Evaluating the environmental impact of the ISIS-II Neutron and Muon Source

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STFC ISIS-II Webinar

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ISIS Neutron and
Muon Source

Overview

1) The intersection of science and the Climate Crisis
2) Environmental Impact & Life Cycle Assessment of ISIS-II
   - Motivation
   - Methodology

The Climate Crisis

What do we really mean by environmental impact and "sustainability"?

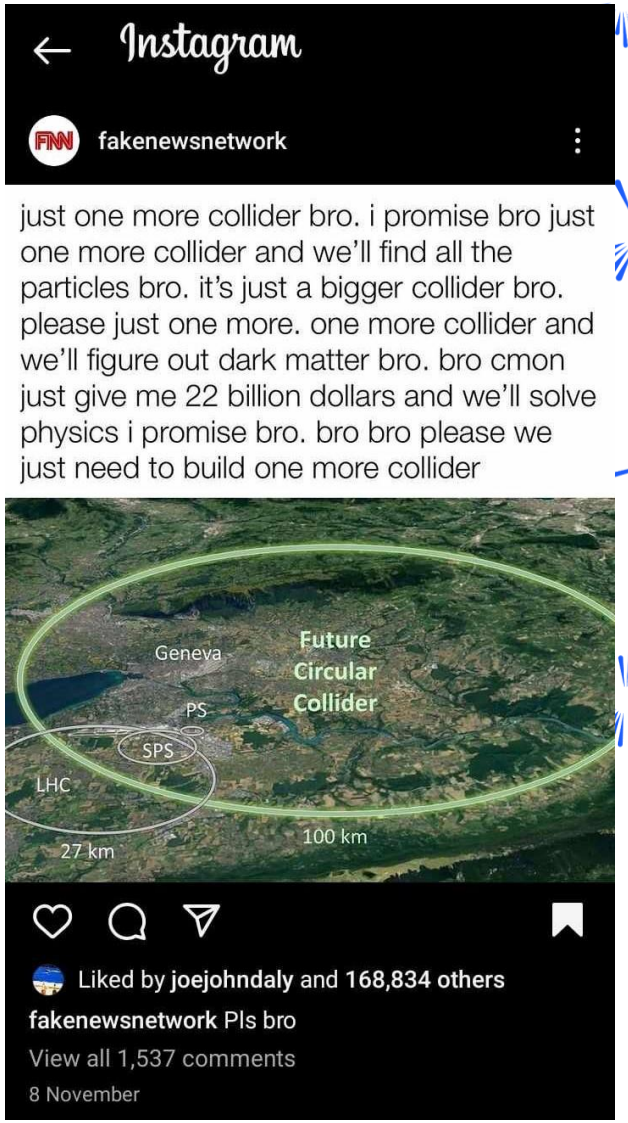
- Sustainability is "a social goal for people to co-exist on Earth over a long time."

Why do we need to care?

- GHG impacts are cumulative.
- Moral and social duty to lead by example.
- Publicly funded.

How does this *actually* relate to the field of accelerator science?

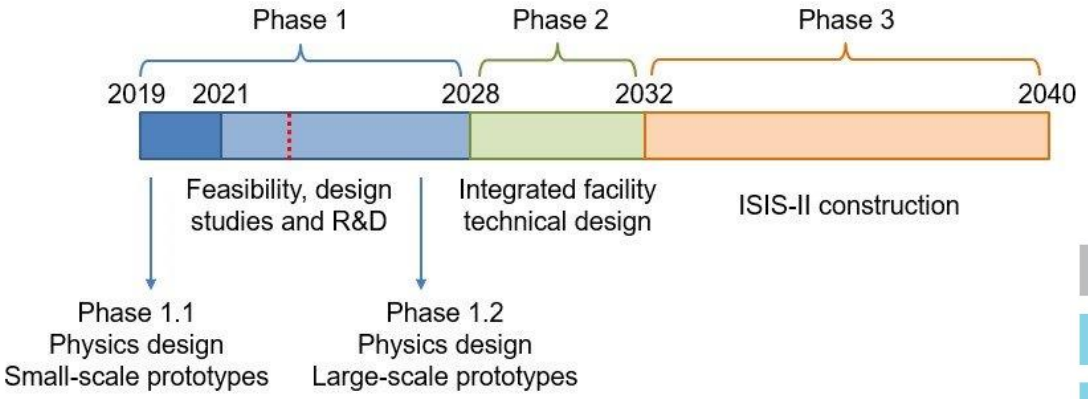
- Large accelerator facilities are generally unsustainable:
  - resource consumptive, and
  - next generations aim to grow in size and/or power, and therefore (generally) consumption.



