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CARBOWASTE

Treatment and Disposal of Irradiated Graphite and Other Carbonaceous Waste

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- Agreement of Lower Level Objectives - and Performance Criteria -

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Document title
Agreement of Lower Level Objectives and Performance Criteria
Executive summary

The report identifies lower level objectives and performance criteria for the assessment of strategy options for the management of irradiated graphite (i-graphite).

15 Lower Level Objectives (Generic Sub-Criteria) are defined:

1. Radiological Impact - Man
2. Radiological Impact - Environment
3. Resource Usage
4. Non-Radiological Discharges
5. Local Intrusion
6. Hazard Potential
7. Worker Safety (Radiological)
8. Worker Safety (Non-Radiological)
9. Security - Misappropriation
10. Cost
11. Spin-off
12. Concept Predictability
13. Operational Predictability
14. Stability of Employment – Employment Factor
15. Burden on Future Generations – Burden Factor

Each of these is underpinned by a Performance Criterion (Measure).

Technology Sub-Criteria are also introduced; these extend the generic criteria and are to be used for technology, rather than strategy selection.

Revisions						
Rev.	Date	Short description	Author	Internal Review	Task Leader	WP Leader
00	dd/mm/yyyy	Issue	Name, Organisation	Name, Organisation *Signature*	Name, Organisation *Signature*	Name, Organisation *Signature*
01	26/03/2010	1st issue	Ross, D N NNL Jarvis, R B NNL	Whitton, J NNL J. Whitton	Banford, A NNL AWB	Banford, A NNL AWB.

Glossary

EQS	Environmental Quality Standard
ERICA	Environmental Risk from Ionising Contaminants
GWh	Giga-Watt Hours
ICRP	International Commission on Radiological Protection
i-graphite	Irradiated Graphite
MCDA	Multi-Criteria Decision Analysis
mSv	Millisievert
TBq	Terabecquerel
te	Tonne
TRL	Technology Readiness Level

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Appendix 1

1 Introduction

1.1 Background

Development of the Multiple Criteria Decision Analysis (MCDA) process for CARBOWASTE strategy selection is delivered through a series of tasks of which this present study is one, as shown in Figure 1 below.

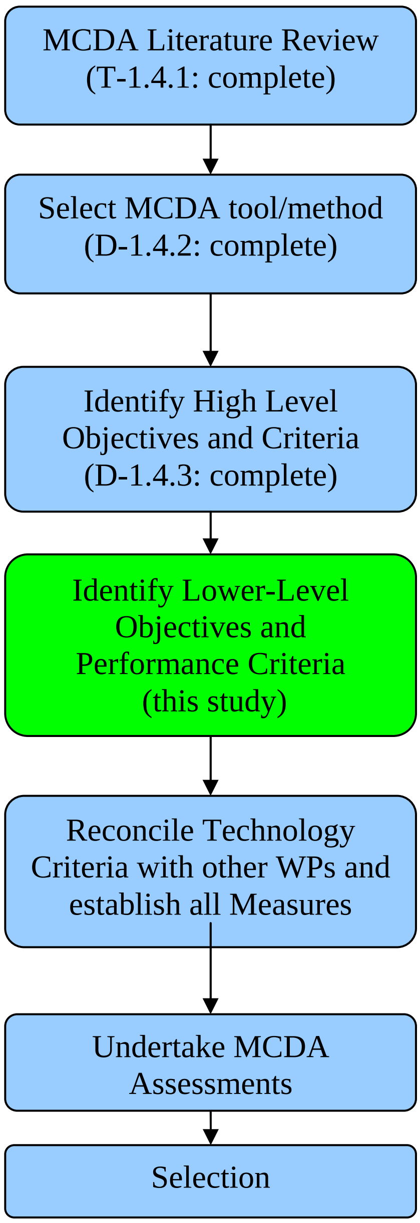

Figure 1: Tasks underpinning development and implementation of the CARBOWASTE MCDA Process

1.2 Terminology

For consistency with previously reported work under CARBOWASTE[1], lower-level objectives are referred to in this report as 'sub-criteria'; performance criteria are referred to as 'performance measures'.

