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Marinal WP5.1: Environmental impact of Aluminium compared to steel in a marine construction

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MarinAl subproject 5.1

- **Goal:** To understand the environmental impact of replacing steel with aluminium in marine constructions.

- **Objectives of study**
  - Choose a suitable marine construction
  - Life Cycle Analysis – compare CO_2 emissions in all stages
  - Compare different material cases
    - Steel
    - Aluminium
      - European Average Ingot
      - Hydro Reduxa 4.0
      - Hydro CIRCAL 75R

What makes Aluminium suitable for marine applications?

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Light weight

Functionality

Corrosion resistance

Moving or floating structures

Economy of power during service

In remote places

Transport costs and ease of assembly are important

When maintenance must be limited

Critical infrastructure where downtime must be low

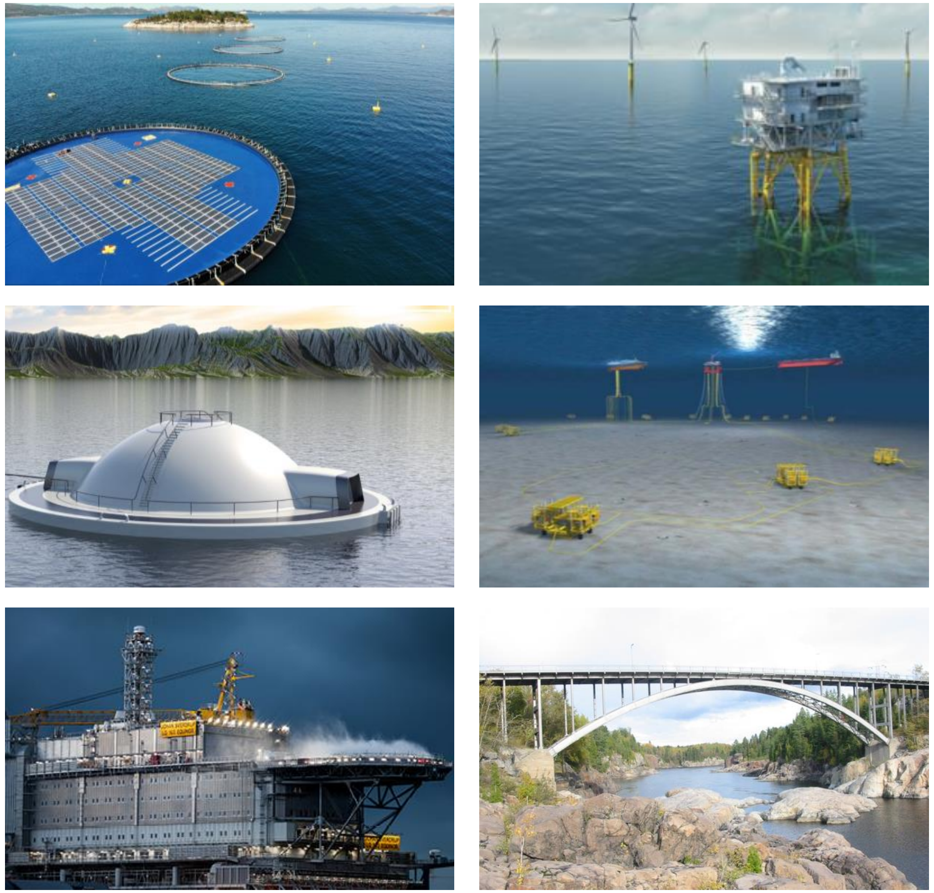
In corrosive environments

Most marine applications

Illustrations: 1) Lifting bridge in Fredrikstad, Sintef (2018) 2) Prefabricated bridge being transported by helicopter, European Aluminium (2020) 3) Sintef 4) Leirvik

Choice of structure for Life Cycle Analysis

- Utilizing benefits of aluminium – low weight, functionality and corrosion resistance
- Focus on impact of material – almost entirely steel or aluminium construction
- Requires a complete redesign from steel, due to different mechanical properties
- Few available sources with alternative aluminium and steel designs.