Instagram: @fakenewsnetwork

The climate issue | Nature Astronomy

Timeline



Proposed ISIS-II timeline.

Now is the ideal time to consider and reduce environmental impacts!

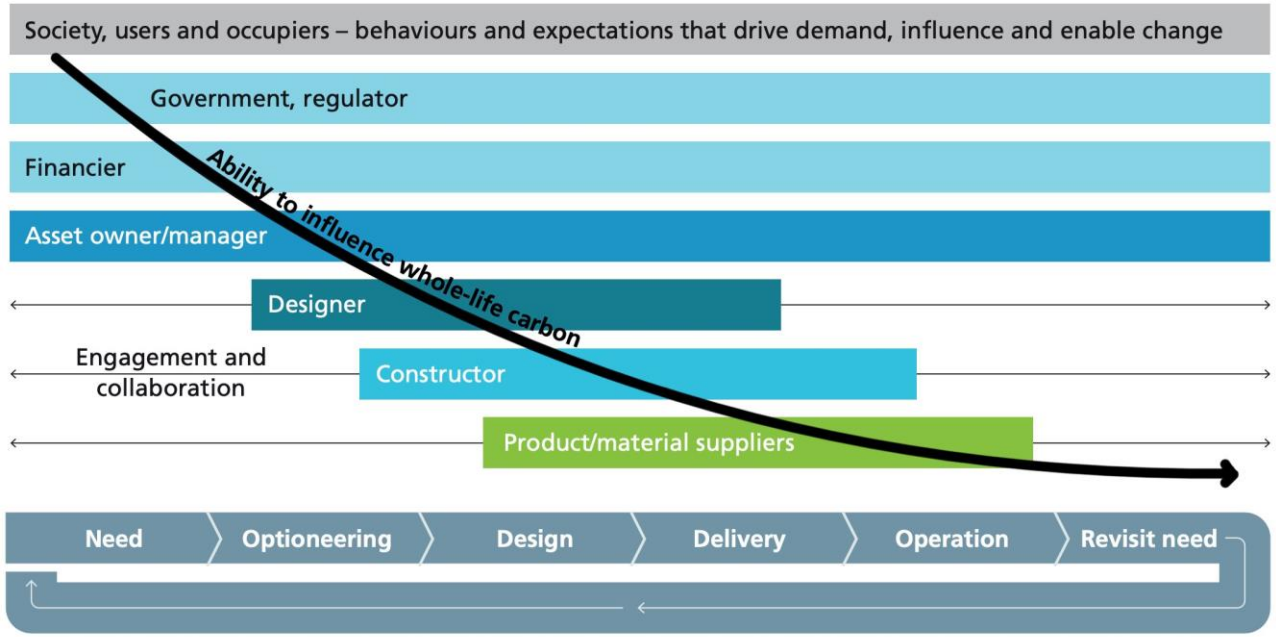


Fig 2.1: Value-chain members' ability to accelerate decarbonisation throughout the delivery process

PAS 2080 guidance document: Practical actions and examples to accelerate the decarbonisation of buildings and infrastructure

Progress on Design Studies for the ISIS II Upgrade (2019)

What do we hope to achieve?

- To inform ISIS-II design options.
- To report on the full lifetime environmental impact expected at ISIS-II.
- To identify hotspots of environmental impact to allow focus to reduce these impacts.
- To help develop a methodology that can be used by other future facilities.