1.3 Purpose

This report identifies generic sub-criteria and performance measures to facilitate the evaluation of strategy options for treating irradiated graphite (i-graphite). Technology Sub-Criteria are also introduced; these sub-criteria extend the strategy sub-criteria for technology selection and allow comparison of the operational performance characteristics of technology options in more depth. Other work packages will supplement these with sub-criteria relevant to the specific work package.

Each sub-criterion is expressed on a numerical scale. Each of these numeric values is called a performance measure. Data requirements to calculate each Generic Performance Measure are also provided in this report. Technology Sub-Criteria Performance Measures will be developed in the next phase of work.

The integration of sub-criteria and performance measures described in this report with previously reported higher level objectives and criteria will be reported separately. The hierarchy of CARBOWASTE Objectives, Criteria and measures is shown in Figure 2 below.

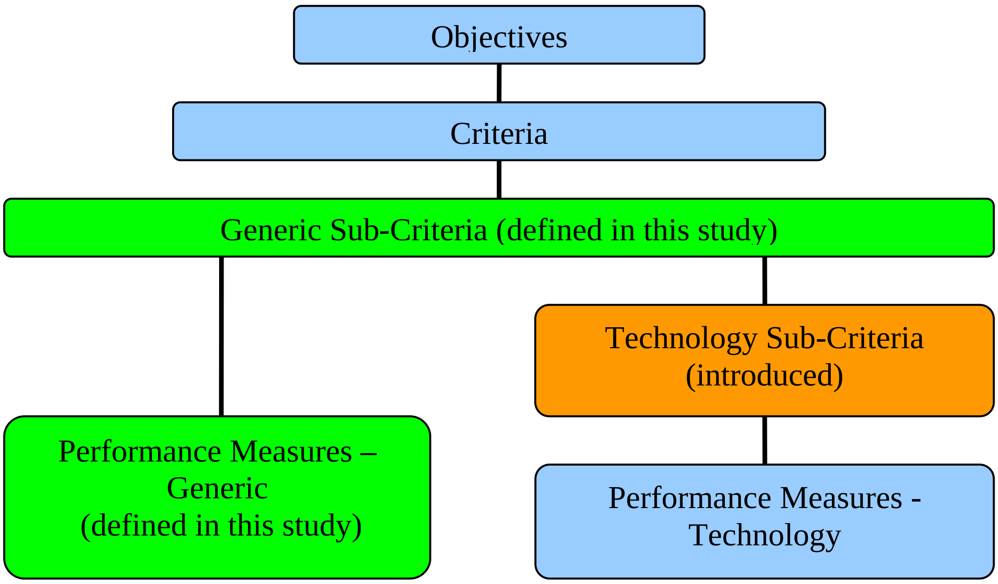

Figure 2: Hierarchy of CARBOWASTE Objectives, Criteria and Measures

2 Sub-Criteria

2.1 Introduction

The sub-criteria described below have been developed to deliver the fundamental aim of the CARBOWASTE project of providing a sustainable solution to the challenge of i-graphite waste management. The concept of sustainability for CARBOWASTE has previously[1] been defined. A comprehensive set of sub-criteria which cover all aspects of safety and environmental, economic and social considerations is essential in achieving this aim.

These sub-criteria are described under two headings – 'Generic' and 'Technology'. Generic Sub-Criteria are to be used when evaluating high level 'strategy' options for retrieval, treatment and disposal of i-graphite, whereas Technology Sub-Criteria are designed for use in more detailed technical evaluation of specific technologies within each of the retrieval, treatment or disposal phases. Technology Sub-Criteria may be used on their own to evaluate technologies predominantly on a technical basis, or they may be used to support Generic Sub-Criteria in providing a more detailed evaluation of technical aspects.

2.2 Sub-Criteria: Generic

The 15 CARBOWASTE Generic Sub-Criteria are discussed in the following sub-sections. Measures underpinning these sub-criteria are detailed in Section 3.