Potential and current use-cases of aluminium in the marine environment. Source: Hydro Market study (2021)

Sources:
Kjell Lunde and Henrik Neshein, «Possibilities and Implications by Designing an Aluminium Integrated Template Structure», Master Thesis at the Department of Geoscience and Petroleum, Norwegian University of Science and Technology (2017)
Martine Bekkelund, «Large Aluminium Constructions – Market Analysis». Hydro Internal Report (2021)

Integrated template structure (ITS)

- Base for tapping several petroleum wells on the seafloor
- High total weight (298 tonnes), completely made of metal, static load scenario
- Master thesis from NTNU (2017)
  - Compares current ITS design using steel at Gjøa field with a proposed aluminium alternative
  - Aluminium design gives a weight reduction of 36%, with an equivalent total cost

A four-slot integrated template structure for use on the Norwegian Continental Shelf. (Pribytkov, 2017)

Sources:
Kjell Lunde and Henrik Neshein, «Possibilities and Implications by Designing an Aluminium Integrated Template Structure», Master Thesis at the Department of Geoscience and Petroleum, Norwegian University of Science and Technology (2017)
Eugene Pribytkov, «Optimization of Integrated Template Structures for Arctic Subsea Production Systems. Or how to save Billions for future Arctic projects.”. Hosted at medium.com (2017)

