ARUP

Environmental Sustainability

Einstein Telescope Collaboration meeting at CERN

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Wednesday 15th January 2025

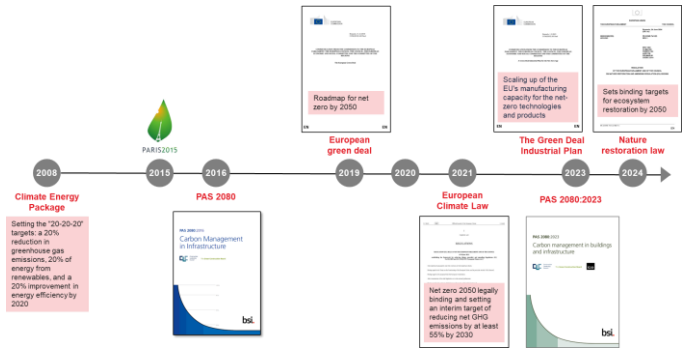
Environmental sustainability

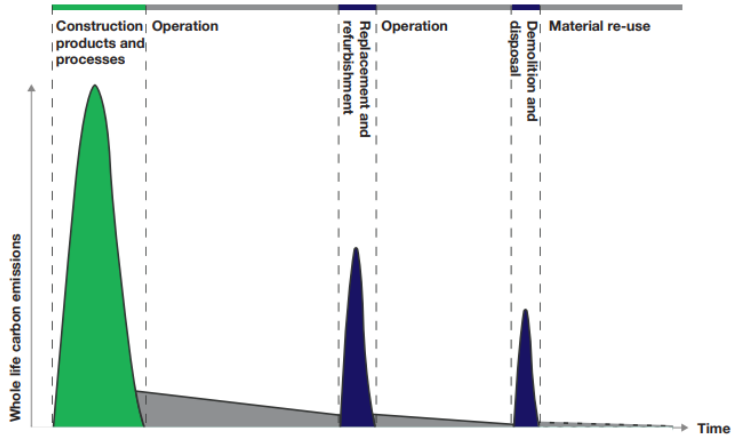
Aims

- To inform ETO WG on sustainability activities at CERN relevant to current ETO studies
- Lessons learnt from CERN:
  - CERN Campus: Regenerative environment and social programme
  - CLIC & ILC: Environmental life cycle assessment
  - Decarbonisation technology
- Comparable underground infrastructure projects
- Steps for implementation at ETO, across sites

Environmental sustainability

Drivers





Vision and ambitions

- Values and contributions science and society beyond the Science.
- Decarbonisation commitments that shape the design and go beyond typical metrics of cost and carbon.
- Social and organisational responsibility

Policies, targets and financing

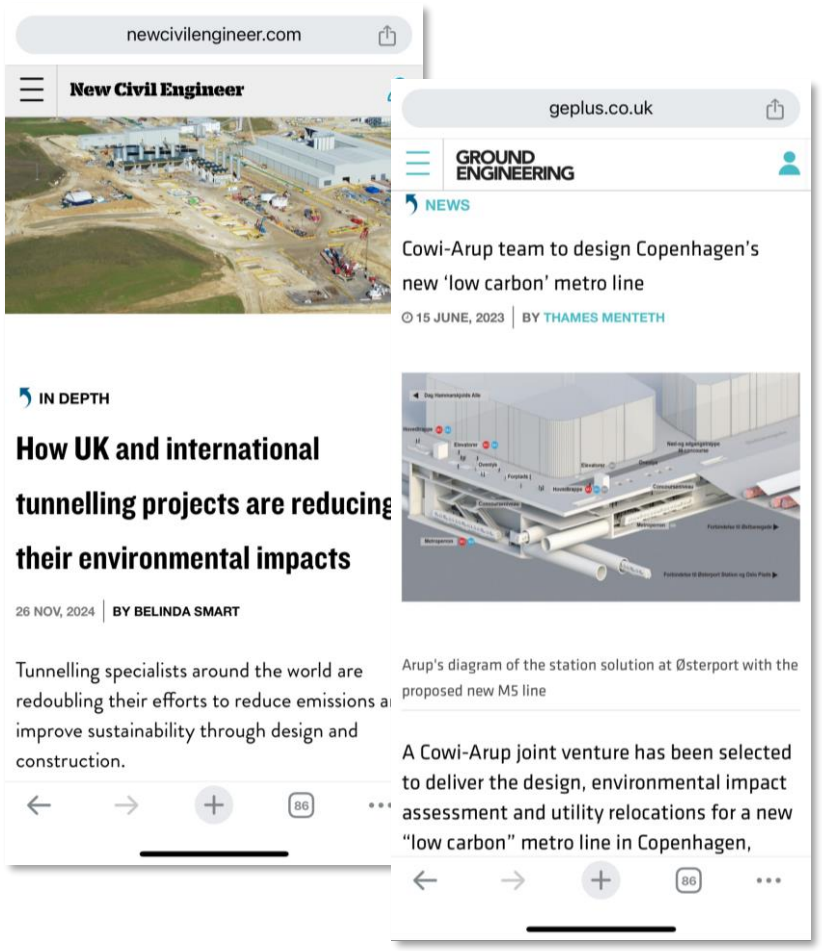
- Compliance -> shaping of expected and future policy
- Stranded asset and technology leapfrogging
- Carbon central to the financing business case and access to finance

Carbon management

- Capital and operational carbon
- Whole life demonstration of carbon and energy performance
- Carbon as a driver and analogy for cost

Vision and ambitions

Climate impact as a decision maker in major projects



https://www.youtube.com/watch?v=AqyjTCP3HX4&t=153s

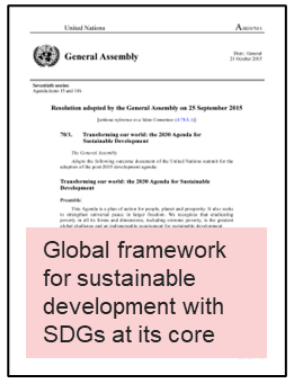
Policies, targets and financing

European policy timeline

2008 — Climate Energy Package

Setting the "20-20-20" targets: a 20% reduction in greenhouse gas emissions, 20% of energy from renewables, and a 20% improvement in energy efficiency by 2020

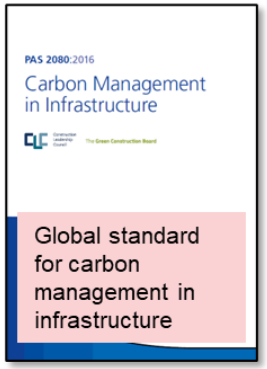
2015 — 2030 agenda for sustainable development



Global framework for sustainable development with SDGs at its core

PARIS2015

2016 — PAS 2080:2016

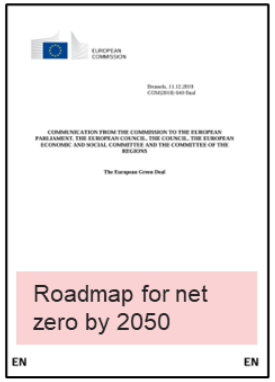


Global standard for carbon management in infrastructure

2018 — ISO 50001:2018

International standard for energy management systems

2019 — European green deal

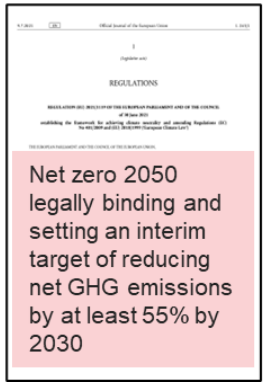


Roadmap for net zero by 2050

2020 — EU biodiversity strategy & EU soil strategy

Legally protect a minimum of 30% of the EU's land area

2021 — European Climate Law



Net zero 2050 legally binding and setting an interim target of reducing net GHG emissions by at least 55% by 2030

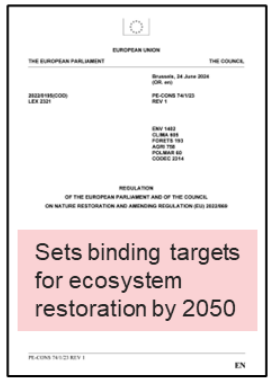
2023 — The Green Deal Industrial Plan

Scaling up of the EU's manufacturing capacity for the net-zero technologies and products

2023 — PAS 2080:2023

Global standard for carbon management in infrastructure

2024 — Nature restoration law



Sets binding targets for ecosystem restoration by 2050

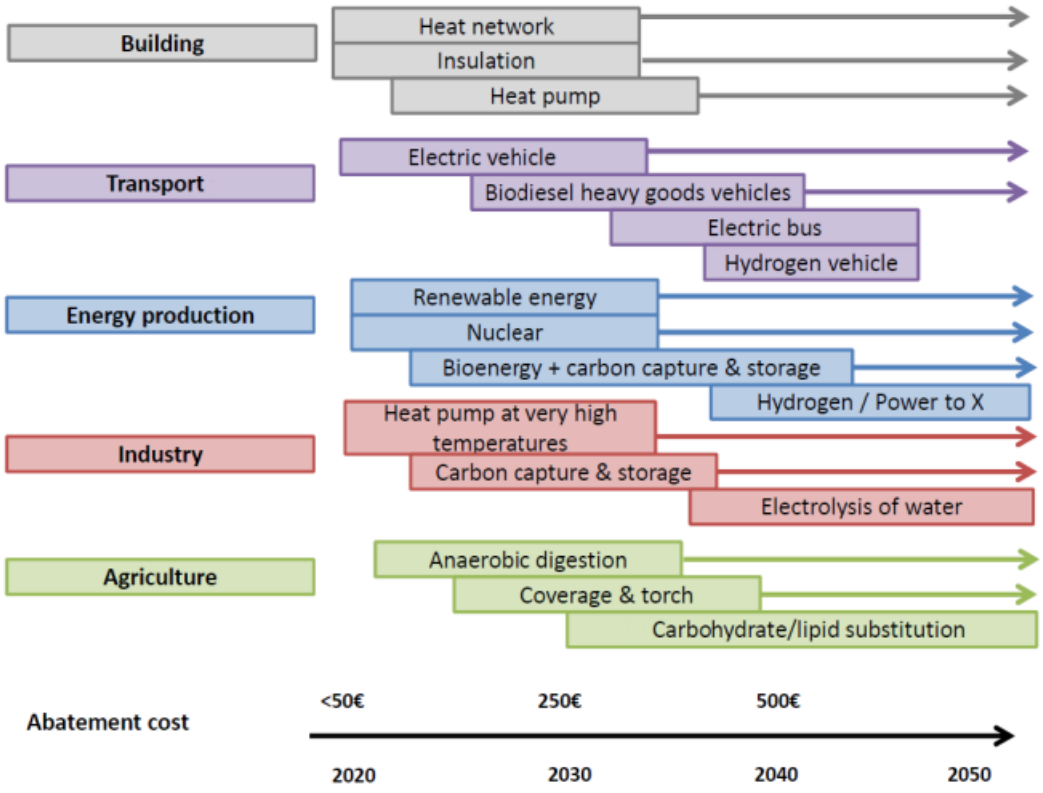
2024 — EU CBAM

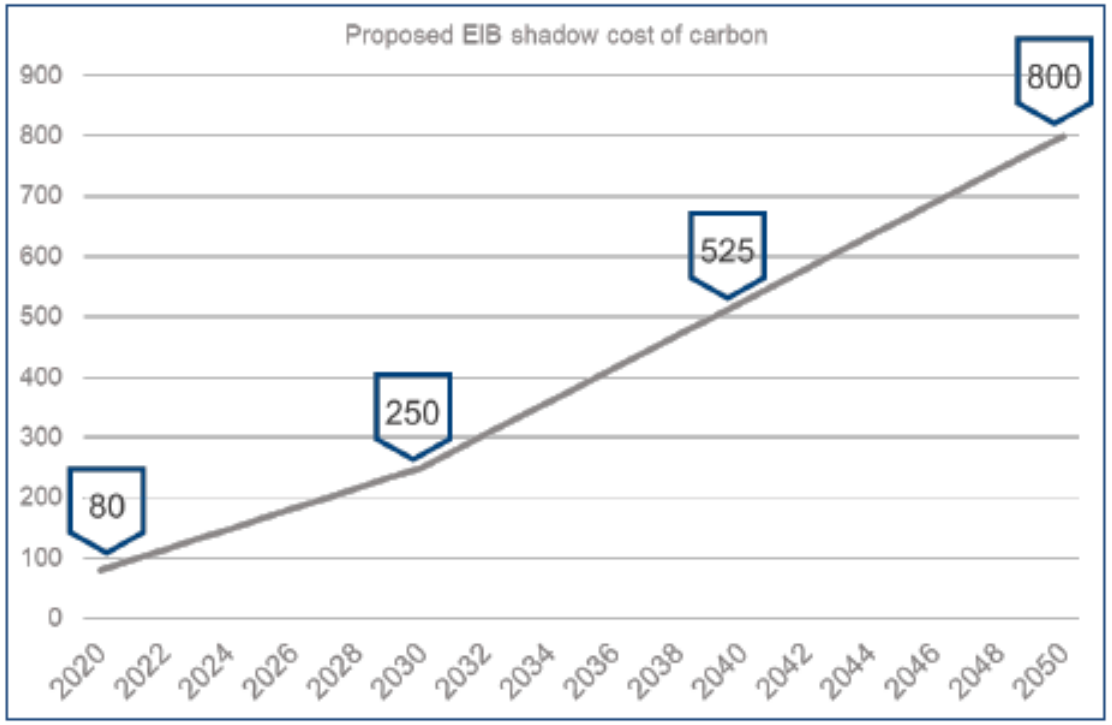
Tariff on carbon intensive products imported into the EU (e.g. steel, cement)

Policies, targets and financing

Shadow carbon pricing - An important incentive to drive lower carbon implementation

"*Penalising the economic performance of carbon intensive projects and sends an important signal to the market*" *European Investment Bank Climate Strategy* https://www.eib.org/attachments/strategies/eib_climate_strategy_en.pdf