2.2.1 Radiological Impact – Man

This sub-criterion considers the impact of regulated discharges on man. The potential effect of accidents is considered in the separate category "Hazard Potential". The world collective dose arising from discharges from all facilities associated with an option (storage, retrieval, treatment and disposal) is calculated over a long period (in the UK 1 million years is considered an appropriate time horizon, though CARBOWASTE participants can select time horizons appropriate to their waste streams).

The ICRP[2] notes that, although not intended as a tool for epidemiological studies and risk projections, collective dose is nonetheless an instrument for optimisation and for comparing radiological technologies/protection measures.

Since the world collective dose is known to be dominated by a large number of very low risks, it is felt that European collective dose is the most appropriate measure and is recommended as the performance measure for this sub-criterion.

2.2.2 Radiological Impact – Environment

There is no guarantee that a measure of collective dose to man will adequately reflect harm to other parts of the environment. Recently the Environmental Risk from Ionising Contaminants: Assessment and Management (ERICA) programme[3] has established a three-tier approach to assessing the impact of radiation on the environment. The first screening tier defined by ERICA provides a measure of the impact of radiation on the environment.

This measure compares the concentration of radioisotopes in the environment to a value which results in a broadly acceptable dose to the most vulnerable organism. When the resulting quantity is summed over all radioisotopes a measure of the impact of the radiation on the environment is obtained.

A tier 1 ERICA assessment therefore produces a measure comparable to collective dose, but applied to the most exposed organisms in the environment rather than to man. The tier 1 ERICA assessment is therefore recommended as the performance measure for this category.

The first step of the assessment is the dispersion modelling of discharged activity into the environment, so that concentrations of contaminants can be obtained. In the absence of dispersion modelling, it will be necessary to take the pessimistic view that end-of-pipe concentrations will be used in the assessment.

It is possible that the impact on man is proportional to the impact on the environment i.e. that the sub-criterion ‘radiological impact – man’ acts as a proxy for this criterion. This can only be established after testing and, if it is found to be the case, member states could choose to assess only one of the two sub-criteria.

2.2.3 Resource Usage

Some options may use more resources than others. Resources may include water, power, steel and concrete. ‘Resources’ can be combined into a single measure by considering the energy used to produce them. For example, the energy used for mining ore, extracting iron and producing steel would all be considered in the impact of using steel. Similarly, the energy used during the extraction and processing of minerals used in the manufacture of concrete can be considered.

This approach assumes that the detriment arising from the use of energy (e.g. global warming as a result of CO_2 discharges) will dominate other detriments such as the depletion of natural resources. This would cease to be true if world stocks of a resource were significantly depleted by the completion of a particular option; this is not expected to be the case for common materials likely to be used for the retrieval, packaging and disposal of i-graphite.

The performance measure for resource usage is therefore the energy used in the lifecycle of each of the resources used for retrieval, treatment and disposal of i-graphite.

2.2.4 Non-Radiological Discharges

In addition to the impact of radiological discharges, the impact of non-radiological discharges will be considered. Similarly to radiological discharges, the impact will be assessed over all stages of the project for a significant period of time. Different discharges can be combined by the use of Environmental Quality Standards to provide reference discharge levels.

2.2.5 Local Intrusion

The other sub-criteria consider national and international impacts of each strategy option. This sub-criterion assesses the local impact of noise, traffic during construction and operations, artificial light, ground vibration and land use on man and the environment. Because this measure is largely qualitative, some form of normalisation is required. This can most readily be done by providing guidance on Local Intrusion ‘scores’ for a range of construction projects of differing sizes.

2.2.6 Hazard Potential

Previous sub-criteria have considered the impact of regulated discharges on man and the environment. However, these sub-criteria have not considered the potential impact of accidents. In principle, such incidents could be incorporated into the sub-criteria above by considering the probability and consequence of each accident. In practice this results in high consequence and low probabilities being combined. The result is very sensitive to the probability which is difficult to establish without considerable work and is consequently rather difficult to explain to stakeholders and time-consuming to generate for a wide range of strategies. For this reason, the hazard potential[4] is considered as the performance measure. The emphasis of the sub-criterion is to encourage the selection of passively safe techniques with minimum hazardous inventory, in accordance with radioactive waste management best practice[5].

