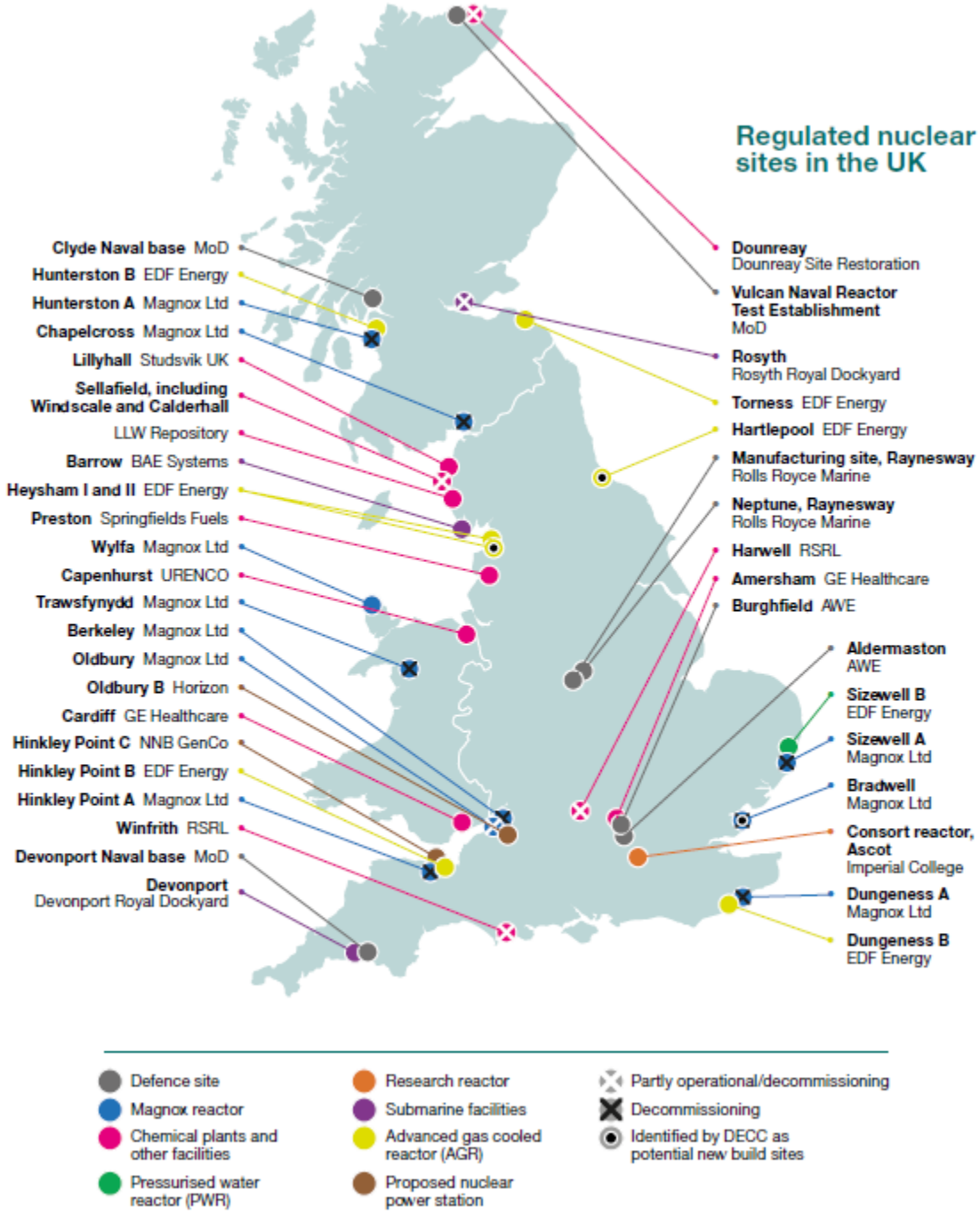

Figure 1: Map of Nuclear Regulated Sites in the UK (courtesy of ONR ref 1)

The material exists in almost every conceivable state from pure metal and oxides to solutions. Some material is well characterised and free from extraneous debris, other material is poorly characterised and contaminated with chemicals, experimental

residues and sweepings. Some of the material is decades old and has therefore experienced radioactive decay. This can be valuable in its own right, producing material that could not, or would be very difficult to produce by other routes. For example, stored plutonium-238 will produce some uranium-234 over time, a very valuable material as a tracer.