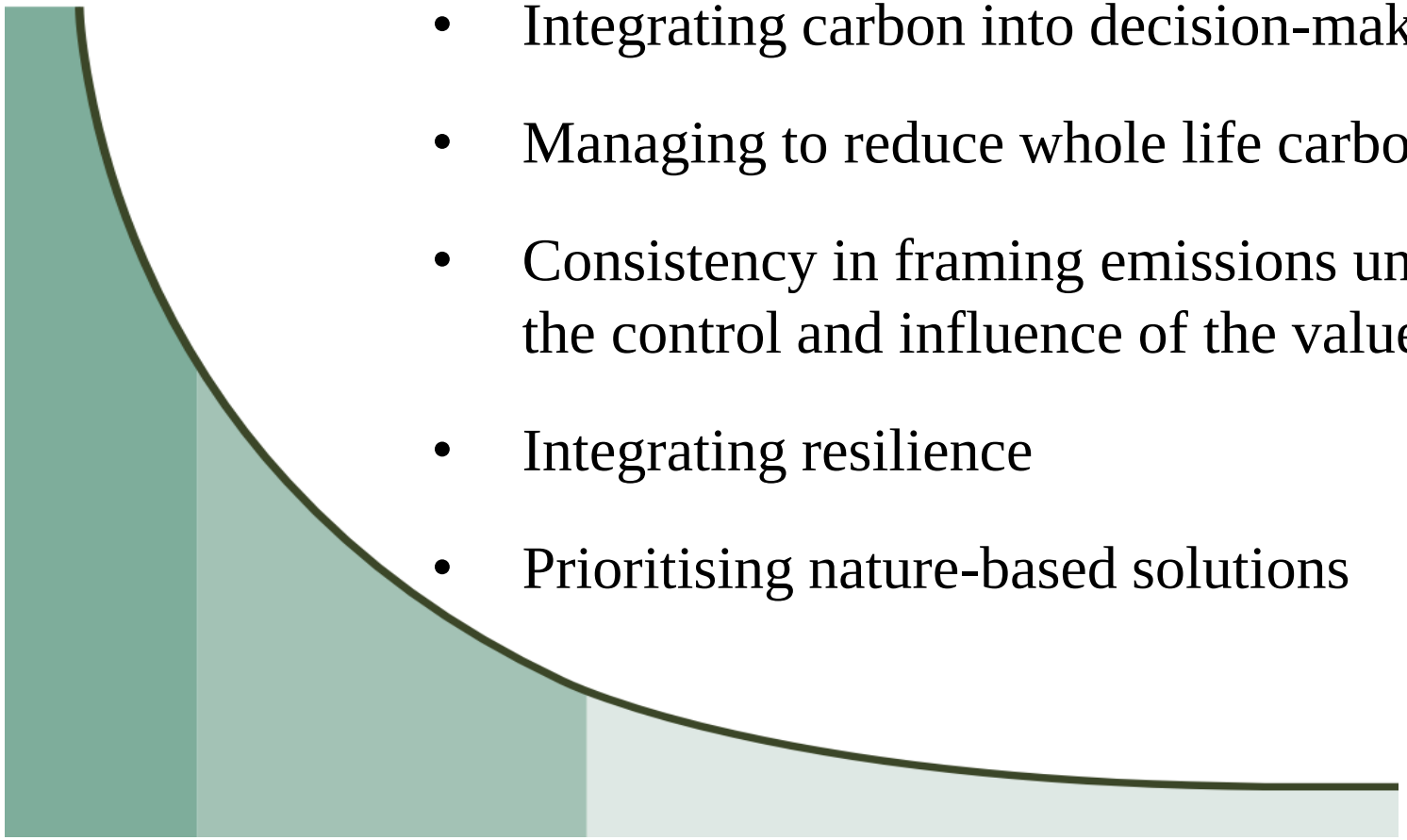




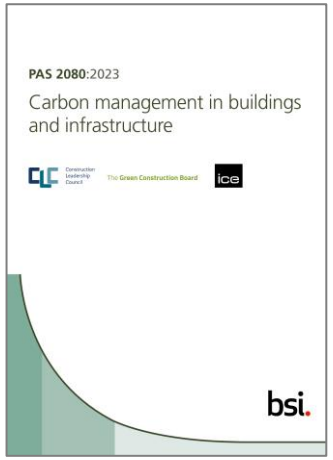
https://www.eib.org/attachments/thematic/eib_group_climate_bank_roadmap_en.pdf

Accelerating decarbonisation

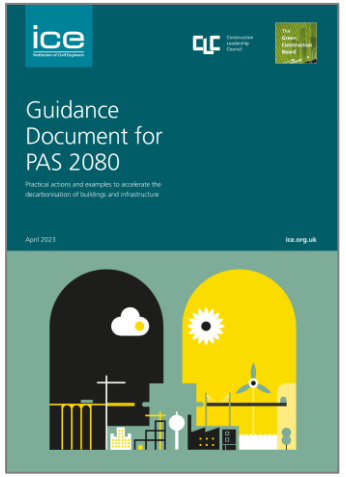
PAS2080:2023 Carbon management in buildings and infrastructure



- Integrating carbon into decision-making
- Managing to reduce whole life carbon
- Consistency in framing emissions under the control and influence of the value chain
- Integrating resilience
- Prioritising nature-based solutions



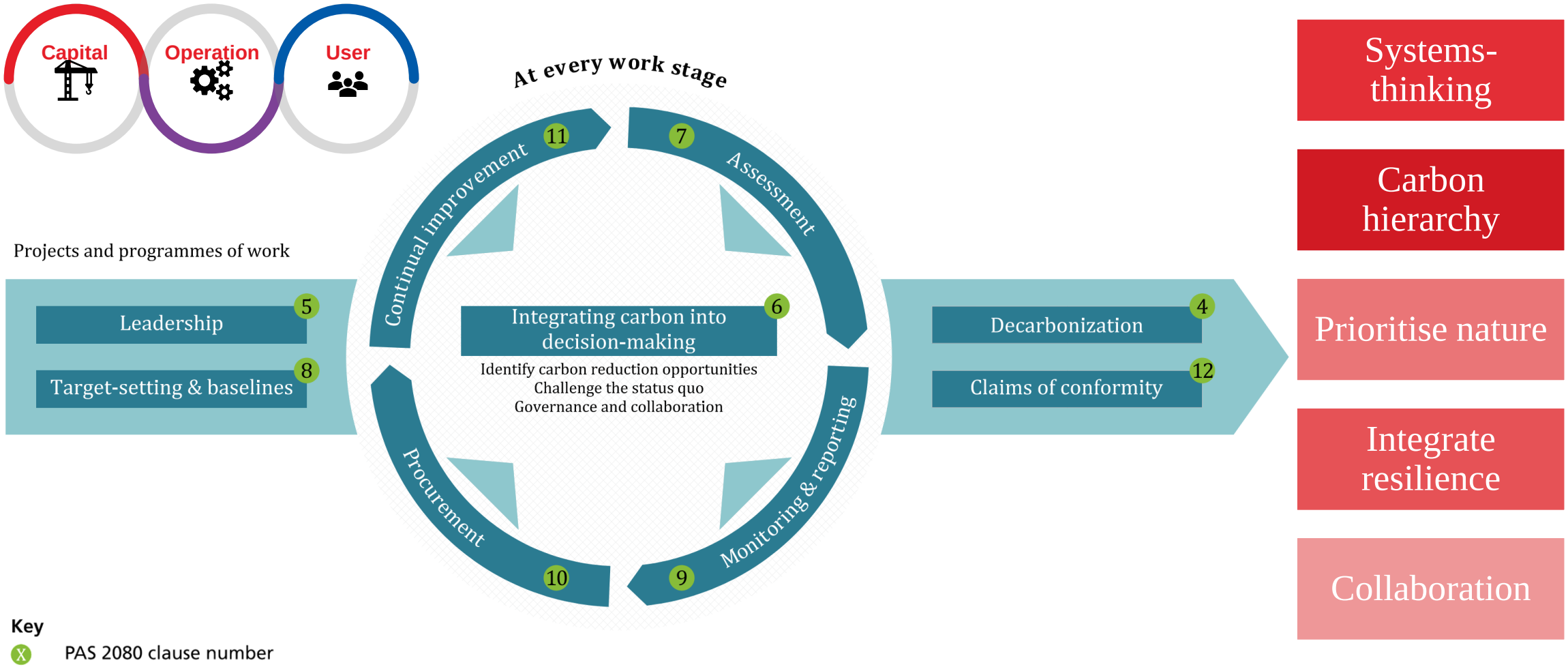
https://www.bsigroup.com/en-GB/standards/pas-2080/



https://www.ice.org.uk/engineering-resources/briefing-sheets/guidance-document-pas2080

Carbon management process

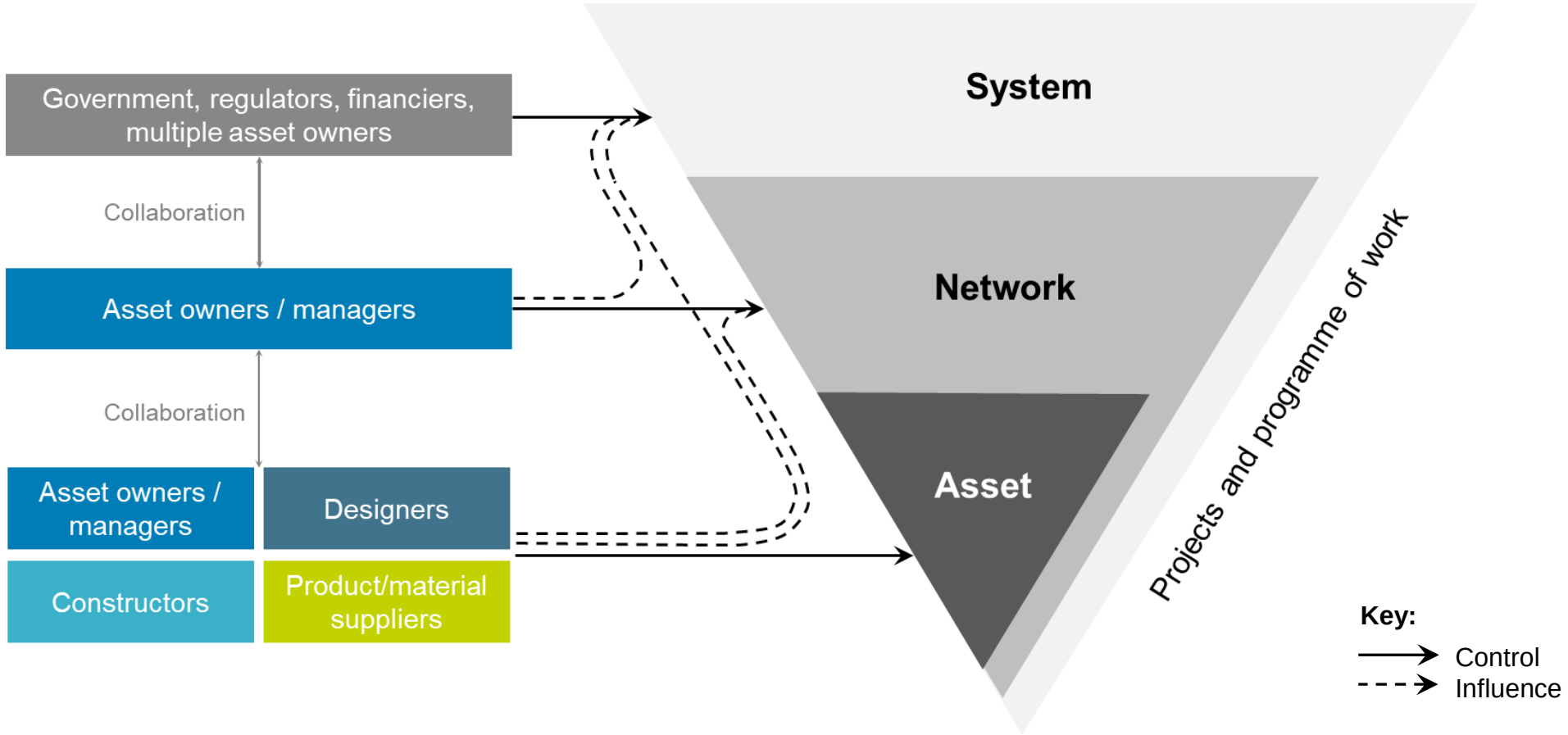
PAS2080:2023



PAS 2080: 2023 Carbon management in buildings and infrastructure: https://www.bsigroup.com/en-GB/standards/pas-2080/

Control and influence

Systems decarbonisation



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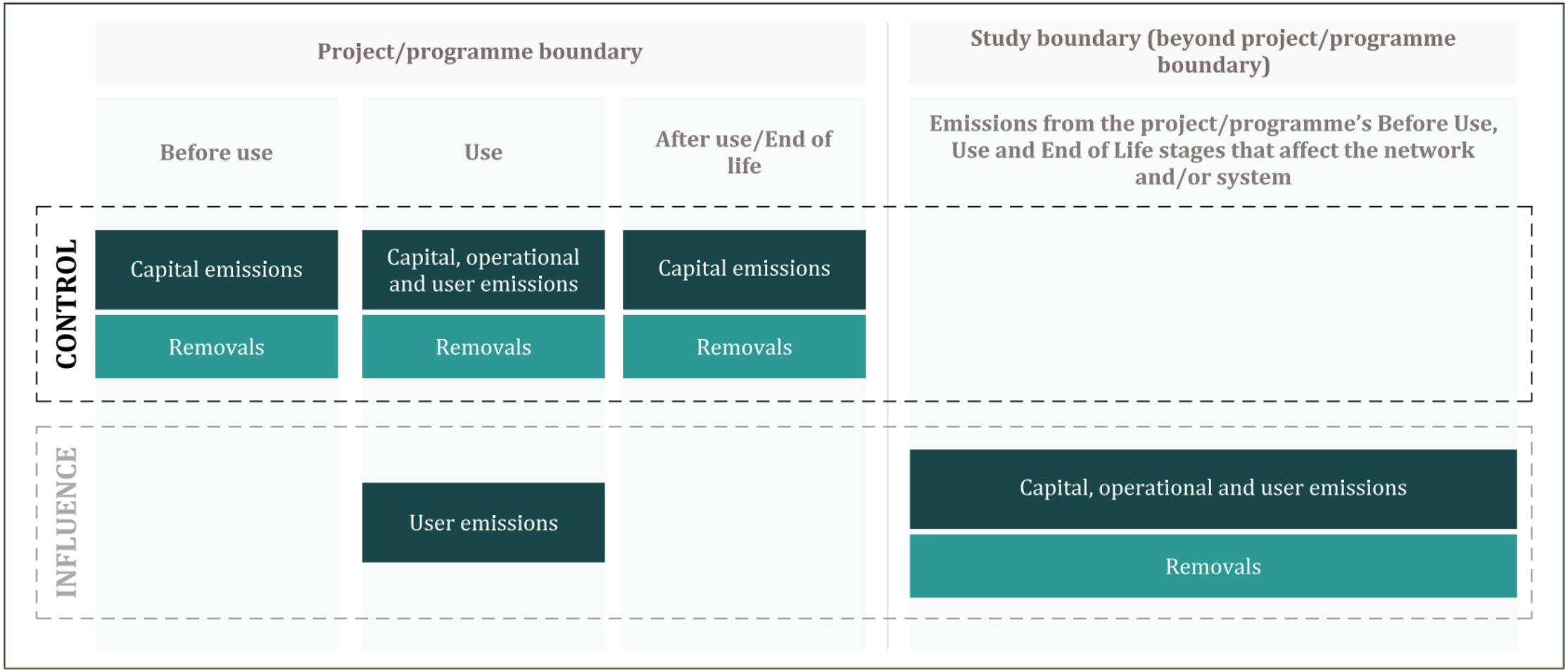
Control and influence