2.2.7 Radiological Worker Safety

Sub-criteria above consider public safety; however the workforce will be exposed to risks over and above those borne by the public since they are working on a nuclear licensed site which is undergoing decommissioning. It is assumed that good working practices will protect individuals from receiving an unacceptable dose; however, cumulative dose to the entire workforce is an appropriate measure of radiological safety for workers.

2.2.8 Non-Radiological Worker Safety

The fatality rate for the relevant industry sector(s) provides a suitable indication of the level of risk from non-radiological hazards (e.g. falls, asphyxiation). The rate is derived from the number of employees for each option together with an assessment of the risk to which they are exposed. Risk will be assessed in categories such as “mining”, “construction” and “industrial activity” with established risk profiles.

2.2.9 Security - Misappropriation

The Hazard Potential sub-criterion discussed above encourages passive storage of material to achieve hazard reduction, in accordance with established[5] radioactive waste management standards and guidance. This assists in the mitigation of both accidents and security issues arising from malicious damage. However the protection afforded against deliberate, malicious misappropriation of materials has not been considered. Protection against misappropriation requires storage of materials at secure sites, in secure buildings and in difficult to move packages. Materials must also be protected during transport. The assessment is conducted at the point where waste is most vulnerable, since misappropriation is a deliberate action that can be targeted.

2.2.10 Cost

Cost of project delivery must consider all aspects of the project including research and development, design, capital expenditure and operating costs with appropriate discounting over the duration of the assessment.

2.2.11 Spin-Off

Investment will lead to spin-off opportunities not directly related to the delivery of the project. For example, metal fabrication skills used in manufacture of waste packages might allow fabrication for other customers, with associated economic benefit.

2.2.12 Concept Predictability

This criterion considers the uncertainty, or 'readiness', associated with the technology chosen for a particular option. Mature technology is associated with a lower risk than completely new concepts.

2.2.13 Operational Predictability

This criterion considers the uncertainty associated with the operational phase of a particular option. Uncertainty may be the result of feed variability, unreliability or equipment complexity or lack of experience with the technology. More detailed Technology Sub-Criteria are presented in the next section, to facilitate the comparison of competing technologies; these will not be used for strategy selection.

2.2.14 Stability of Employment

Delivery of some options will temporarily result in greater levels of employment than others. This sub-criterion considers wider economic concerns such as targeting areas of high unemployment, acquiring transferable skills and stability (rather than absolute levels) of employment.

2.2.15 Burden on Future Generations

A problem with the criteria above is that continual delay appears to be a good option: activity decays, costs are depreciated and arisings of activity are deferred and potentially reduced. However, staff experienced in the operation of the plant retire and knowledge about the nature of the wastes is lost, buildings decay and there are moral concerns in leaving work for future generations when the benefits of the reactor operation have been experienced by the current generation. These aspects are grouped together here under this sub-criterion.

2.3 Technology Sub-Criteria

The key eight technology considerations are outlined below, these supplement the strategy sub-criteria when assessing technology selection. Measures to evaluate these more detailed considerations will be the subject of the next phase of work.

2.3.1 Versatility

The ability to accommodate a range of process feeds e.g. from different reactors, is an important attribute for a processing option because it reflects the benefits of as much as possible of the total feedstock being processed by a single processing route.

2.3.2 Flexibility

Variations in process parameters/conditions such as temperature, pressure, humidity, dust etc. are common in radioactive decommissioning environments. These and other process parameters can have a detrimental effect on product quality. This in turn can have an adverse effect on the next processing stage. Flexible technology solutions are able to adapt to such variations with minimal effect on product quality.

2.3.3 Simplicity

Processing technologies that require minimal operator intervention, or are automated, are preferred over those which require a high degree of operator control. From an engineering perspective, simplicity of operation contributes to achieving the desired processing efficiency.