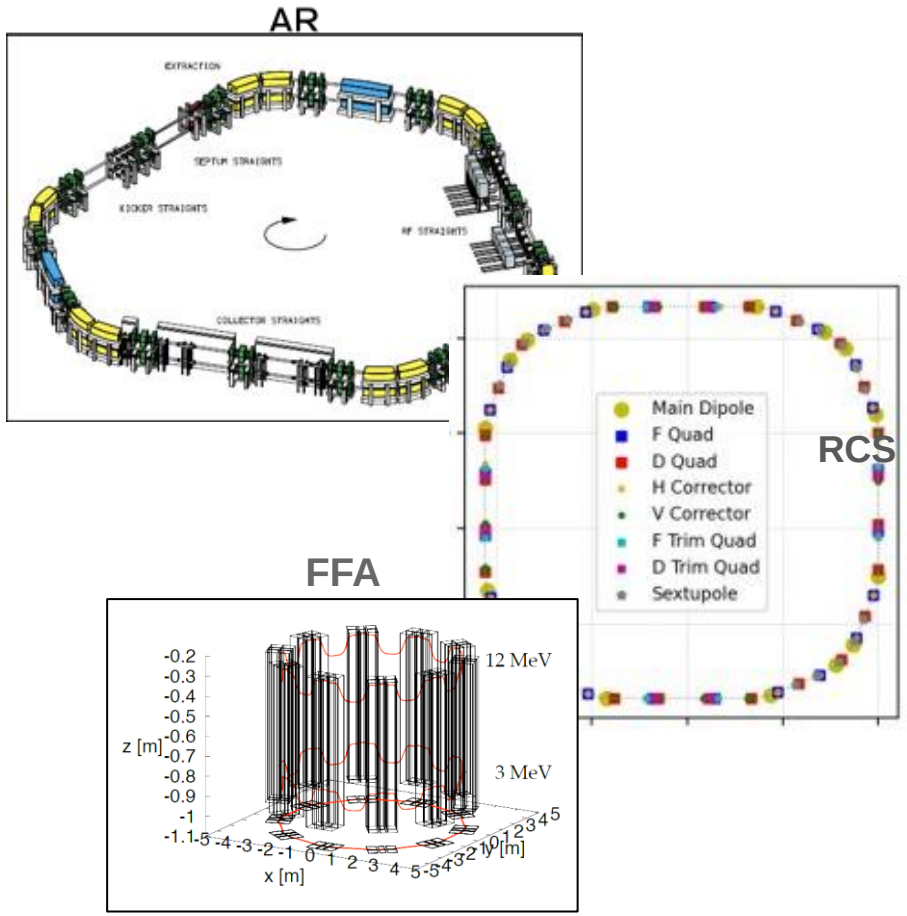
Methodology

Three major design considerations:

- Accumulator Ring (AR)
- Rapid Cycling Synchrotron (RCS)
- Fixed Field Alternating Gradient Ring (FFA)
- Fall back option: 180 MeV LINAC upgrade to ISIS

Two key stages to this analysis:

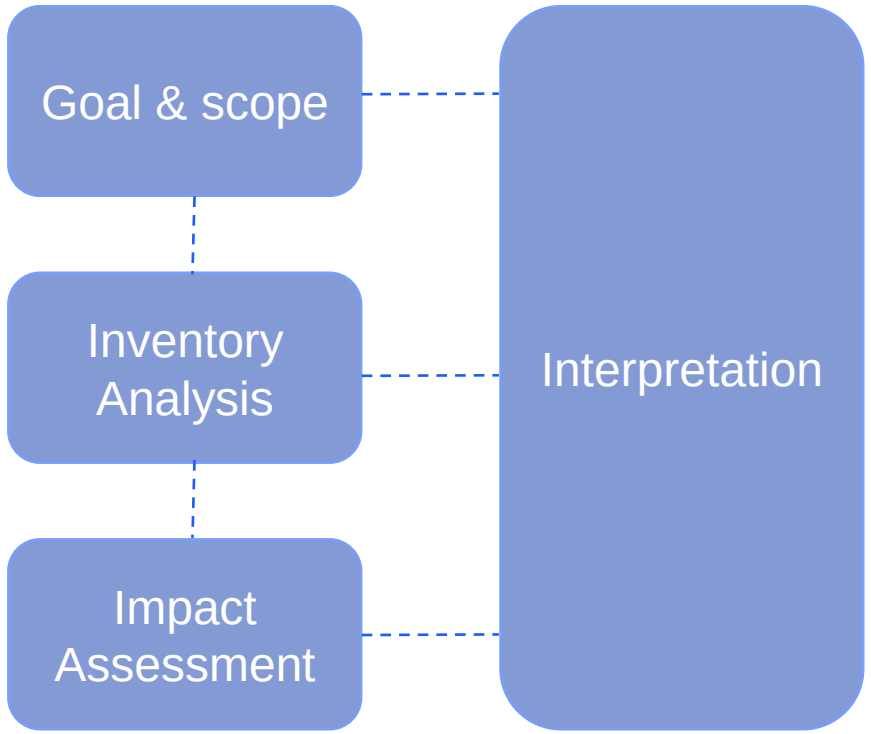
1. Core components of ISIS-II and an estimation of their environmental impact through modelling and simulation.
2. (Simplified) **Life Cycle Assessment** (LCA)



3 ring options for ISIS-II.