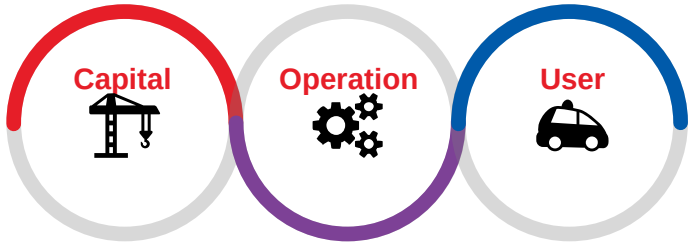
Systems decarbonisation

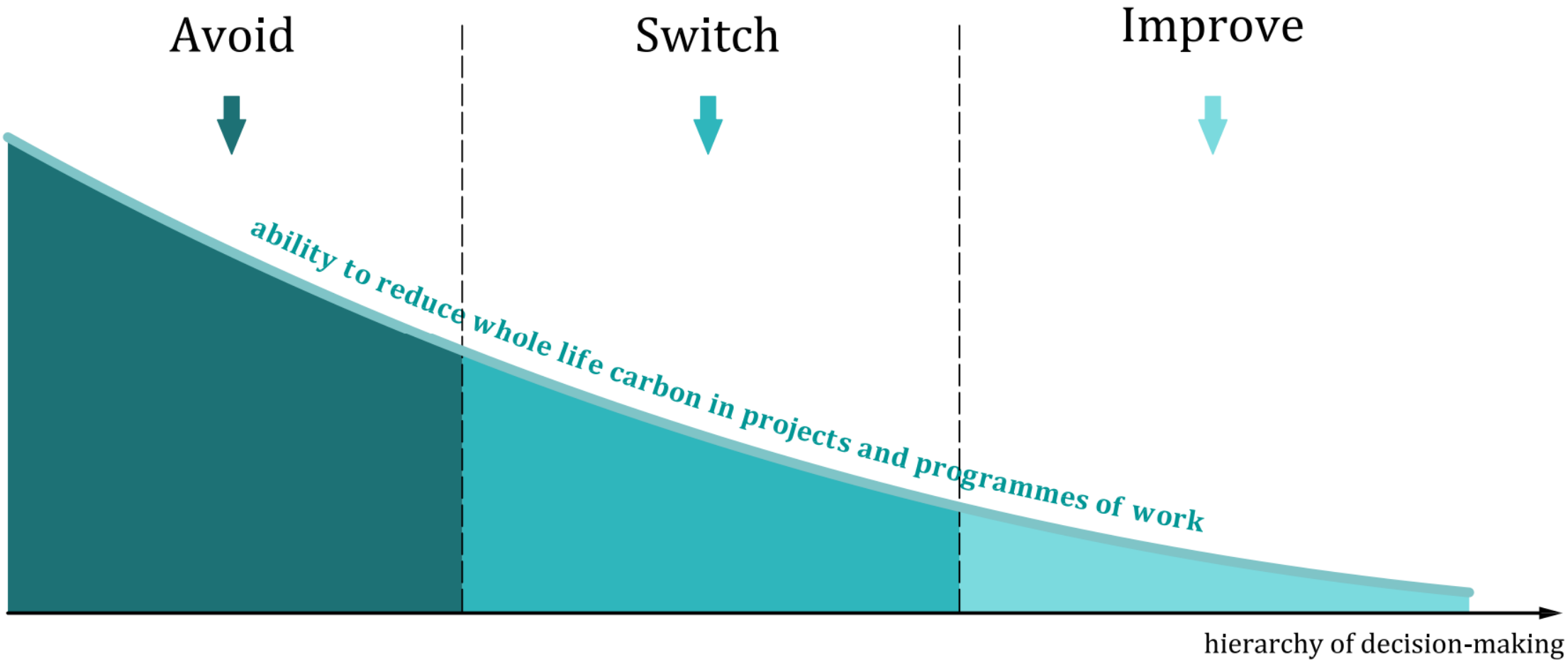


PAS 2080: 2023 Carbon management in buildings and infrastructure: https://www.bsigroup.com/en-GB/standards/pas-2080/

Carbon reduction hierarchy

Prioritise meaningful decarbonisation





PAS 2080: 2023 Carbon management in buildings and infrastructure: https://www.bsigroup.com/en-GB/standards/pas-2080/

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Life Cycle Assessment of CLIC & ILC

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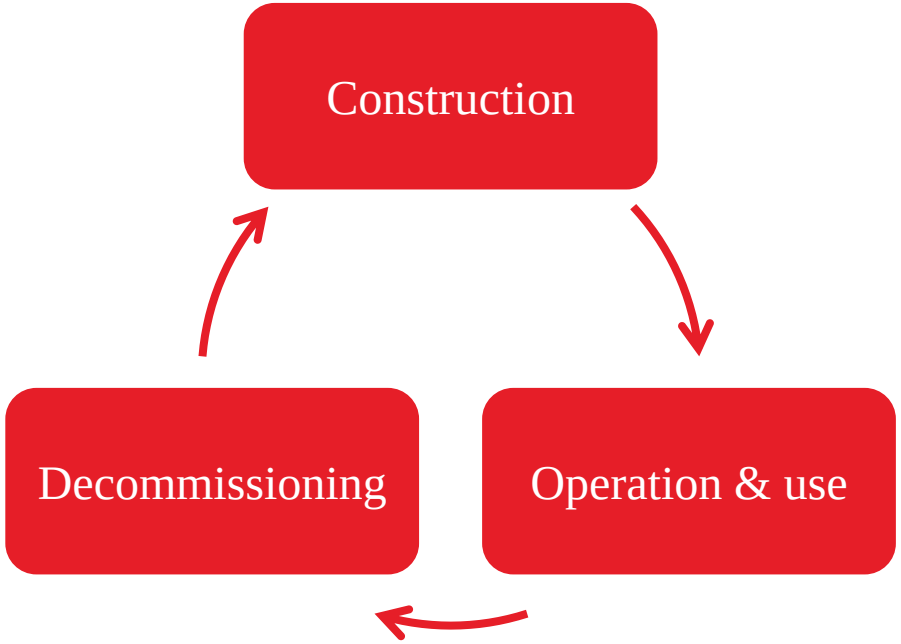
Aims

1. Whole life cycle impact assessment of CLIC and ILC, considering construction impact of the infrastructure and whole life impacts of the machine componentry

2. Identify hotspots and reduction opportunities to influence design development

Life cycle assessment

A life cycle assessment systematically assesses the environmental impact of a product or asset throughout its life cycle

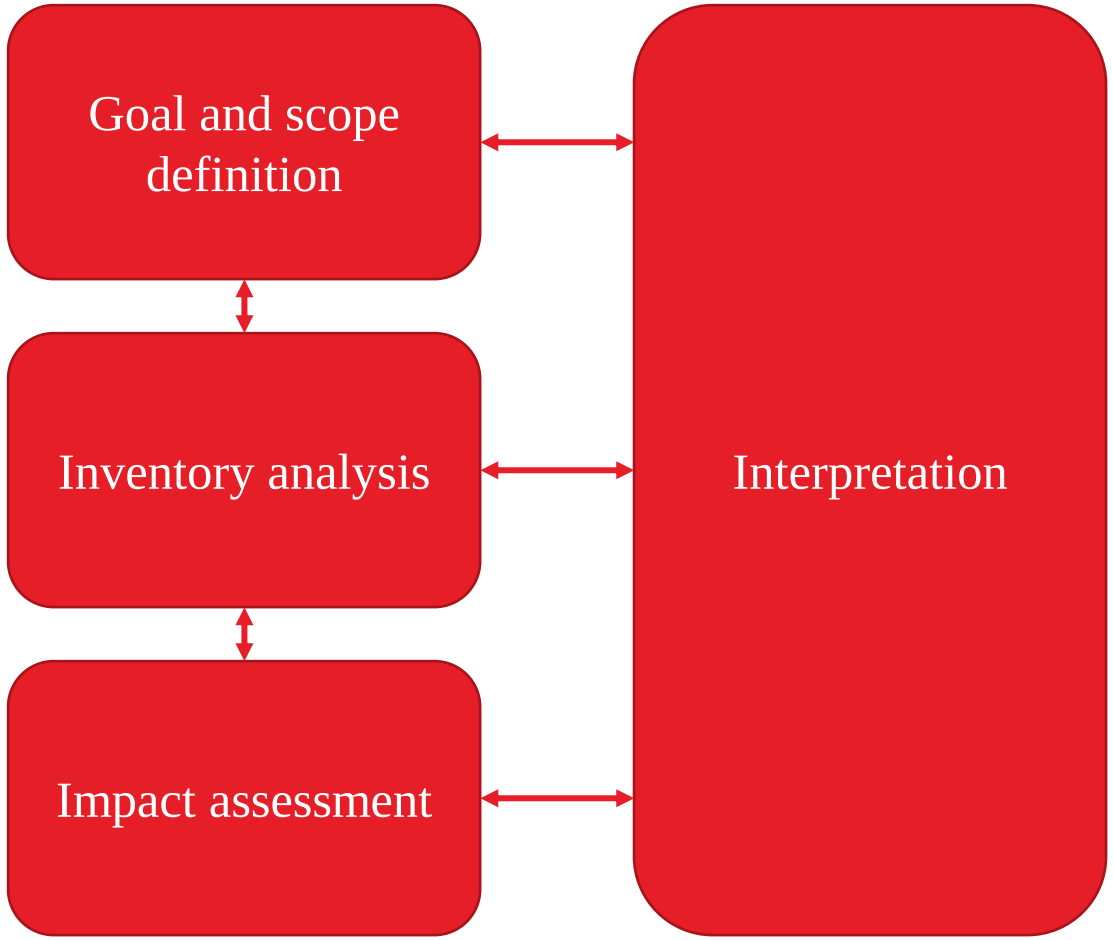


Life cycle assessment

Intended application
Reasons for carrying out study
System boundaries
Assumptions and limitations

Data collection
Data validation
Data aggregation

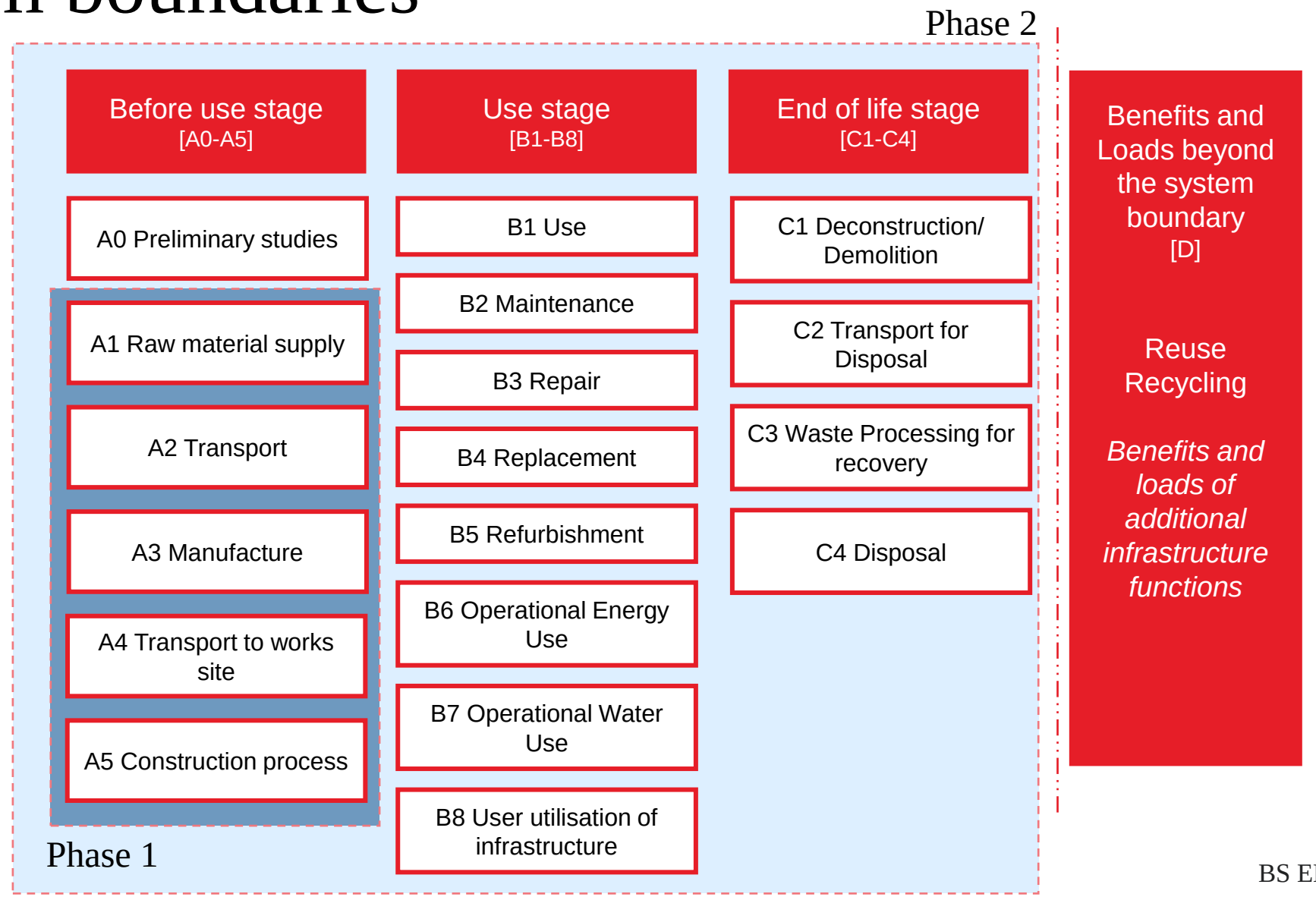
Evaluate potential environmental and human health impacts