2.3.4 Robustness

Mal-operations and system faults can occur even with the most straightforward manual operations or mature technologies. Processing technology needs to be inherently reliable and robust to deviations from normal conditions in the sense that there should be minimal resulting effect on environment, safety and product quality.

2.3.5 Efficiency

The most efficient processes require minimal rework and wastage to achieve product quality. The generation of secondary wastes such as filters and packaging should also be avoided or minimised.

2.3.6 Predictability

It is important to be able to predict, with certainty, the outcome of a decommissioning process because the opportunity to re-configure in-situ is often extremely limited. Being able to model, and optimise, the process accurately before installation has significant advantages.

2.3.7 Compactness

There are benefits from process equipment having a small footprint, given the limited availability of suitable space within, and adjacent to, reactor cores. Being able to deploy a modular approach to decommissioning nuclear reactor cores can also provide significant benefits. Once the decommissioning task on one site is complete, equipment can be transported to another site for use.

2.3.8 Product Quality

Processing technology should achieve the stated output quality e.g. treatment methods achieving a defined decontamination factor, package conditioning for disposal meeting the conditions for acceptance or recycled material meeting a product (or product feed) specification.

3 Performance Measures

3.1 Introduction

Performance Measures are the means by which sub-criteria are quantified. It is not always possible to allocate a quantitative value due to the subjective nature of the criteria, in which case a qualitative measure is used.

3.2 Measures and Data Requirements

The hierarchy of Sub-Criteria, Measures, Measurement Units, Data Requirements and Data Units is summarised in Appendix 1. A brief description of the measurement rationale is included in the following sub-sections.

3.2.1 Radiological Impact – Man

The measure of the radiological impact on man is the European collective dose in man-Sieverts when evaluated over a long period of time (defined by CARBOWASTE participants, and can be as long as 10^6 years). Data requirements are the activity in Terabecquerel (TBq) versus time for radioactive discharges from the facility, together with a representative collective dose factor in man-Sieverts/TBq.

3.2.2 Radiological Impact – Environment

Discharges are assessed and expressed in terms of their concentration. This may require the use of dispersion modelling or a conservative "end-of-pipe" figure. The risk quotient is then calculated for each radioisotope by dividing the concentration of that radioisotope by the environmental media concentration limit for the given radionuclide for the most limiting reference organism.

The sum over all radioisotopes gives the total risk quotient. When used within ERICA as a screening quantity this value is examined. If less than 1, there is a very low probability that the absorbed dose rate to any organism exceeds the screening dose rate, and the situation may be considered to be of negligible radiological concern. For CARBOWASTE, it is recommended that the total risk quotient is used as the performance measure.

3.2.3 Resource Usage

For each tonne of the resources used (steel, concrete etc.), the energy required in Giga-Watt hours (GWh) to produce the resources is calculated for the facility lifecycle. The overall resource usage is then derived by calculating the sum of principal contributions. A judgement will need to be made on limiting the assessment to those resources which are most energy-intensive and/or are used in large quantities.

3.2.4 Non-Radiological Discharges

Non radiological discharges will be assessed by comparison to Environmental Quality Standards (EQS). The discharge of each material (in mass units) will be divided by the EQS for the material to give the amount of water needed to dilute the material to the EQS. The sum of these dilution factors over all species is treated as a performance measure for the impact of non-radiological discharges.

3.2.5 Local Intrusion

Whilst it is possible to make semi-quantitative assessments of certain intrusive impacts e.g. noise, light and vibration, qualitative evaluation will be necessary for impacts such as wildlife disturbance. The measure assigns a value between 0 (no impact) and 1 (significant impact) to each of the following categories (definition of the "most exposed" member of the public will be addressed in the next phase of work):

- Off-site noise to "most exposed" member of the public;
- Off-site visual impact to "most exposed" member of the public;
- Impact of construction traffic and off-site transport of process feeds/products/wastes on "most exposed" member of the public;
- Land use (compare both hectares used and time for which they are used);
- Impact of noise on wildlife (both on and off-site);
- Impact of artificial light on wildlife (both on and off-site);
- Impact of excavation on wildlife (both on and off-site); and
- Impact of vibration (e.g. due to piling) on wildlife (both on and off-site).