Life Cycle Assessment of the ISIS-II rings

Life Cycle Assessment/Analysis (LCA):



LCA steps.

Goal & Scope

Goal

- To evaluate and inform the design of ISIS-II with a comparison of the options available for the compression rings of ISIS-II.
- To **identify the lowest lifetime environmental impact between a Rapid Cycling Synchrotron (RCS) and Accumulator Ring (AR)** and the corresponding linear accelerator (LINAC) designs necessary to deliver a 2.4 MW beam of protons to the neutron and muon community over a period of 60 years.

Goal & Scope

Scope

- Two of the four ring design options of ISIS-II:
  - **RCS (low energy LINAC)**
  - FFA (low energy LINAC)
  - **AR (full energy LINAC)**
  - Fall back option: 180 MeV LINAC upgrade to ISIS
- Initially CO_2e is used as assessment parameter but other environmental impacts will not be ignored and not deemed negligible for the comparison.
- Currently the functional unit is "one ISIS-II facility that will deliver a beam of protons at an energy of 1.2 GeV to the neutron and muon community over a period of 60 years", with the view to investigate updating this in the future to, e.g., "user hours".

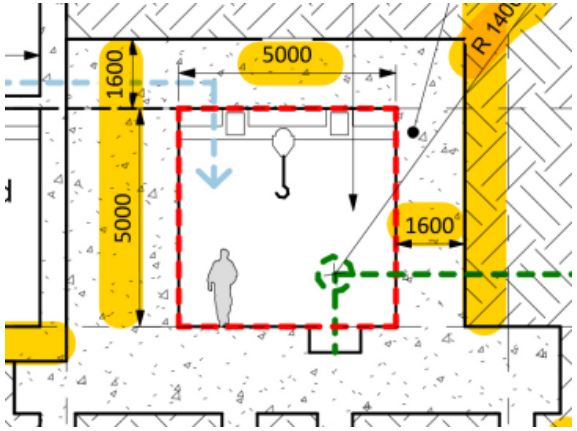
Inventory Analysis

Modelling performed using existing facilities such as SNS and J-PARC, where ISIS-II designs not yet available

Construction

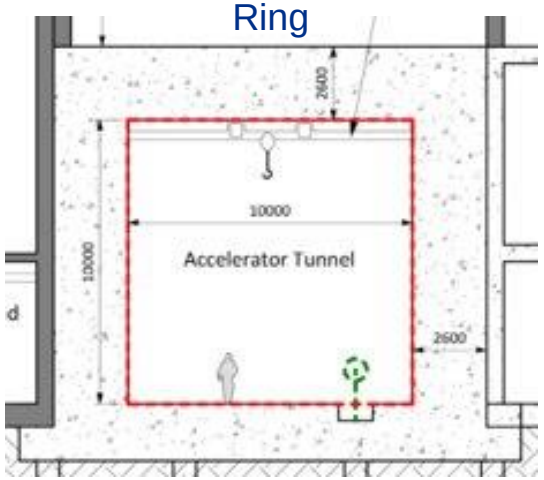
- Facility (Buildings, Tunnelling, Location)
- Machine (Accelerator Components, Ancillaries)
- Shielding
- Computing

LINAC



10s ktCO$_2$

Ring



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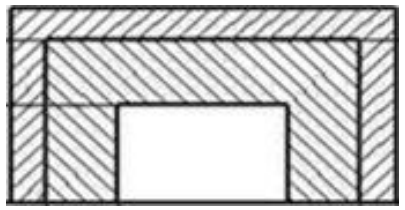
EPB