Conclusions, limitations and recommendations

ISO 14040:2006

System boundaries



BS EN 17472:2022

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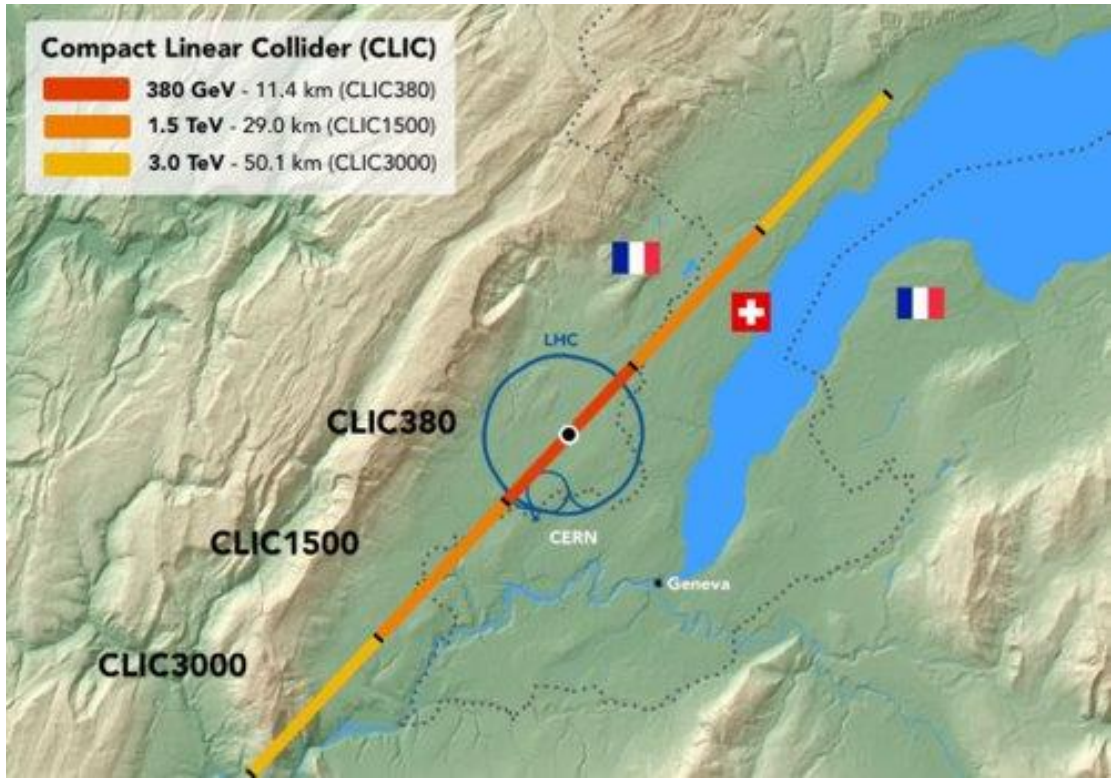
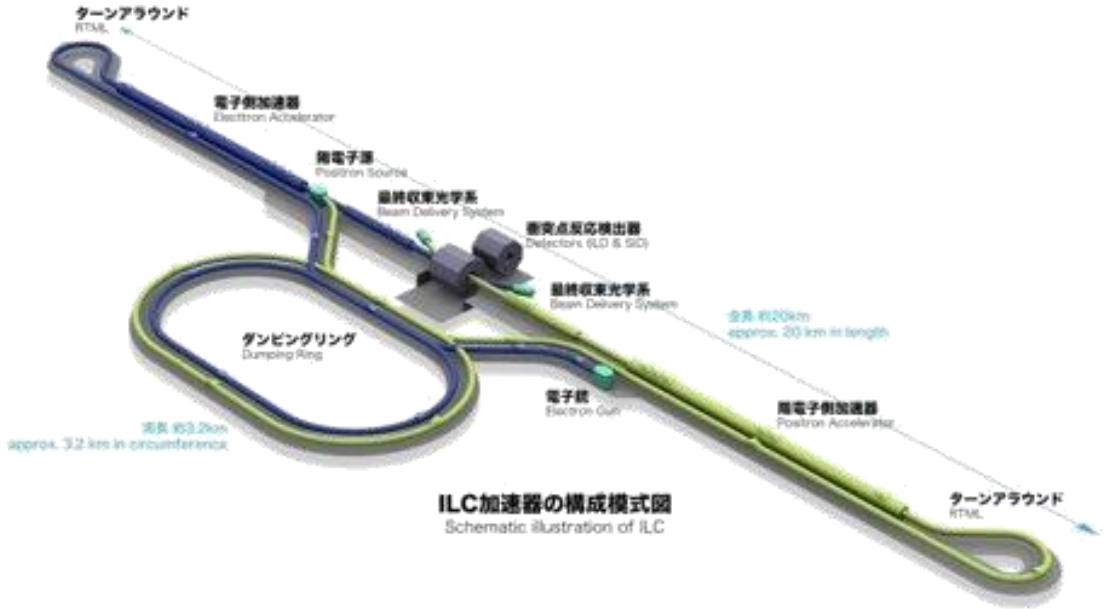
Linear collider options

Compact Linear Collider (CLIC)

a) Drive Beam b) Klystron



International Linear Collider (ILC)

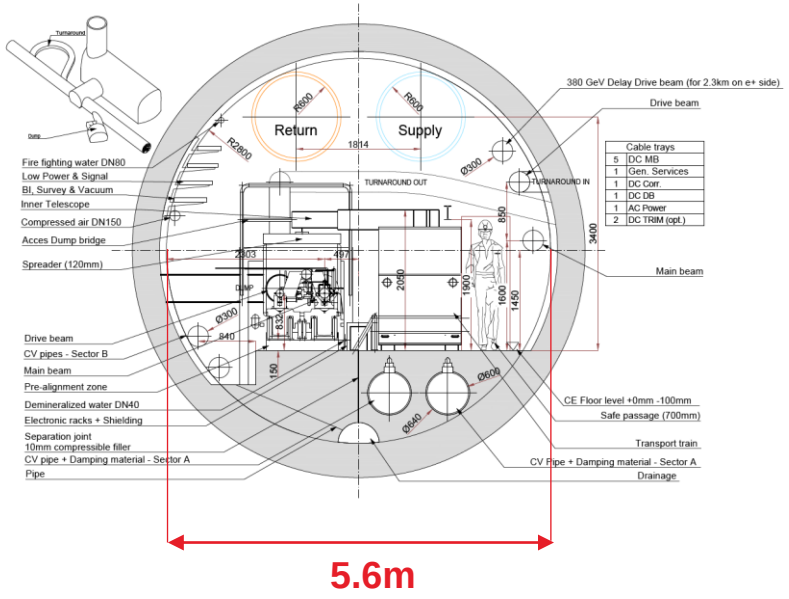


Proposed construction 2030

Linear collider options

CLIC Drive Beam

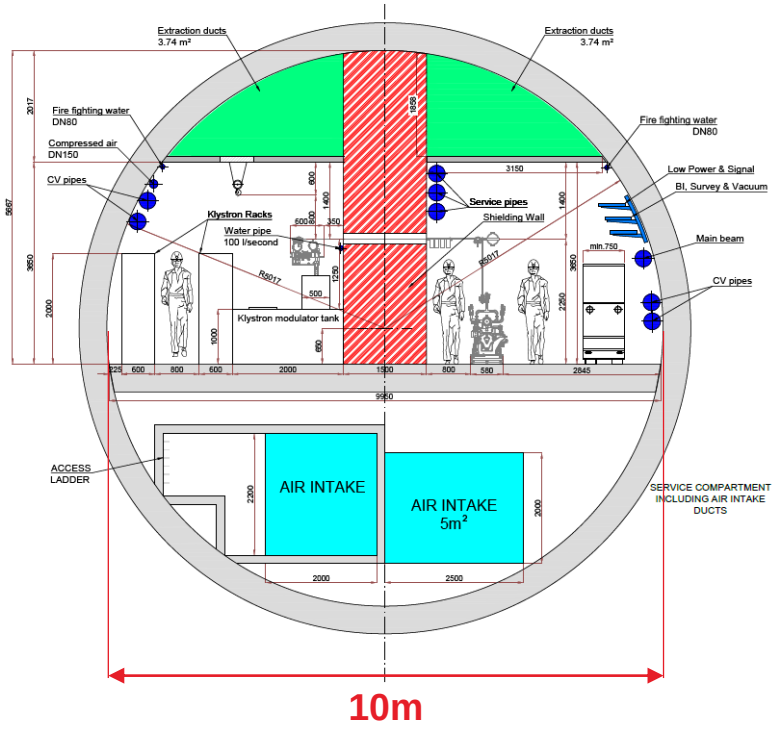
5.6m internal dia. Geneva.
(380GeV, 1.5TeV, 3TeV)



Reference: CLIC Drive Beam tunnel cross section, 2018

CLIC Klystron

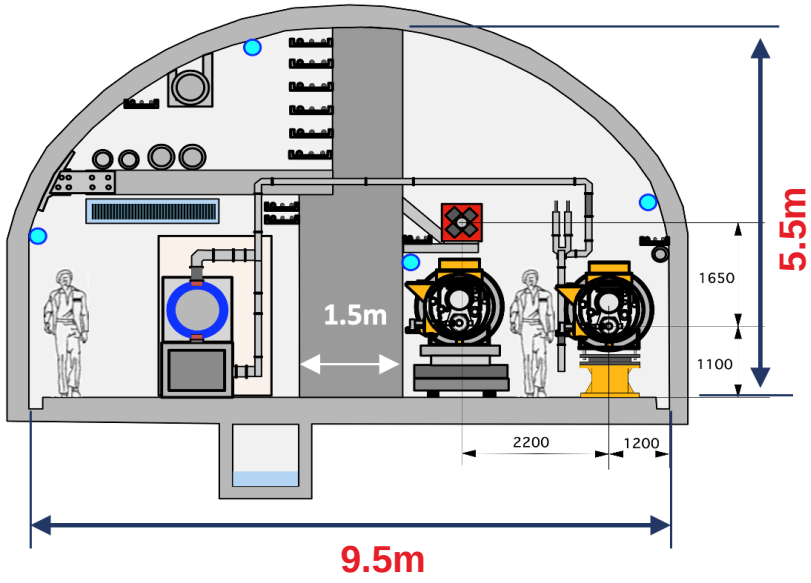
10m internal dia. Geneva.
(380GeV)



Reference: CLIC Klystron tunnel cross section, 2018

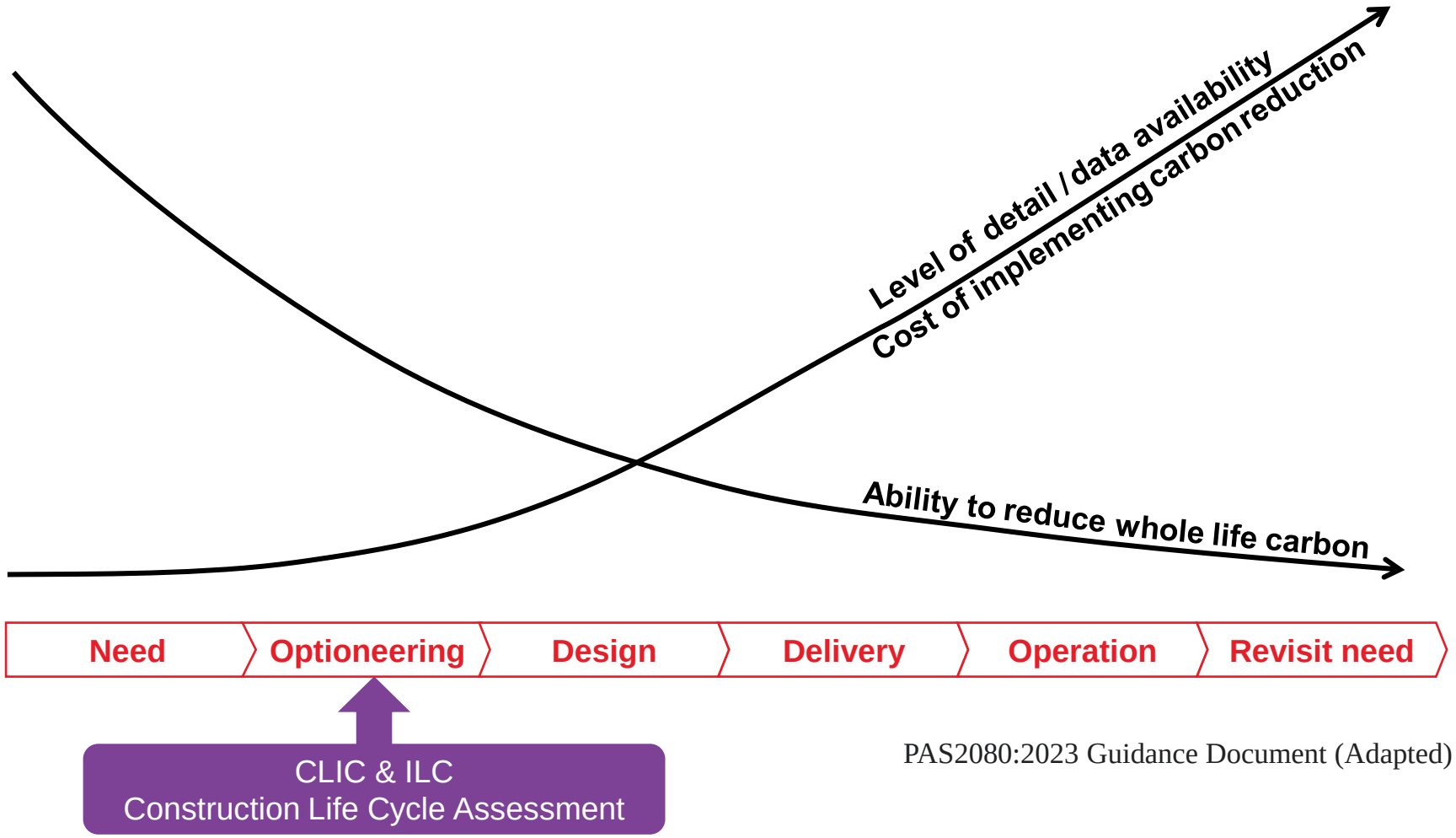
ILC

Arched 9.5m span. Tohoku region, Japan.
(250GeV)



Reference: Tohoku ILC Civil Engineering Plan, 2020

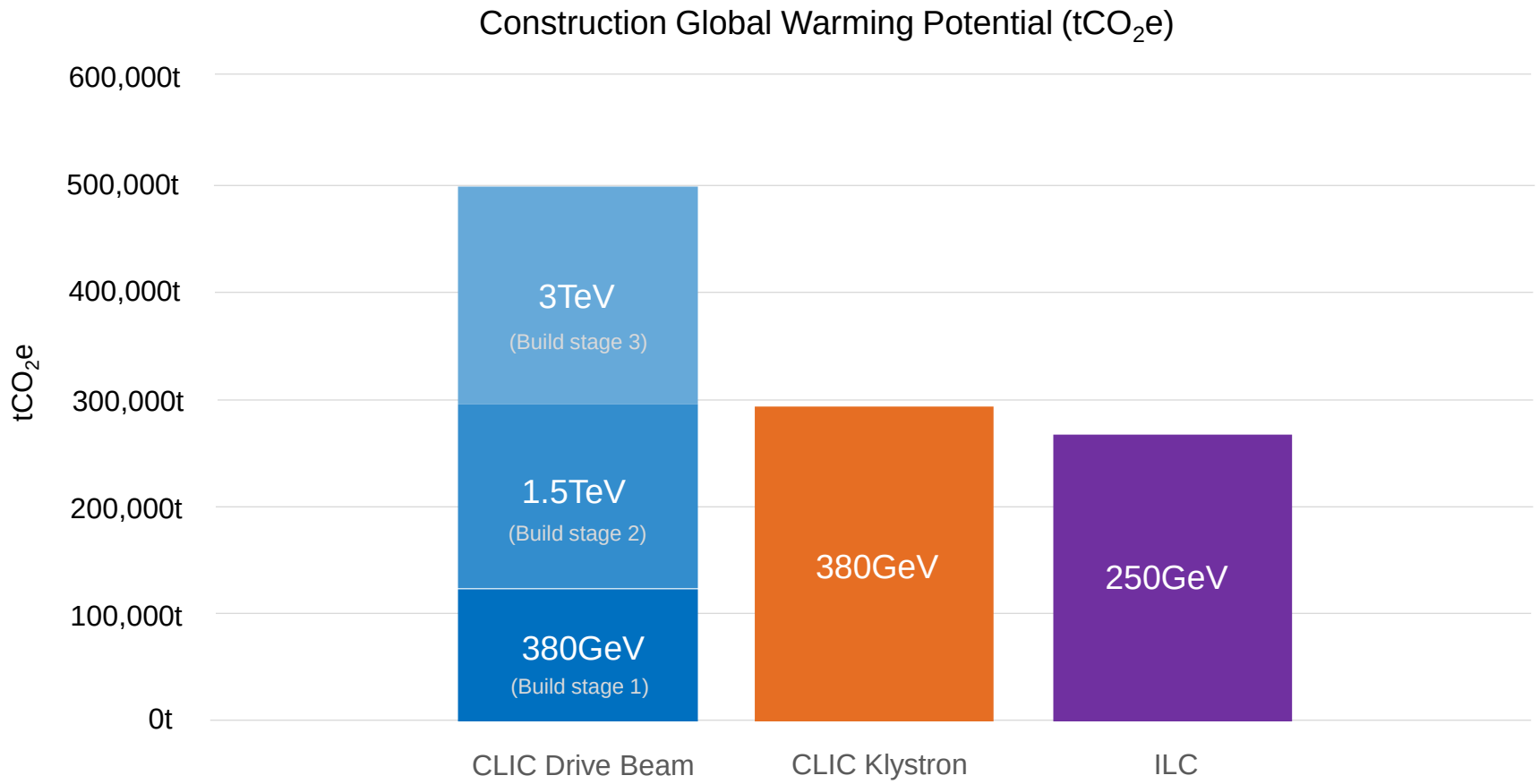
Early stage Influence



PAS2080:2023 Guidance Document (Adapted)