The sum of the categories is a measure of local intrusion. Judgement is to be based on assessments of the activities needed to deliver the project, the physical size of any construction and of wildlife present on the proposed construction site.

3.2.6 Hazard Potential

Assessment is performed by multiplying the maximum mass of material in each form (gases, liquids, powders, solids and monolithic solids) in each process stage by the number of years the process stage will continue to operate and by a risk factor which considers the probability of an incident, and a modifier for accidents considered essentially irreversible. This is a variation of the Hazard Potential concept[4] developed as part of the NDA prioritisation process in the UK. A flow diagram of the assessed process is needed to underpin the assessment. Since the duration of each process stage is considered (unlike in the NDA hazard potential approach) the result is therefore an *integrated* Hazard Potential.

3.2.7 Radiological Worker Safety

Collective Dose in Man Sieverts is used as the measure of worker radiological safety. The number of workers, the period in years for which they are required, and the predicted dose per operator in millisieverts (mSv) are combined to derive the measurement value.

3.2.8 Non-Radiological Worker Safety

An estimate of the fatal injury rate per 100,000 workers per year is made by comparison to published figures for industry sectors relevant to CARBOWASTE participants. The number of operators, the number of years the operators are required, and the environment (services, manufacturing or construction sectors) operators are exposed to are used to estimate a fatal injury rate for the decommissioning process(es).

3.2.9 Security - Misappropriation

Misappropriation is calculated in a similar manner to the Hazard Potential. Assessment is made of:

- Barriers that must be breached;
- Ease of transporting material away;
- Amount of material that can be misappropriated; and
- Time that the material is 'vulnerable'.

From the above factors, a misappropriation factor is derived. The calculation method is currently being developed.

3.2.10 Cost

Discounted lifecycle costs over a long period of time will be measured, as agreed for the environmental assessment. Due to the use of discounting for future expenditure, this measure will be less sensitive to future actions than the environmental effects. An appropriate discount rate, selected by the member state will be applied.

3.2.11 Spin-Off

The measure of spin-off is an estimate of the discounted value (Net Present Value) of spin-off opportunities. The monetary value, after discounting, will be used as the performance measure.

3.2.12 Concept Predictability

The Technology Readiness Level[6] (TRL) is to be used as the measure for this criterion.

CARBOWASTE processing options under evaluation are likely to be based on more than one key technology, each having a distinct TRL value. The calculation method for deriving an overall TRL value is under development.

3.2.13 Operational Predictability

The Operational Predictability Level is to be derived in the form a subjective score from the assessment of:

- Process Flow Diagram;
- Throughput sensitivity to feed variations;
- Feed probability distribution;
- Equipment/System Reliability Data; and
- Equipment/System interface (familiarity and ease of use).

3.2.14 Stability of Employment – Employment Factor

Determination of the Employment Factor is achieved through subjective assessment of:

- Employment profile for project lifecycle;
- Employment history in project region (numbers, skills, stability); and
- Transferable skills derived from project.

Further development of this measure will be undertaken in the next phase of work.

3.2.15 Burden on Future Generations – Burden Factor

A measure of the burden level is assessed subjectively from consideration of the following factors:

- Lifecycle project cost profile vs. time;
- Discharge profile for radioactive species vs. time;
- Discharge profile for toxic species vs. time;

- A future cost 'inflation' parameter (penalty); and
- A future discharge parameter (penalty).

Further development of this measure will be undertaken in the next phase of work.

4 Conclusions

The report identifies lower level objectives and performance criteria for the assessment of options for the management of irradiated graphite (i-graphite), as follows:

- 15 Lower Level Objectives (Generic Sub-Criteria).
- Performance Criteria (Measures) for each of the lower level objectives.
- 8 Technology Sub-Criteria.