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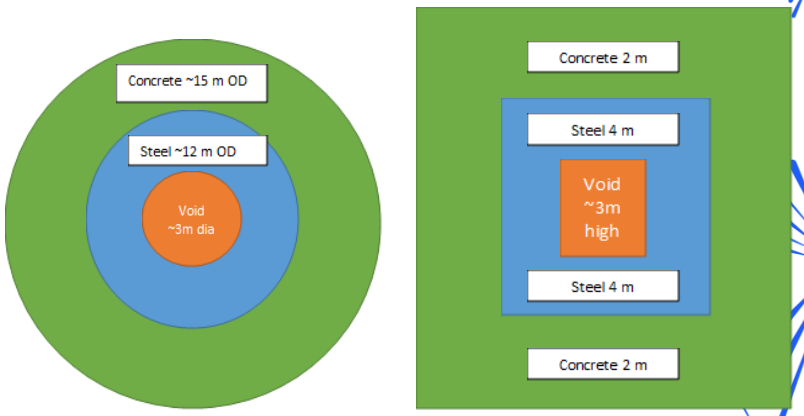
Targets



10s ktCO$_2$

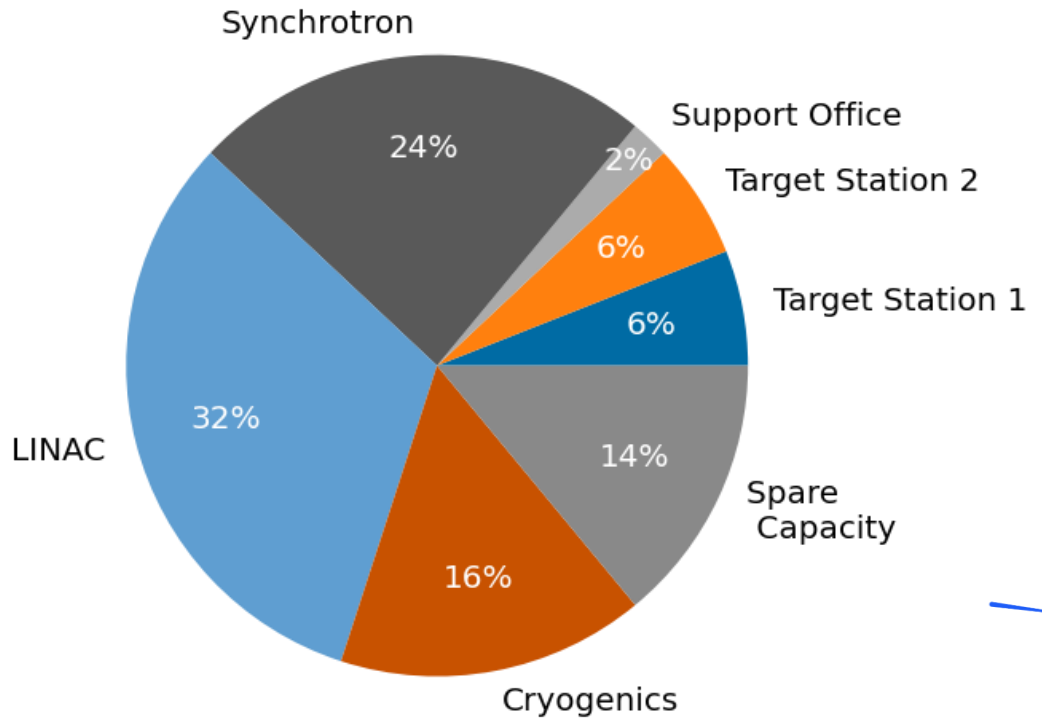
Inventory Analysis

Construction

- Facility (Buildings, Tunnelling, Location)
- Machine (Accelerator Components, Ancillaries)
- Shielding
- Computing

Operation/Active life

- Energy consumption
- Resource consumption inc. leakage
- Failure likelihoods/risks inc. replacement/repair
- Staff and user travel
- Radioactive waste



Estimated ISIS-II electricity requirements
Big Science Scheme

Inventory Analysis

Construction

- Facility (Buildings, Tunnelling, Location)
- Machine (Accelerator Components, Ancillaries)
- Shielding
- Computing

Operation/Active life

- Energy consumption
- Resource consumption inc. leakage
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- Radioactive waste

Decommissioning (~2100 – 2170)