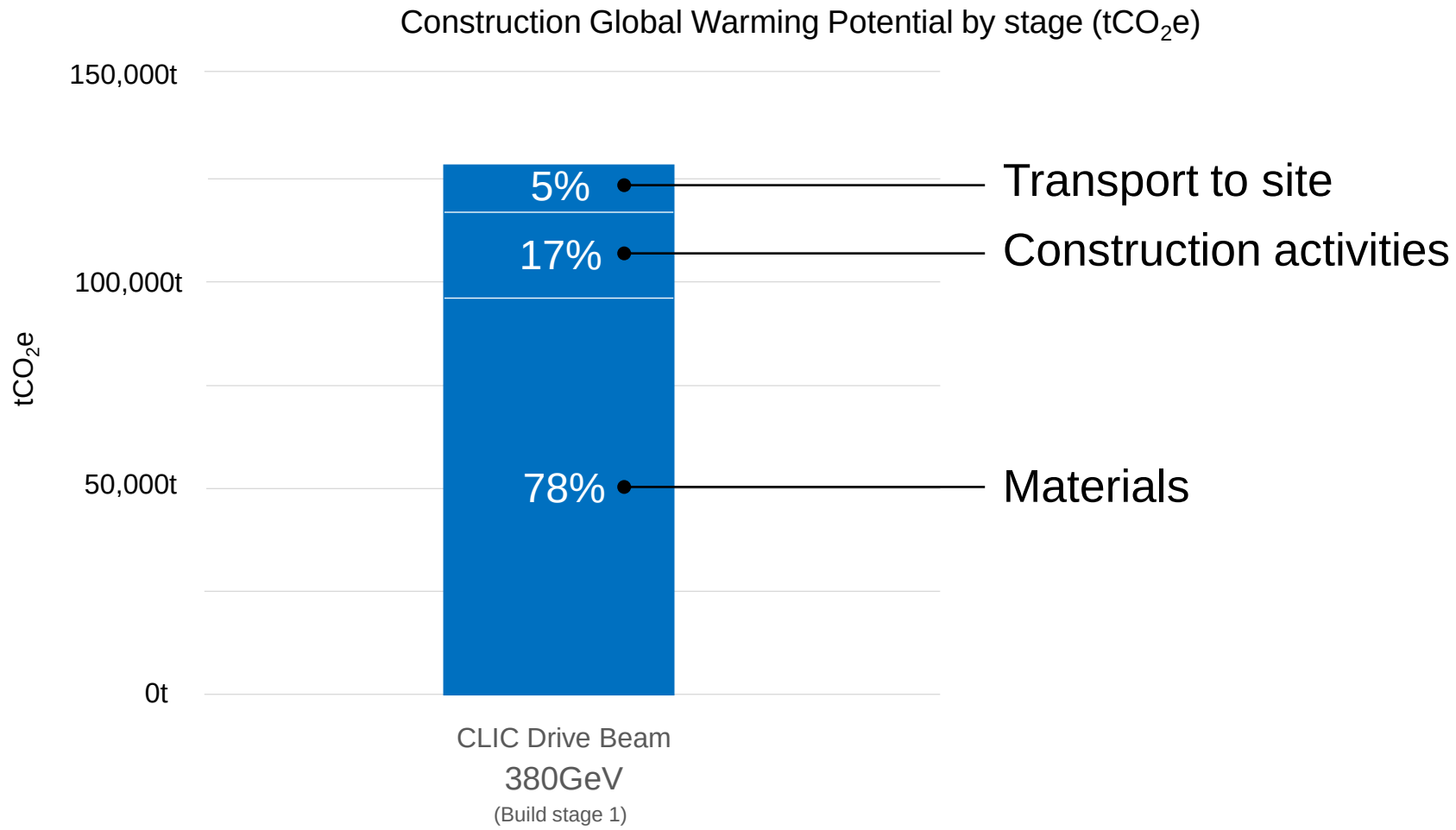
Life Cycle Assessment

CLIC & ILC



Impact assessment

CLIC Drive Beam 380GeV



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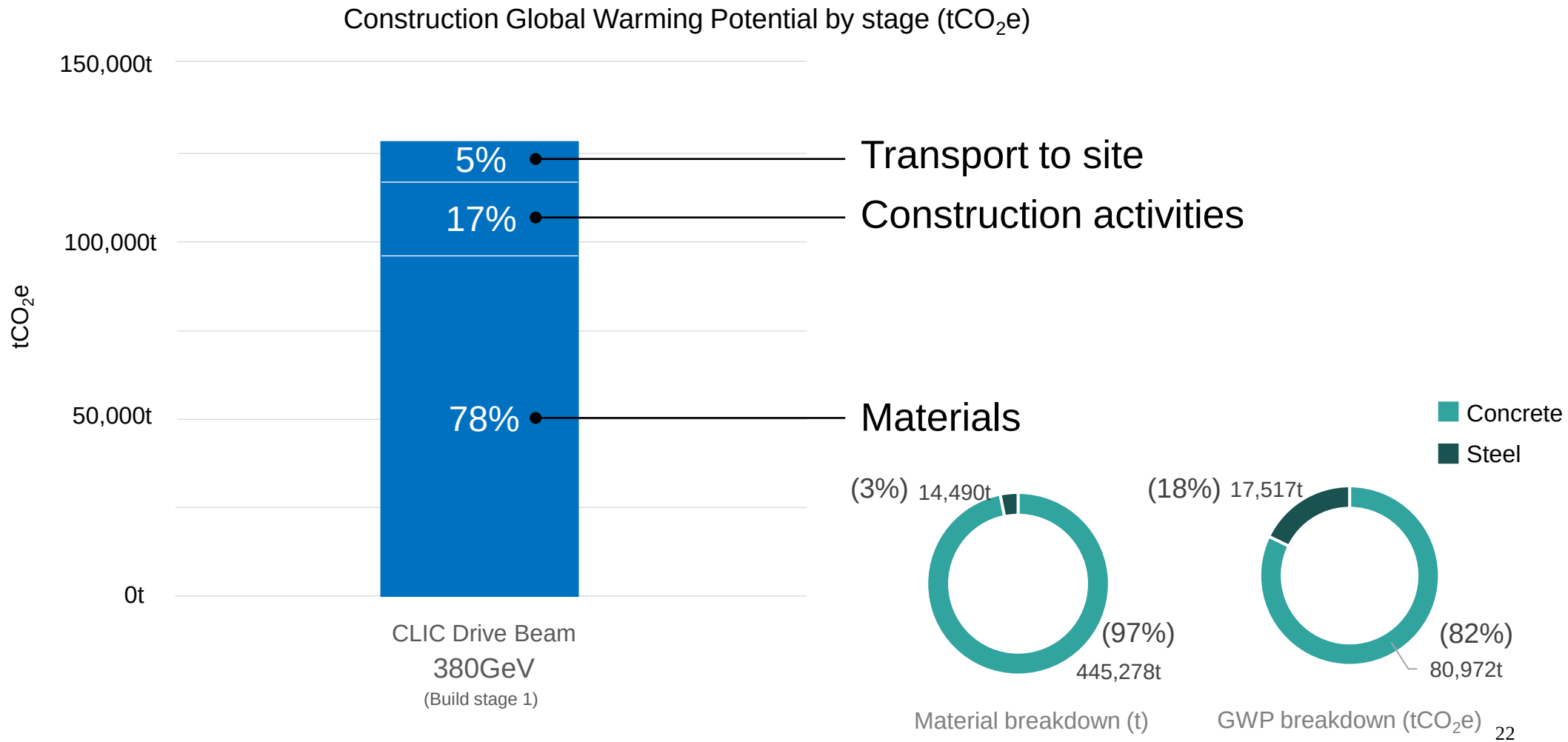

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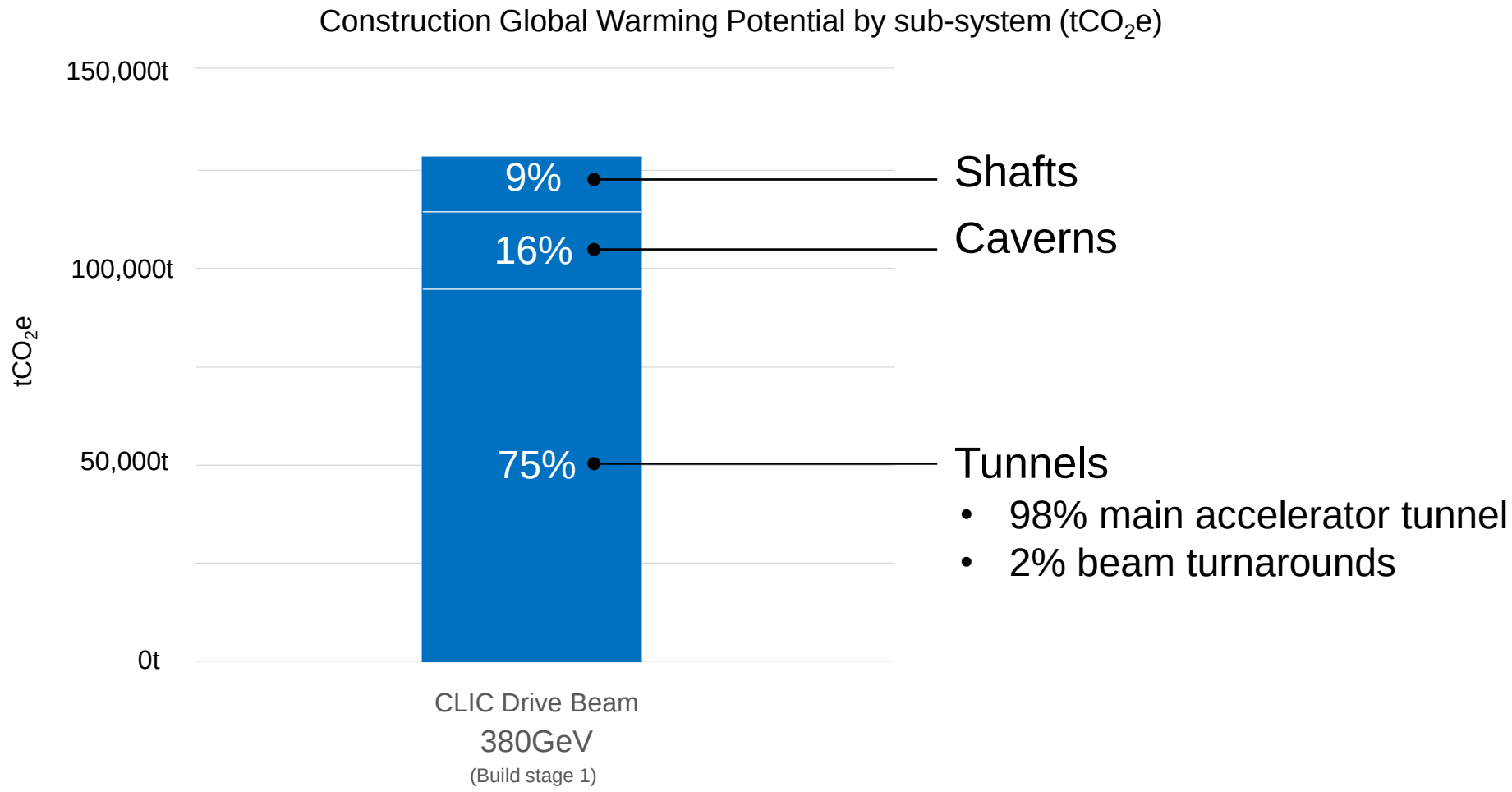

Impact assessment

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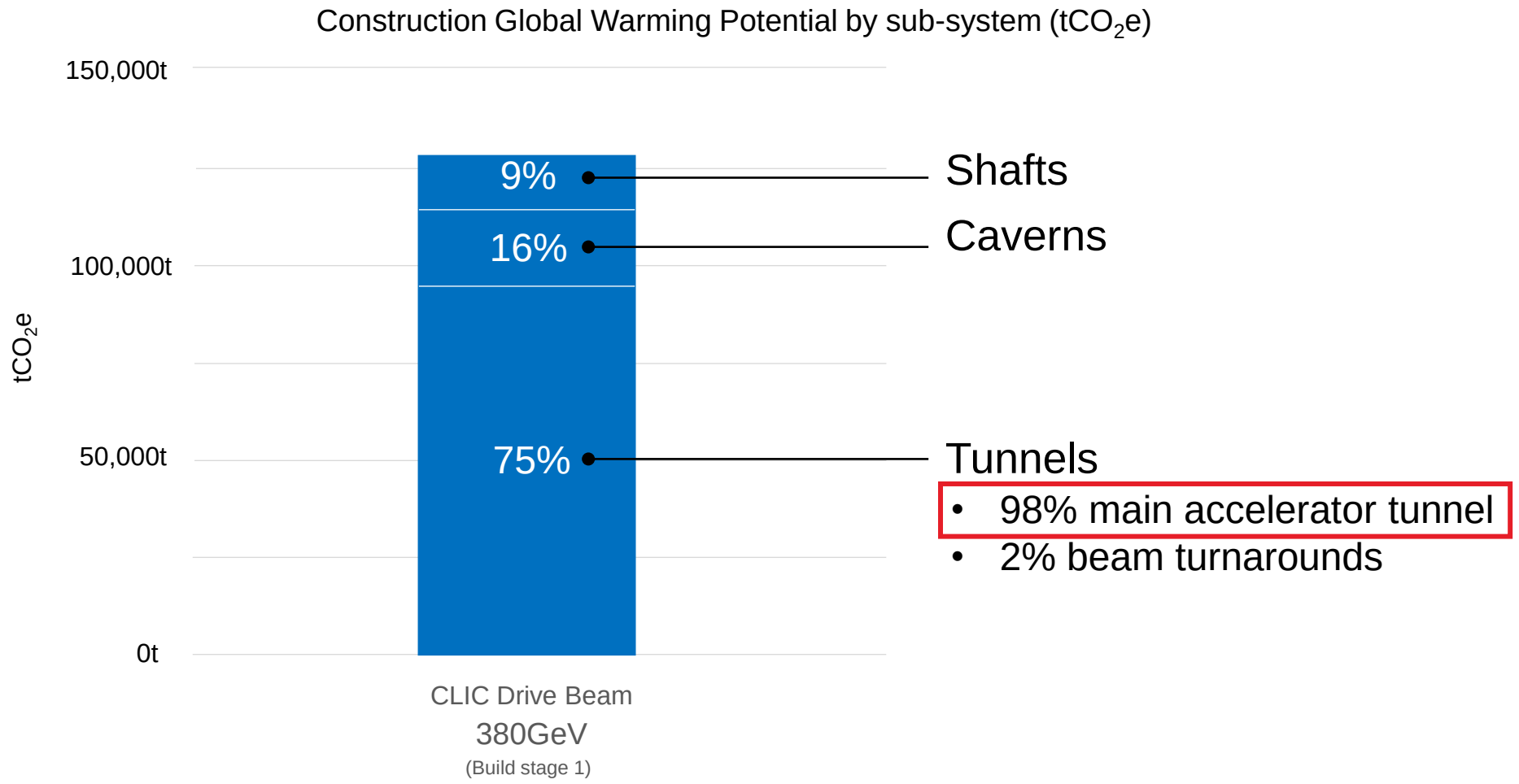