Assumed life cycle

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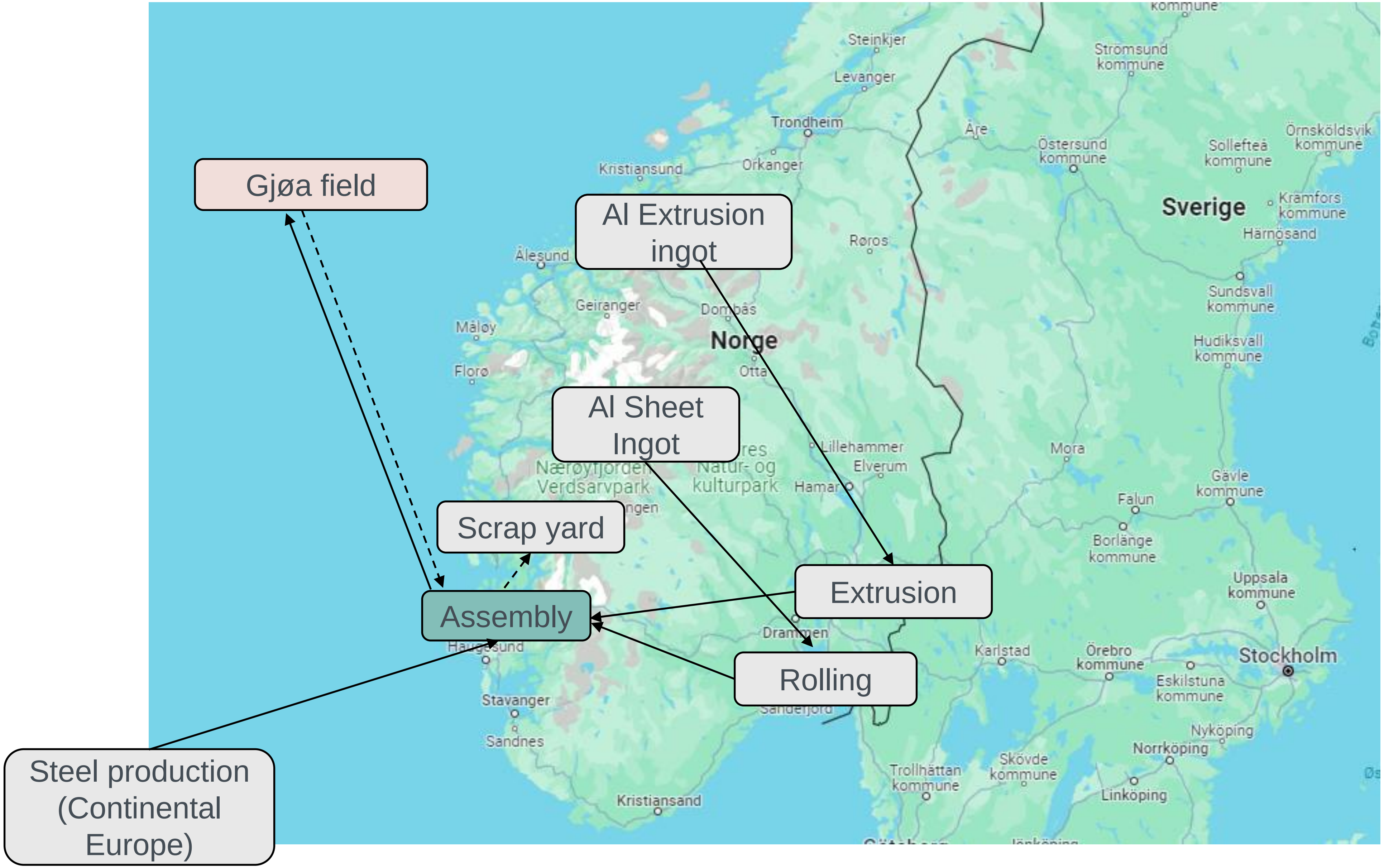
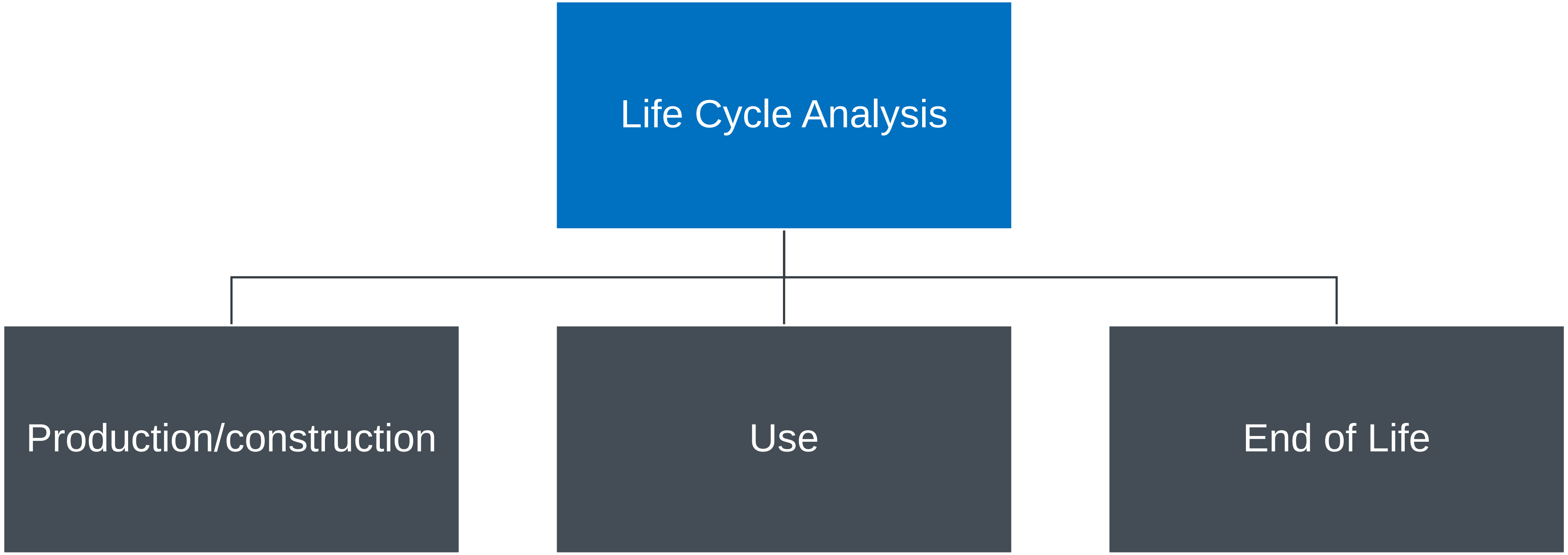


LCA methodology

Data gathered from environmental product declarations, calculations done in accordance with EN 15804