- Recycling/re-use of components/materials
- Storage of radioactive materials

ISIS radioactive waste
150 – 300 tonnes of radioactive waste per year
~30,000 – 35,000 tonnes decommissioning

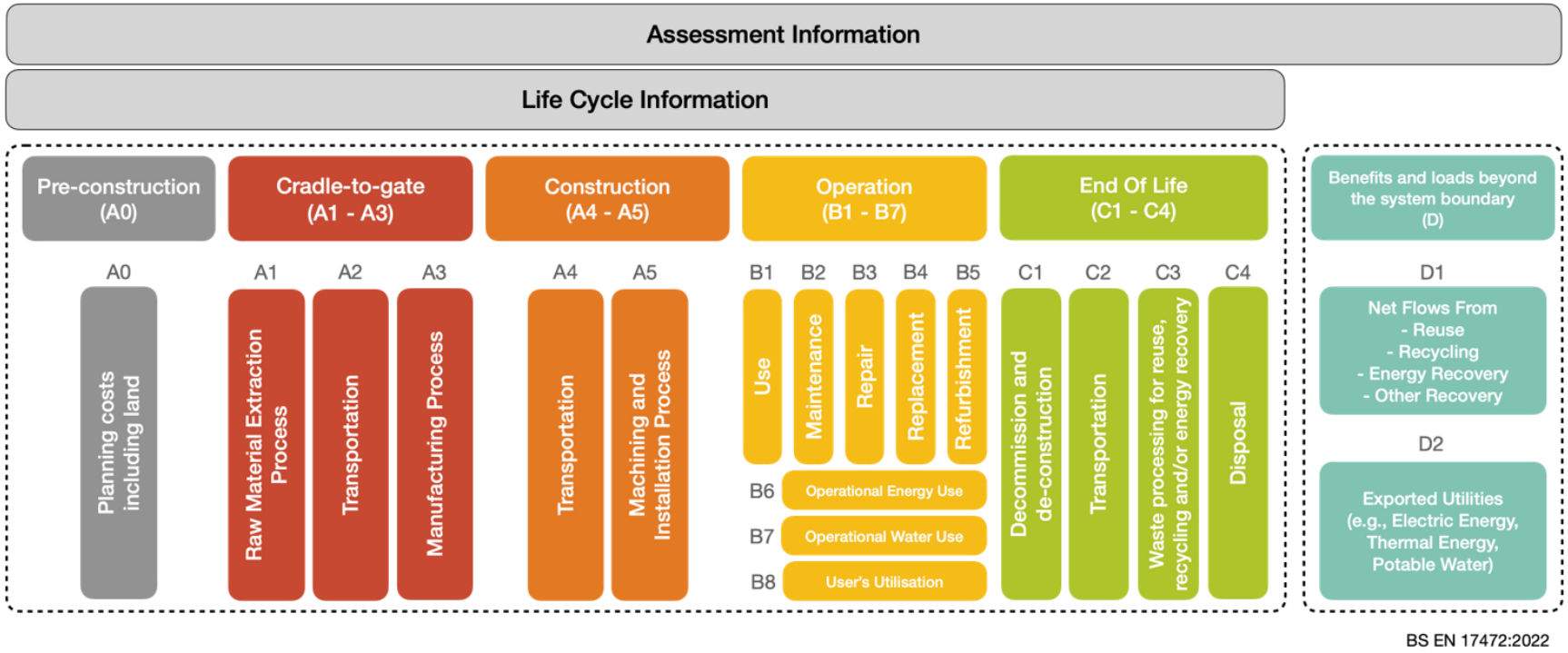
What would it cost to dispose ISIS current waste right now?