Hotspots

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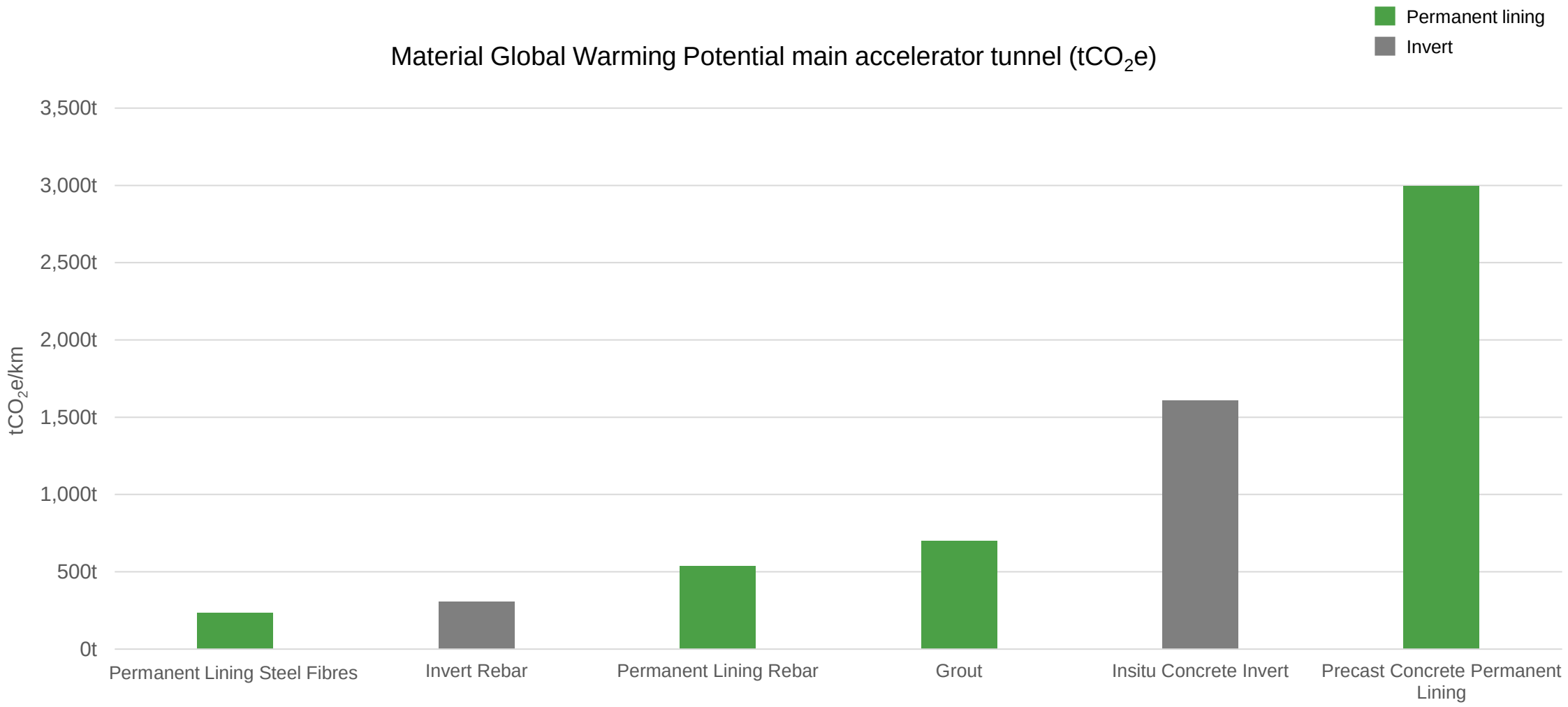
CLIC Drive Beam 380GeV main accelerator tunnel



Benchmarks

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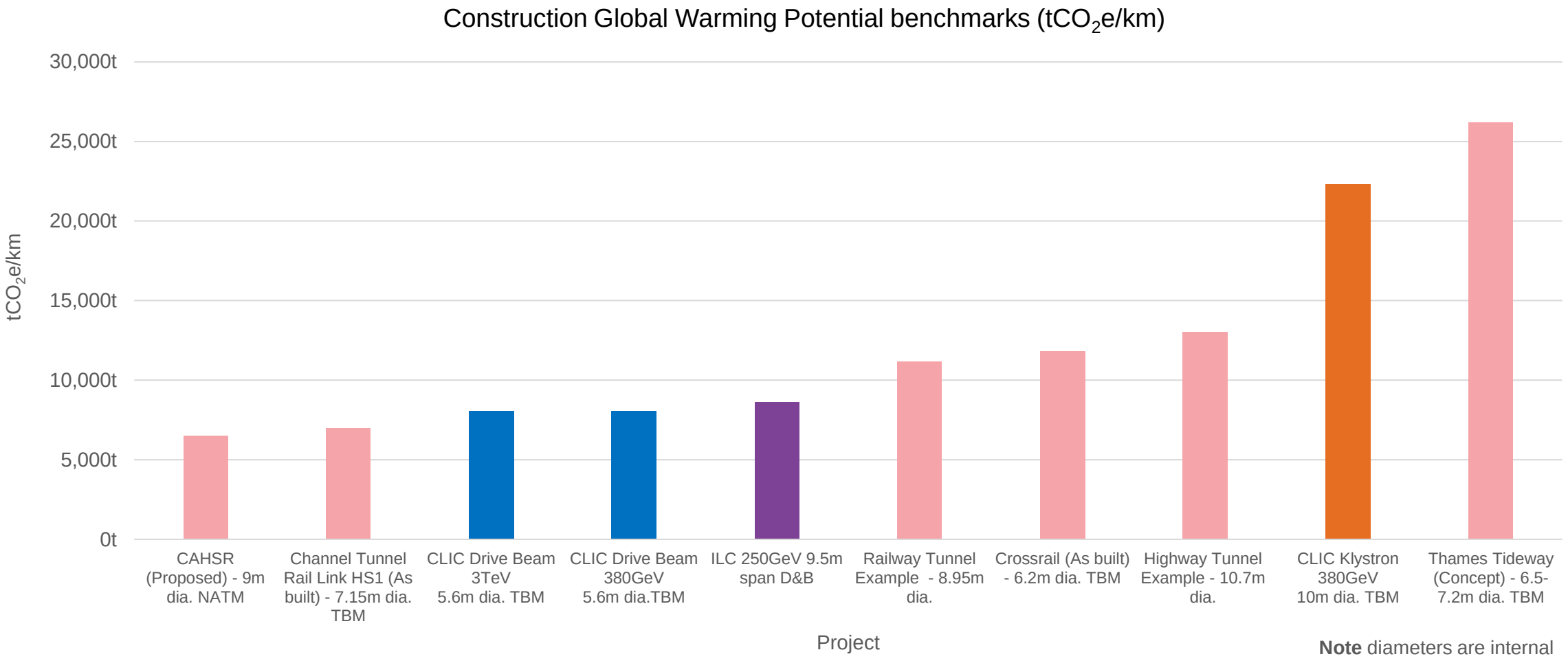
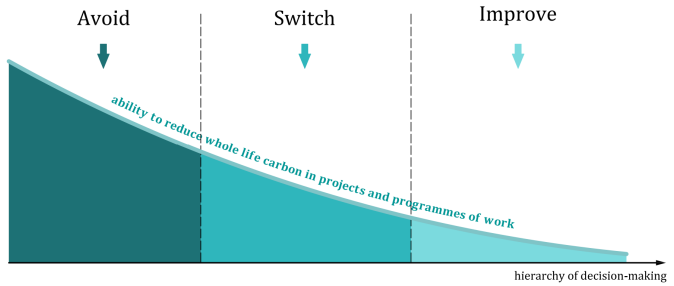
CLIC & ILC main accelerator tunnel



Note diameters are internal

Reduction opportunities

CLIC Drive Beam 380GeV tunnels



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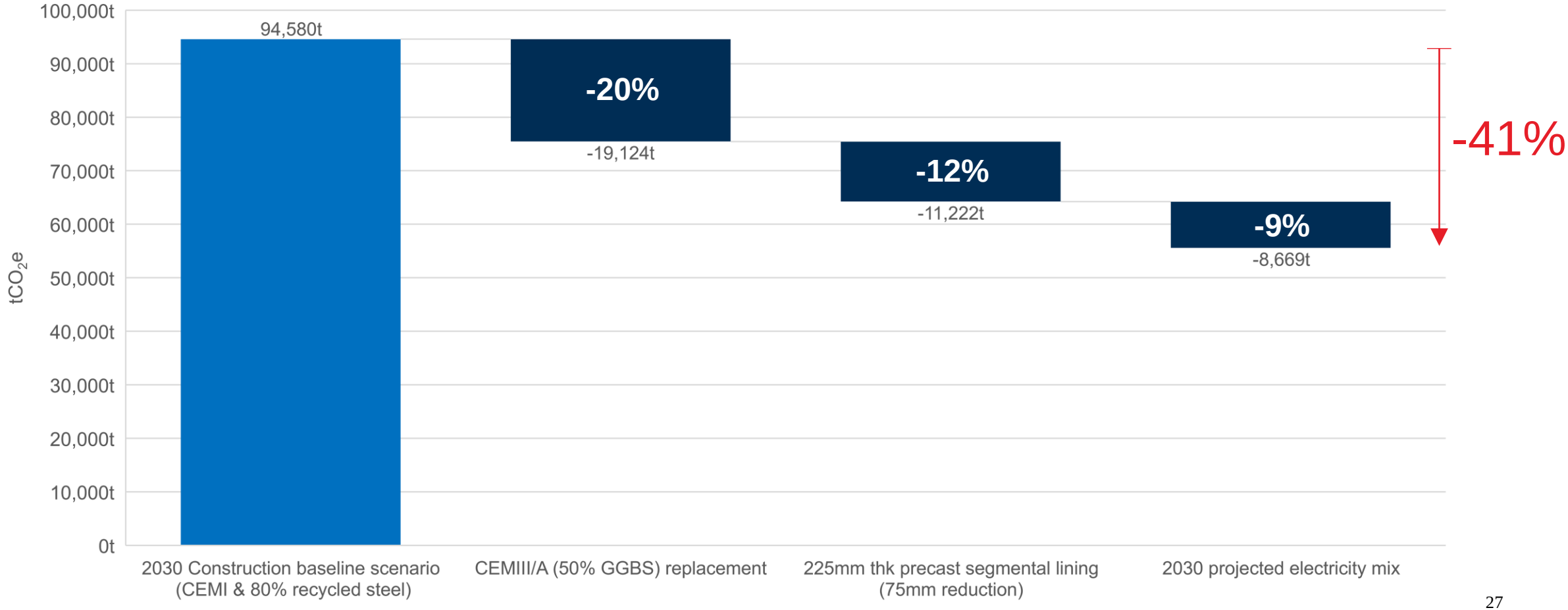
Construction GWP possible reduction opportunities (tCO_2e)



Reduction opportunities

What else?

- Partially replacing Portland cement (CEMI)
- Totally replacing Portland cement with “Portland cement-free”
- Carbon sequestering in concrete
- Rubber tyre steel fibres
- Collaborating with suppliers dedicated to achieving net zero steel production
- Alternative use of steel in construction and temporary works

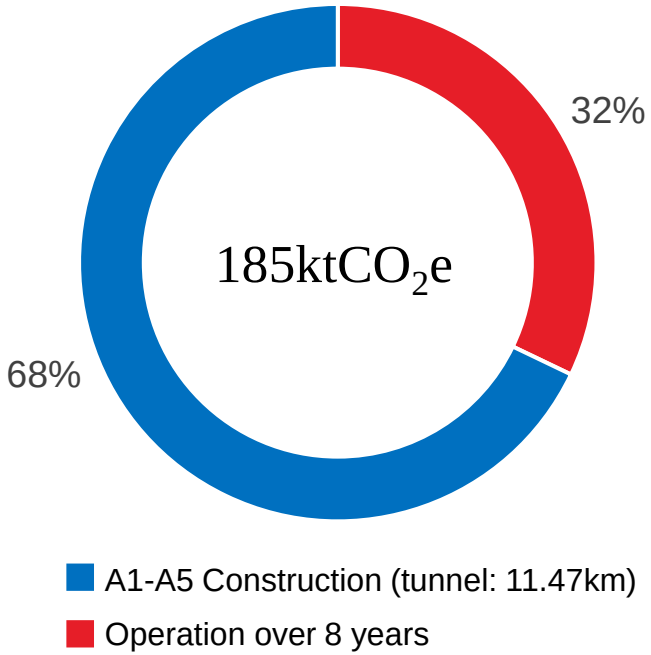
Construction and operation carbon of CLIC

CLIC Drive Beam

Operational estimates provided by CERN. Based on a projected electricity mix in 2050 (50% nuclear, 50% renewables).