In the UK the majority of material is owned by the Nuclear Decommissioning Authority (NDA). The NDA has responsibility for overseeing continuing operations and the decommissioning and clean up at its 16 sites. It has established Site Licence Companies (SLCs), which carry the licences to operate these sites:

- Sellafield Ltd operates Sellafield in Cumbria. Sellafield is home to the world's first commercial nuclear power station – Calder Hall, which generated electricity from 1956 to 2003. Today the site is home to a wide range of operations including the decommissioning of redundant buildings associated with early defence work; spent fuel management including Magnox and Oxide fuel reprocessing; and the safe management and storage of nuclear waste.
- Magnox Ltd operates ten Magnox power station sites. Wylfa in Anglesey is the only operational power station. The following power stations are no longer operational and are being decommissioned: Berkeley in Gloucestershire; Bradwell in Essex; Dungeness A in Kent; Hinkley Point A in Somerset; Oldbury in South Gloucestershire; Sizewell A in Suffolk; Chapelcross in Dumfries and Galloway; Hunterston A in Ayrshire and Trawsfynydd in Gwynedd.
- LLW Repository Ltd operates the Low Level Waste Repository (LLWR) in Cumbria. The site has operated as a national disposal and storage facility for Low Level Waste since 1959.
- Dounreay Site Restoration Ltd (DSRL) operates Dounreay in Caithness. The site was the UK centre for fast reactor R&D comprising three reactors, fuel reprocessing and various other fuel cycle facilities. The reactors and other facilities are no longer operational and are being decommissioned.
- Research Sites Restoration Ltd (RSRL) operates Harwell in Oxfordshire and Winfrith in Dorset. These sites carried out nuclear R&D work. All facilities, including a number of research, experimental and prototype reactors, have closed down and have either already been decommissioned or are currently being decommissioned.
- Springfield Fuels Ltd operates Springfields near Preston in Lancashire. Nuclear fuel products are manufactured for the UK's nuclear power stations and for international customers. Natural Uranium hexafluoride is supplied to Urenco and other organisations for enrichment.

There is also material owned by private industry for use in, for example healthcare and life science research or industrial sources. In some cases this material has been moved during a period of consolidation to locations within sites owned by the NDA ready for eventual disposal.

For some of the research radioisotopes, the facilities e.g. reactors and accelerators

which produced materials in the past may no longer be in operation. This makes some of the radioisotopes potentially very valuable, for example uranium-233. However it's clear that the focus within the UK on site clean-up and liability reduction will drive towards disposal of material unless alternative solutions are proposed and accepted.

USES FOR RADIOISOTOPES

There is a significant and growing market for radioisotopes across the world with the market being split into three core areas; medical, industrial and research.

Medical radioisotopes tend to be a specialist field where specific short lived radioisotopes are produced in dedicated facilities. They can be sealed sources or material that can be administered to the patient. However the use of radioisotopes in medical procedures is growing and the market is struggling to meet the demand. In addition, new procedures may well require new radioisotopes to become available.

Industrial radioisotopes are typically sealed sources. They are used in a wide range of industries, from calibration sources for instruments, food irradiation, sources for non-destructive examination and measurements, or even heating and power in a spacecraft. Whilst a lot of these sources tend to use relatively freely available material such as strontium-90 or ceasum-137, there is a great diversity of needs resulting in demand for a wide range of different isotopes, some which are very difficult to obtain.

The most complex but smallest section of the market is the research market. Nuclear and non-nuclear research institutions require radioisotopes for a wide range of research purposes. Some radioisotopes are used to enable tracing of the chemical in the experiment, others are used to enhance a specific feature of the experiment. Within the UK, research on a wide range of advanced fuels and reactors concepts has been proposed as possible future fuel cycles. These include fuels in a range of chemical forms (metal, oxide, carbide, nitride and even molten salt) containing a range of fissile materials (uranium, plutonium and thorium as well as combinations of these materials with or without the addition of minor actinides). It is important to maintain an understanding of how this range of fuels can be manufactured and whether fuel manufacture could be a constraint in selecting future fuel cycles.