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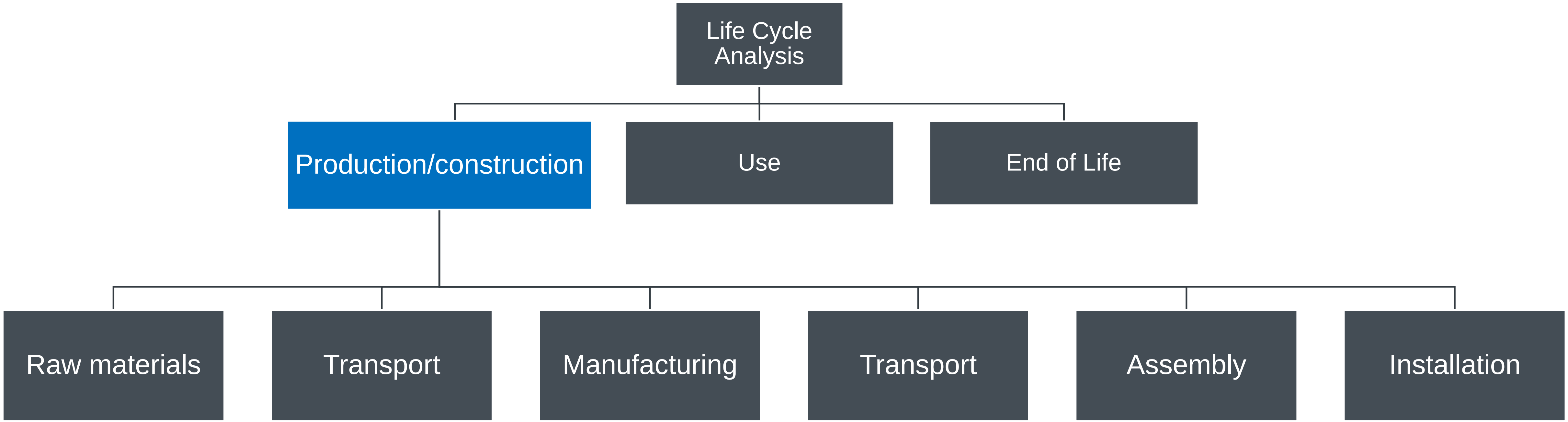
LCA methodology



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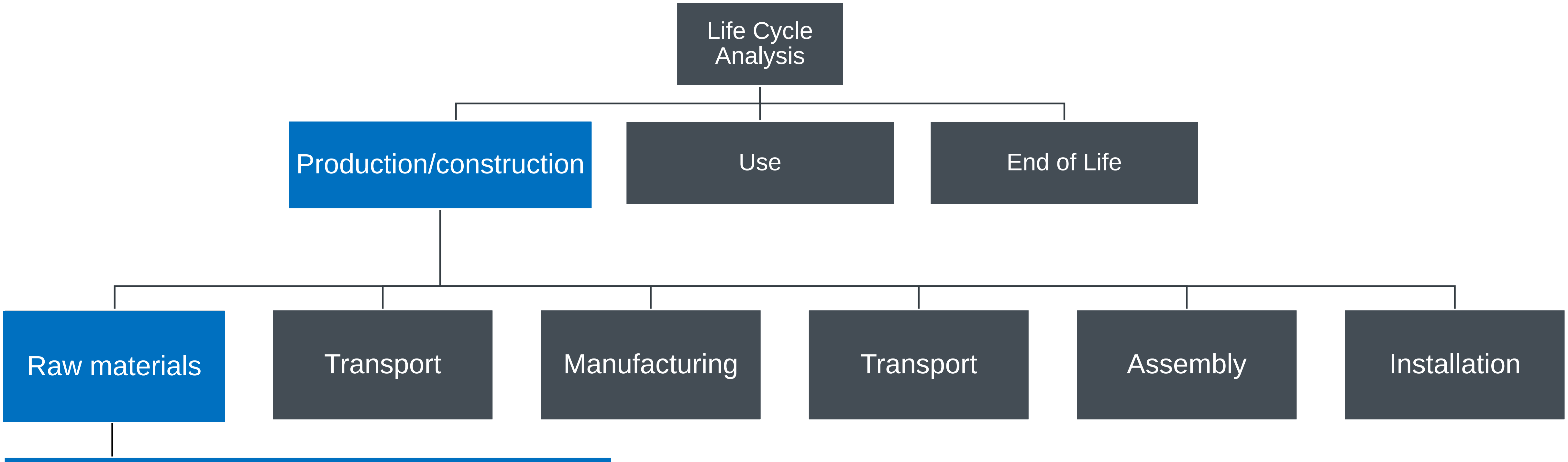
LCA methodology