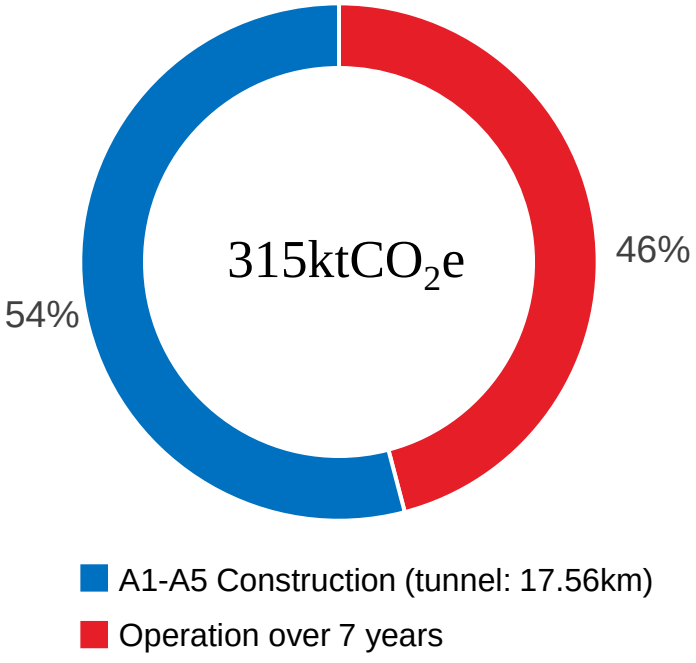
380GeV

Construction GWP is equivalent to 1.7 decades of running accelerator



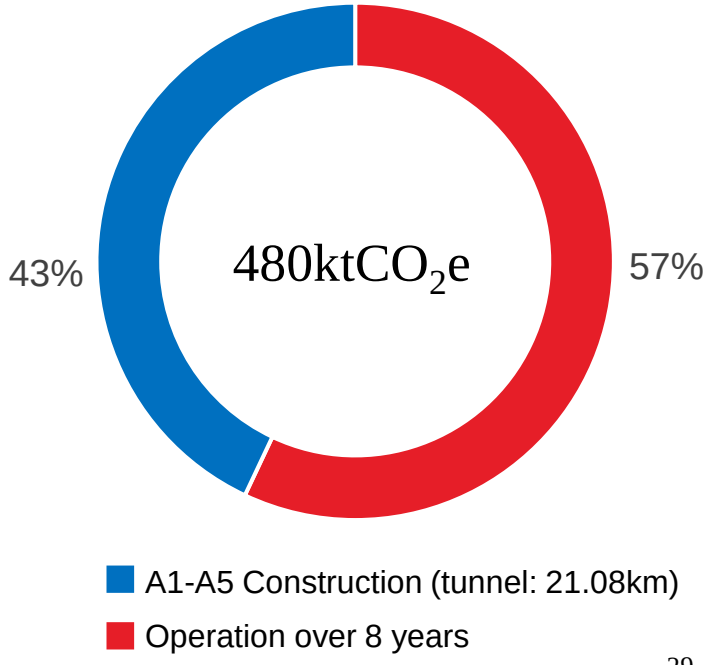
1.5TeV

Construction GWP is equivalent to 0.8 decades of running accelerator



3TeV

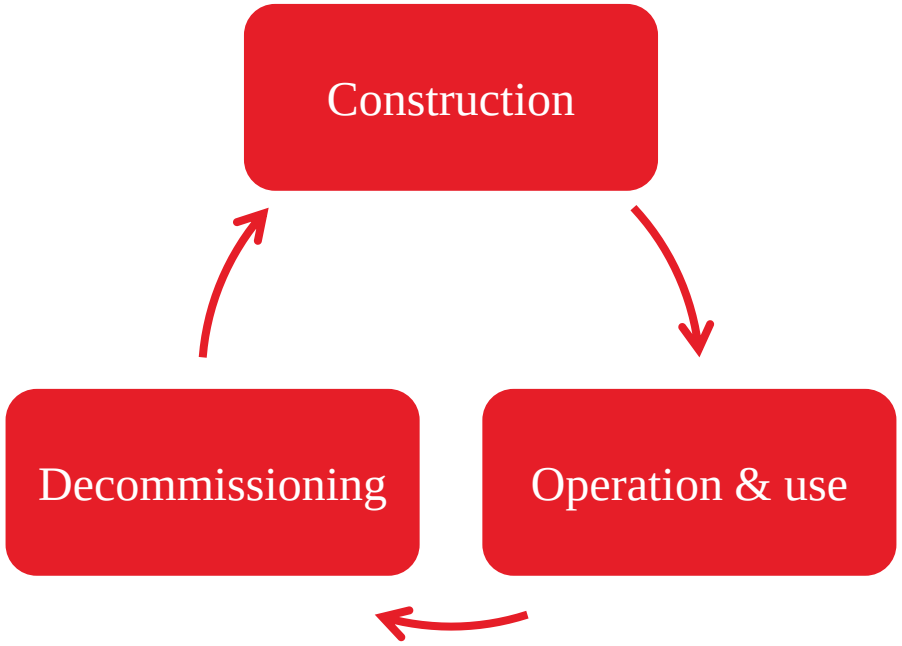
Construction GWP is equivalent to 0.6 decades of running accelerator



Current work

Phase 2

- Construction life cycle assessment of CLIC injector complex and CLIC & ILC tunnel services systems (Construction)
- Whole life cycle assessment of the machine componentry for CLIC & ILC (Construction, operation & use, decommissioning)



Learning points

- Establish a baseline at early stage of design to inform design development
- Managing carbon throughout the project's lifecycle is integral to understand and reduce carbon impacts
- Evaluate hotspots and reduction opportunities e.g. design changes, optimisation, material alternatives
- Evaluate whole life carbon to influence operational / end of life of asset

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Holistic Impact Framework for CERN Campus

Aims

1. Help to shape the vision & ambition of SCE Net Zero Consolidation Programme

2. Evaluate an impact framework which:
   - captures the carbon impact of projects, and captures any intended or unintended, positive or negative impacts on other environmental and social aspects
   - apply to both existing and future projects across the Campus, also providing insights for the decision-making of the masterplan implementation
   - consider buildings and wider campus in an integrated, systems-thinking manner

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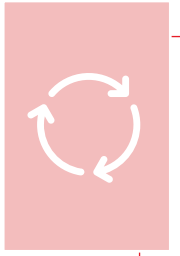
Vision and ambition

Systems thinking decarbonisation



Regenerative environmental stewardship

Positive social purpose

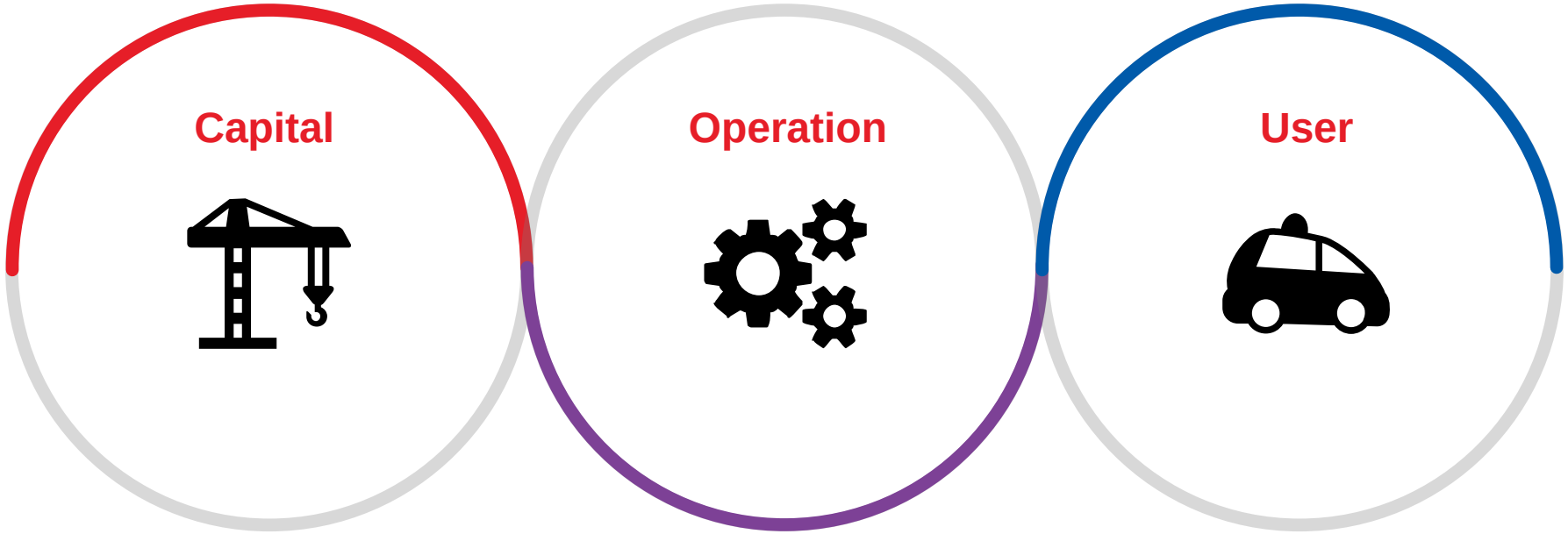
Holistic Impact Framework

HIF is a simplified impact framework to aid campus-wide gap analysis and early project definition and prioritisation

$$Index = \frac{\sum Indicator\ scores}{3 * \sum Indicators}$$

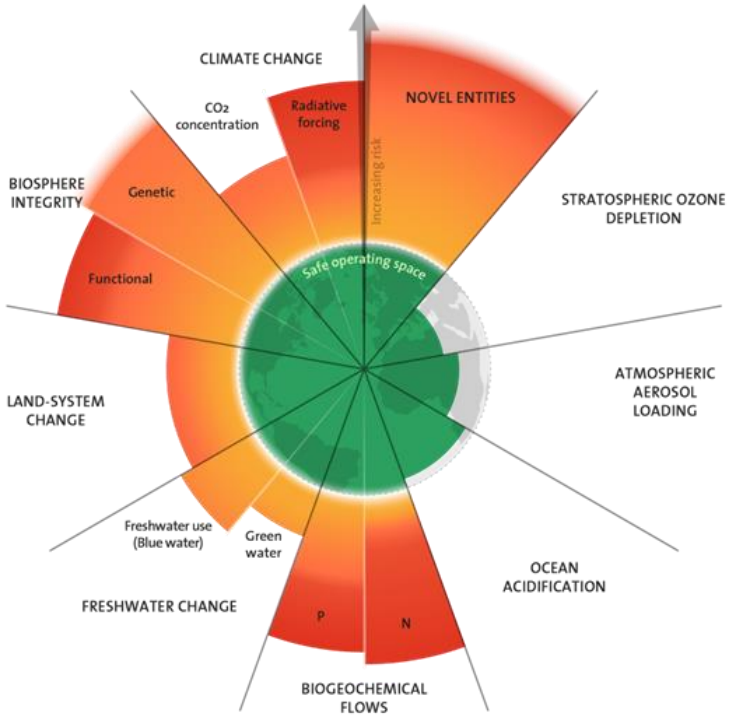
Carbon Impact

PAS2080:2023 Carbon Management in Buildings & Infrastructure

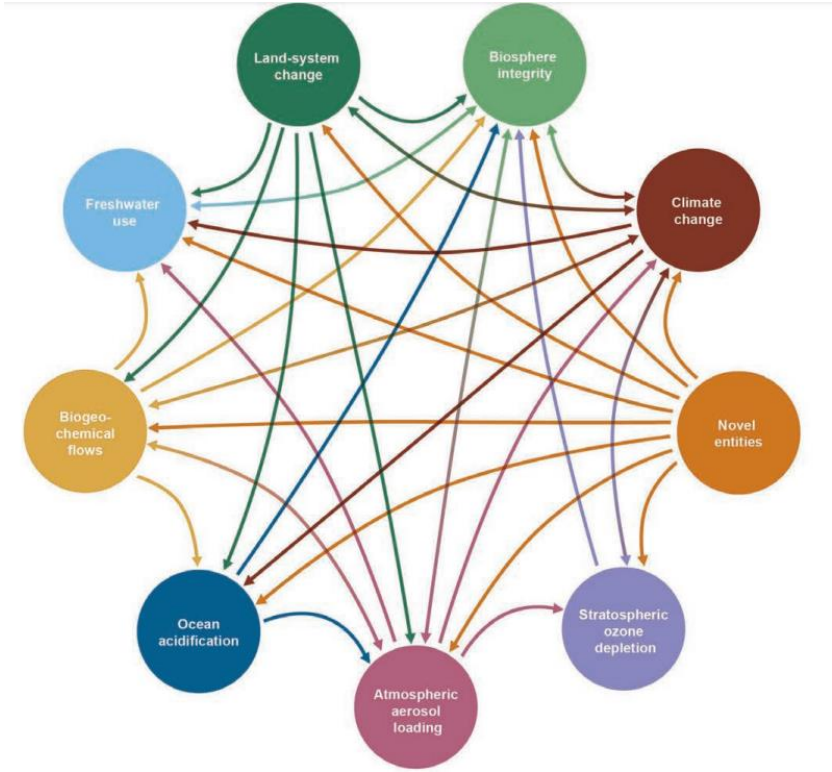


Environmental Impact

Planetary Boundaries Framework



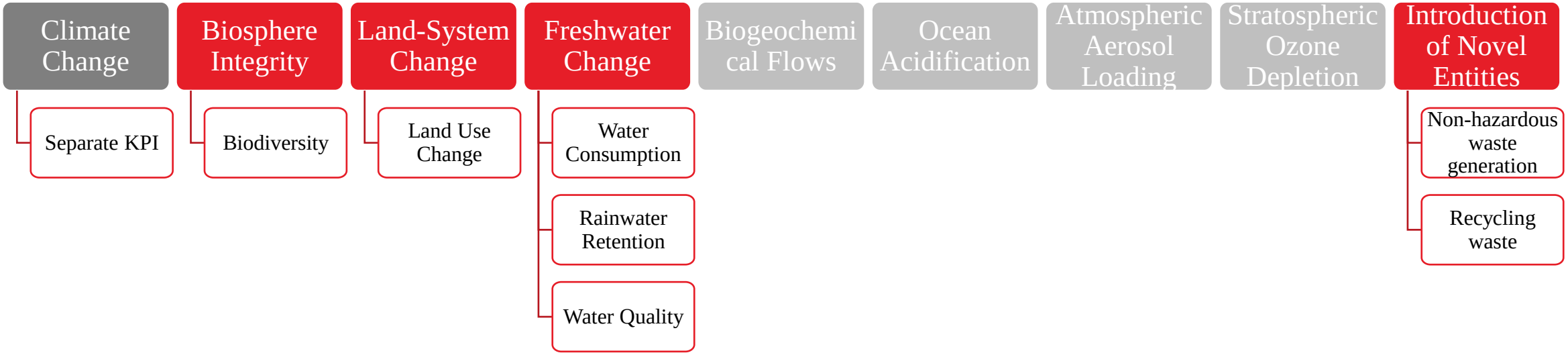
The 2023 update to the Planetary boundaries.
"Azote for Stockholm Resilience Centre, based on analysis in Richardson et al 2023".