RECYCLE AND REUSE

The waste hierarchy is an established principle for the management of wastes, radioactive or otherwise. Its principles are set out in figure 2, and it gives top priority to prevention in the first place. Where waste is produced, it gives priority to preparation for re-use, then recycling before consideration for disposal as a last resort (ref 2).

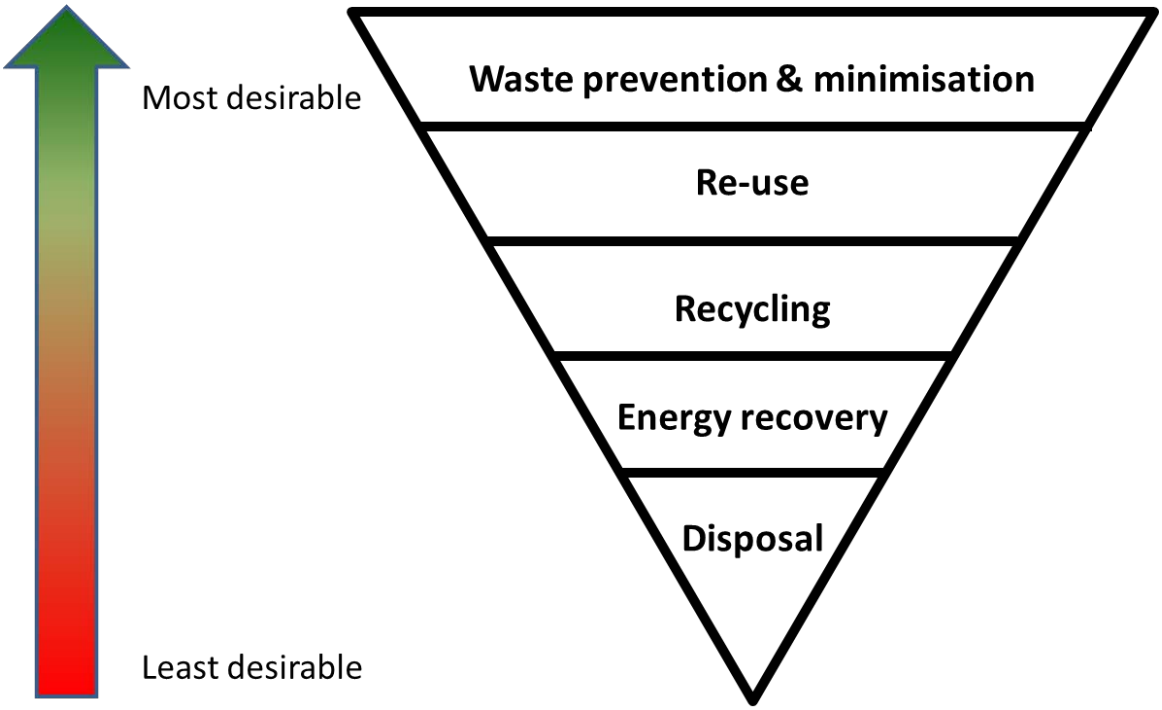

Figure 2, illustration of the waste hierarchy

The term wastes may only be applicable to the owner of the material where they may view the material as unwanted, unusable, or a by-product. It does not necessarily follow that the material is a waste to all potential owners. Therefore it is important to consider the potential value of material before it is considered for disposal.

Due to the structure of the nuclear industry in the UK, the owners of the radioisotopes may not be aware of the need from potential users for specific radioisotopes. Equally, potential users or suppliers may not be aware of legacy material that could be being stored destined for eventual disposal. The National Nuclear Laboratory (NNL), as an operator of facilities that provide radioisotope storage and disposal service in addition to knowledge of historic material, are able to advise owners of material which they consider to be wastes on alternative options for the material. NNL are also able to advise potential users of radioisotopes where supplies could exist. For example, recently NNL was able to advised the European Space Agency on the availability of americium-241 for use in spacecraft Radioisotope Power Systems (RPS) using a by-product waste from long term stored civil plutonium (ref 3).

Figure 3, Hot cell operation at the National Nuclear Laboratory

CONCLUSION

Sixty plus years of nuclear research and operation in the UK has produced significant quantities of nuclear material which, to the operators of the sites, represents a legacy material needing disposal. With the significant and growing market for radioisotopes across the world, there is therefore an opportunity to create a win-win by identifying material that could be recycled or reused, removing it from being a liability and creating value from what is considered a waste.

REFERENCES

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