Waste Category	Current Volume	Disposal Cost
LA-LLW	1,140 te	~ £2.2 M
LLW	100 te	~ £1.5 M
ILW	70 te	~ £ 70 M

This is just disposal cost

Impact Assessment

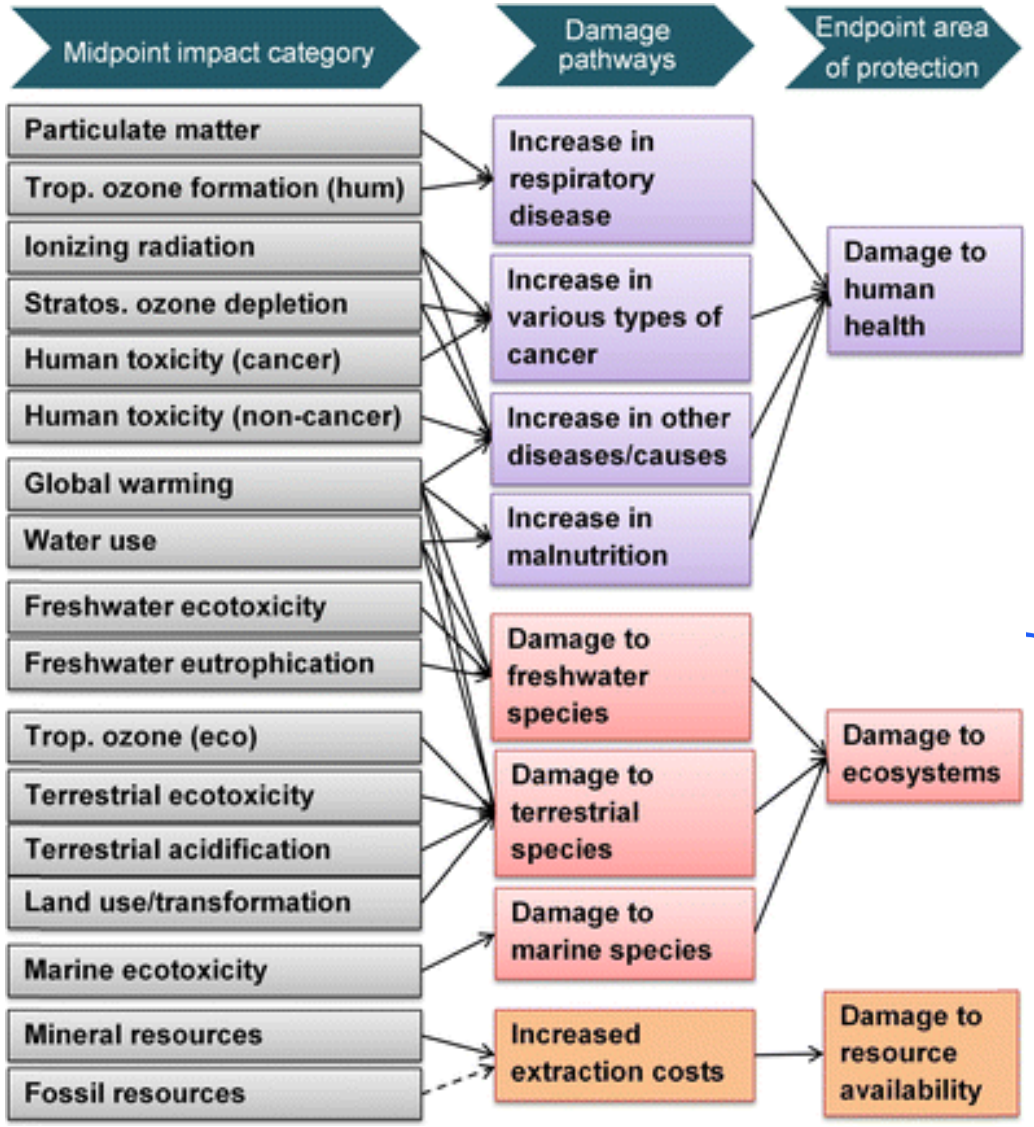
- Following the EN 17472:2022 standard as a basis.



A. Construction
B. Operation
C. Decommissioning

Impact Assessment

- Following the EN 17472:2022 standard as a basis.
- Many impact assessment methods exist, no standard yet set within our field.
- Using the ReCiPE:2016 Midpoint (H) Life Cycle Impact Assessment Method.
- Using openLCA with the Idemat database (currently, fluid, incomplete database for study)
  - One good outcome of this: naturally creates a database with key particle accelerator components such as magnets.



Summary and Conclusion

- Understanding and reducing the environmental impact of *all aspects* of research is necessary.
- To evaluate the environmental impact of ISIS-II, an impact analysis is well underway.
- To inform the design options for ISIS-II and the next funding bid, a simplified Life Cycle Assessment will be performed.

Thank you for your attention, questions welcome!

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