Impacts of Earth system processes on each other.
"Designing for planetary boundaries", Arup

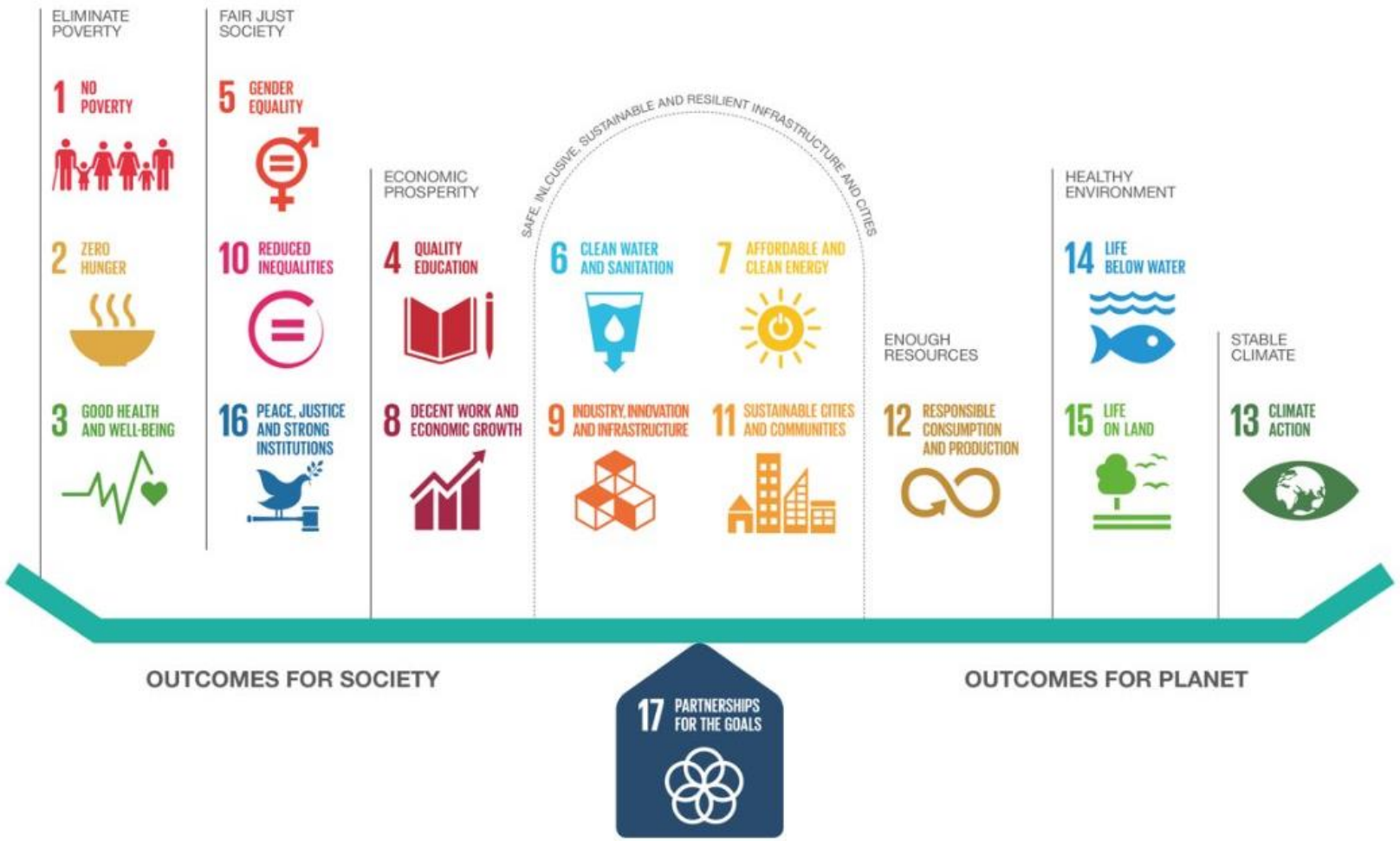
Environmental Impact

Sub-set of indicators



Social Impact

Sustainable Development Goals Framework



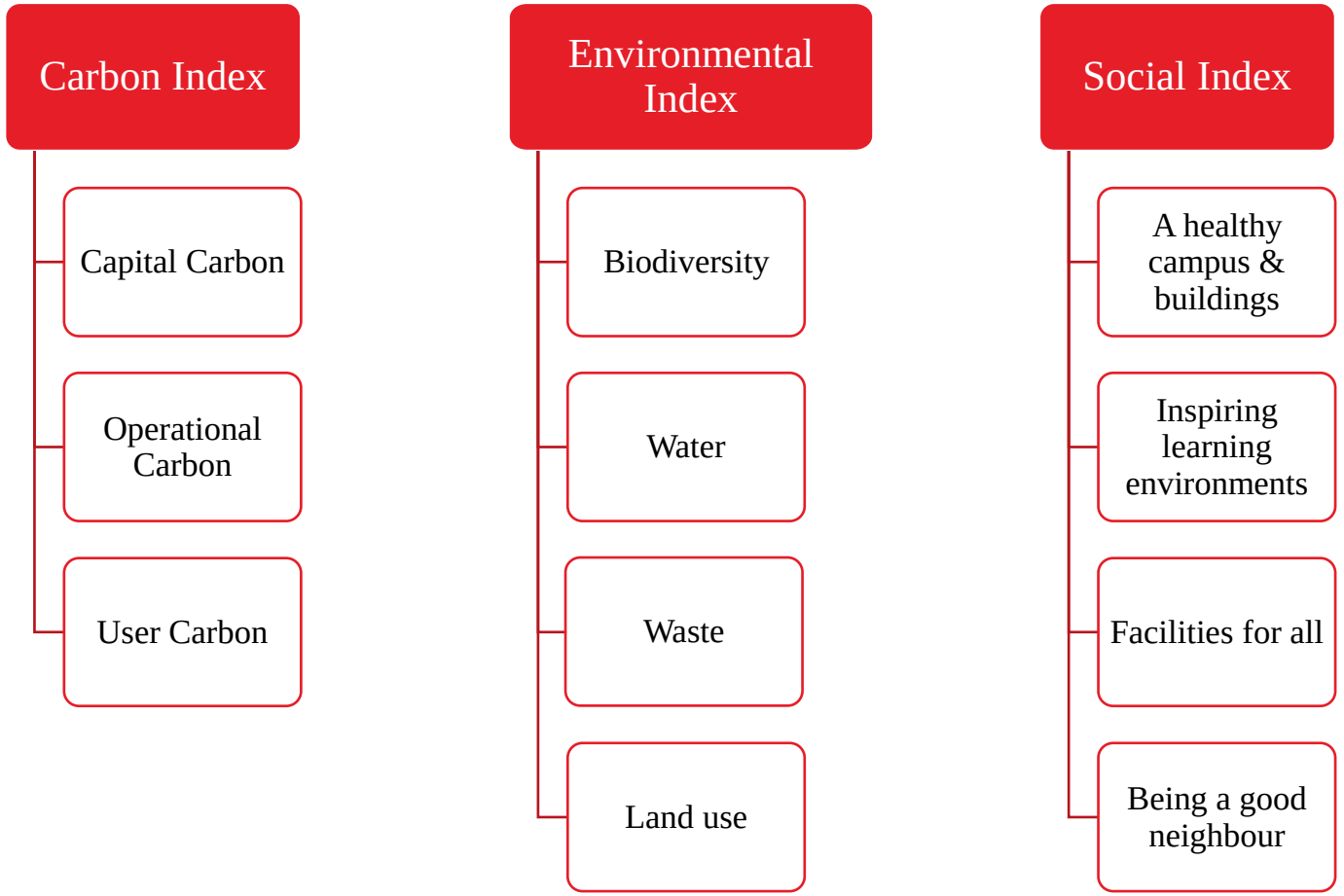
Social Impact

Sub-set of indicators

- A healthy campus and buildings
- Inspiring learning environments
- Facilities for all
- Being a good neighbour

Holistic Impact Framework

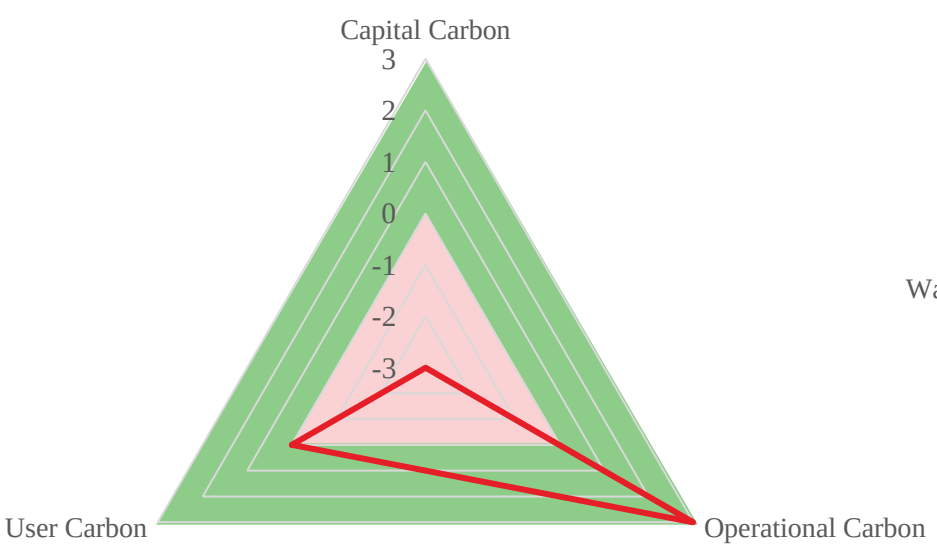
Indicators feeding into the 3 Indexes



Holistic Impact Framework

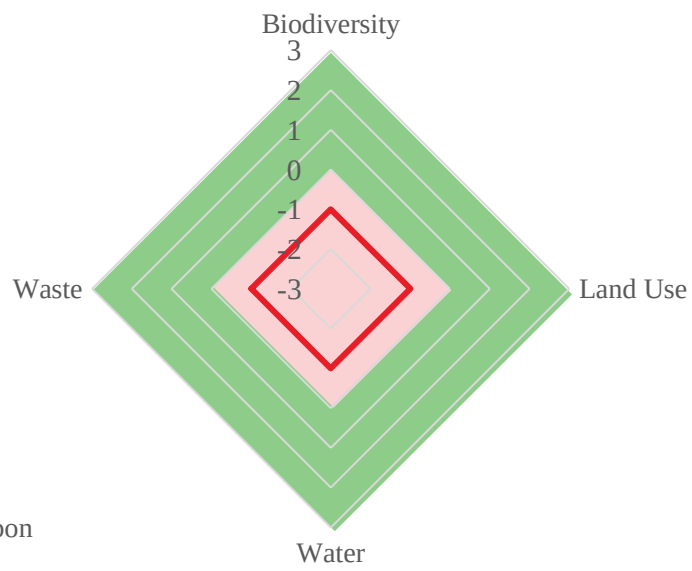
Summary of results for Project B776: Prevessin heating plant

Carbon Impact



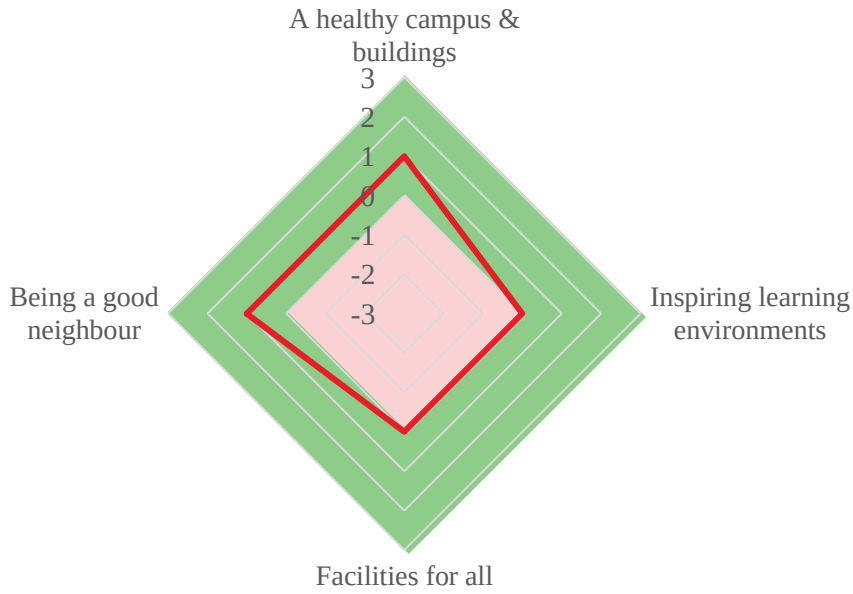
Carbon index: 0.00

Environmental Impact



Environmental index: -0.33

Social Impact



Social index: 0.17

CERN RESP Dashboard

Home | Progress summary | Interventions | Benchmarking | Project impacts (HIF) | Campus impacts (HIF) | Campus map | Assumptions

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Last updated: December 2024

CERN Campus Regenerative Environment and Social Programme (RESP)

Project impacts

The Holistic Impact Framework (HIF) provides a process for including carbon, environmental and social impacts in decision making for campus projects on a scale of +3 to -3.

Select a project or domain to compare scores for the Carbon, Environmental and Social indicators.

Project

Multiple selections

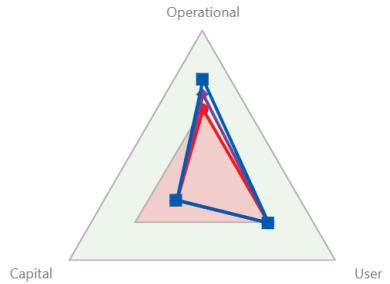
Domain

All

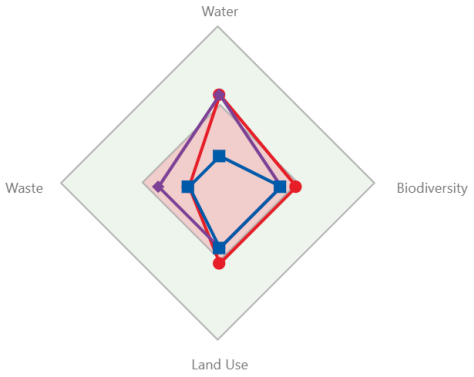
Key

- Score - B3150
- Score - B60 consolidation
- Score - B777

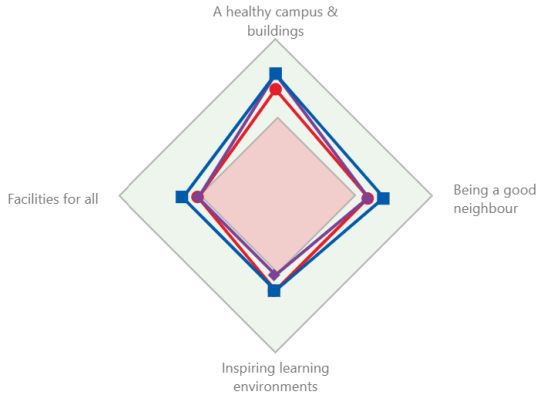
Carbon impact



Environmental impact



Social impact



Learning points

- Consider the holistic impacts of a project to inform decision making
- Use a consistent framework that can be applied to multiple project options to enable fair comparison
- Clear data visualisation (e.g. through dashboards) can enable stakeholders to use the holistic impact framework more readily

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STFC Environmental sustainability strategy

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STFC Environmental sustainability strategy

Arup experience: example of environmental sustainability strategy with Science and Technology Facilities Council, UK

UK HEP Forum 2024: Sustainable future for HEP

https://conference.ippp.dur.ac.uk/event/1322/timetable/#20241126

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Key takeaways for ETO

- Lessons learnt from CERN demonstrate importance of considering sustainability at the early stage, in a wide and holistic sense.
- The importance of sustainability considerations is core to the value engineering, costing and design optimisation decision making process.
- Various drivers and challenges which need to be identified and planned through in consistent ways.
- Collaboration and coordination is key for successful implementation of sustainable development.
- Using a consistent framework enables evaluation and fair comparison of of baselines that can be continuously evaluated with design development.

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