5 References

1. Identify High Level Objectives (End Points) for all Key Stages, CARBOWASTE Deliverable D-1.4.3, David N Ross and Richard B Jarvis 30 September 2009
2. The 2007 Recommendations of the International Commission on Radiological Protection. ICRP Publication 103. Ann ICRP, 37 (2-4)
3. D-ERICA: an integrated approach to the assessment and management of environmental risks from ionizing radiation, Beresford et al, EC, February 2007
4. The Radiological Hazard Potential: a progress measure for nuclear cleanup, UK Nuclear Decommissioning Authority EGR009, R Jarvis, July 2006
5. IAEA Safety Standards: Storage of Radioactive Waste, Safety Guide WS-G-6.1, 2006
6. Lifetime Plan Procedure, UK Nuclear Decommissioning Authority PCP-07, June 2006

Appendix 1: Sub-Criteria, Measures and Data Requirements

Sub-Criteria	Measure	Measure Units	Data Requirement	Data Units
Rad Impact - Man;	Collective Dose over 10^6 years	Man Sieverts	Time Varying Discharge Profile	End of pipe Tbq vs. time
			Aerial and Liquid Collective Dose Factors for each site	Man Sieverts/TBq
Rad Impact - Environment	Tier 1 ERICA score	Dimensionless	Edge of mixing zone activity concentration for discharged species	TBq/m^3
Resource Usage	Energy	GWh	Lifecycle resource usage	tonne
			Energy required to manufacture unit of resource	GWh/tonne
Non-rad discharges	Sum of dilution required to meet EQS for all toxic species	m^3	Time Varying Discharge Profile	te discharged
			Environmental Quality Standards	te/m^3
Local Intrusion	Impact value between 0 (no impact) and 1 (significant impact) normalised to known projects	Subjective Score	Lifecycle Environmental Impact Assessment of facility	None
(Integrated) Hazard Potential	Hazard Potential	None	Duration of each processing stage	Years
			Active Process Materials Inventory	TBq
			Process Materials Inventory	te
			(Control and Form) Risk Factors	Numerical
Worker Safety (Radiological)	Collective Dose	Man Sieverts	Number of Operators	Numerical
			Number of Years Operators Required	Numerical
			Predicted	mSv

Sub-Criteria	Measure	Measure Units	Data Requirement	Data Units
			Dose/Operator	
Worker Safety (Non-Radiological)	Fatal Injuries	Numerical	Number of Operators	Numerical
			Number of Years Operators Required	Numerical
			Industrial Sector applicable to working environment	Information only
			Industrial Sector Death Rates	Number/100,000 workers/year
Security - Misappropriation	Misappropriation Factor	Numerical Value	Number of barriers to overcome Amount of each radioisotope vulnerable Duration of vulnerability	Numerical
Cost	Discounted Lifecycle Cost	Monetary Values	Lifecycle Cost (assumes no income from Graphite disposal)	Monetary Value
			Discount Rate	Annual Percentage
Spin-Off	Discounted Lifecycle Value	Monetary Values	Lifecycle Net Present Value (NPV)	Monetary Value
			Discount Rate	Annual Percentage
Concept Predictability	Technology Maturity Level	Numerical	Technology Readiness Level	Numerical Value
			Process Flow Diagram	Information only
Operational Predictability	Operational Predictability Level	Subjective Score	Process Flow Diagram	Information only
			Throughput sensitivity to feed variations	Information only

Sub-Criteria	Measure	Measure Units	Data Requirement	Data Units
			Feed probability distribution	Information only
			Equipment/System Reliability Data	Information only
			Equipment/System interface (familiarity and ease of use)	Information only
Employment Level	Employment Factor	Subjective Score	Employment profile for project lifecycle	Information only
			Employment history in project region (numbers, skills, stability)	Information only
			Transferable skills derived from project	Information only
Burden Level	Burden Factor	Subjective Score	Costs profile vs. time	Monetary Value
			Discharge profile for rad. species vs. time	TBq/m3 vs. time
			Discharge profile for toxic species vs. time	Mass concentration vs. time
			Future cost parameter (penalty)	Numerical
			Future discharge parameter (penalty)	Numerical