Steel, EU average:	1.59 kg CO2/kg
Al, EU average:	6.78 kg CO2/kg
Al, Hydro Reduxa:	4.00 kg CO2/kg
Al, Hydro CIRCAL 75R:	1.86 kg CO2/kg

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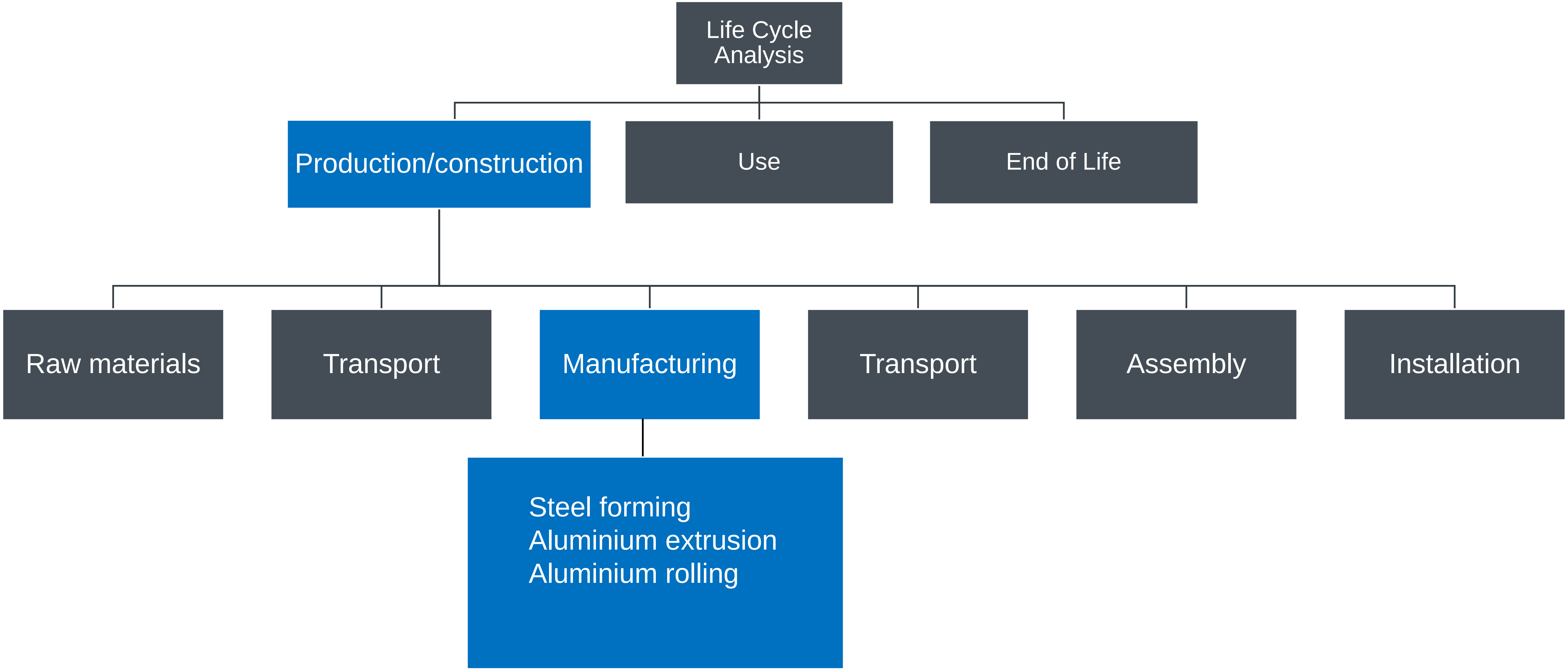
LCA methodology



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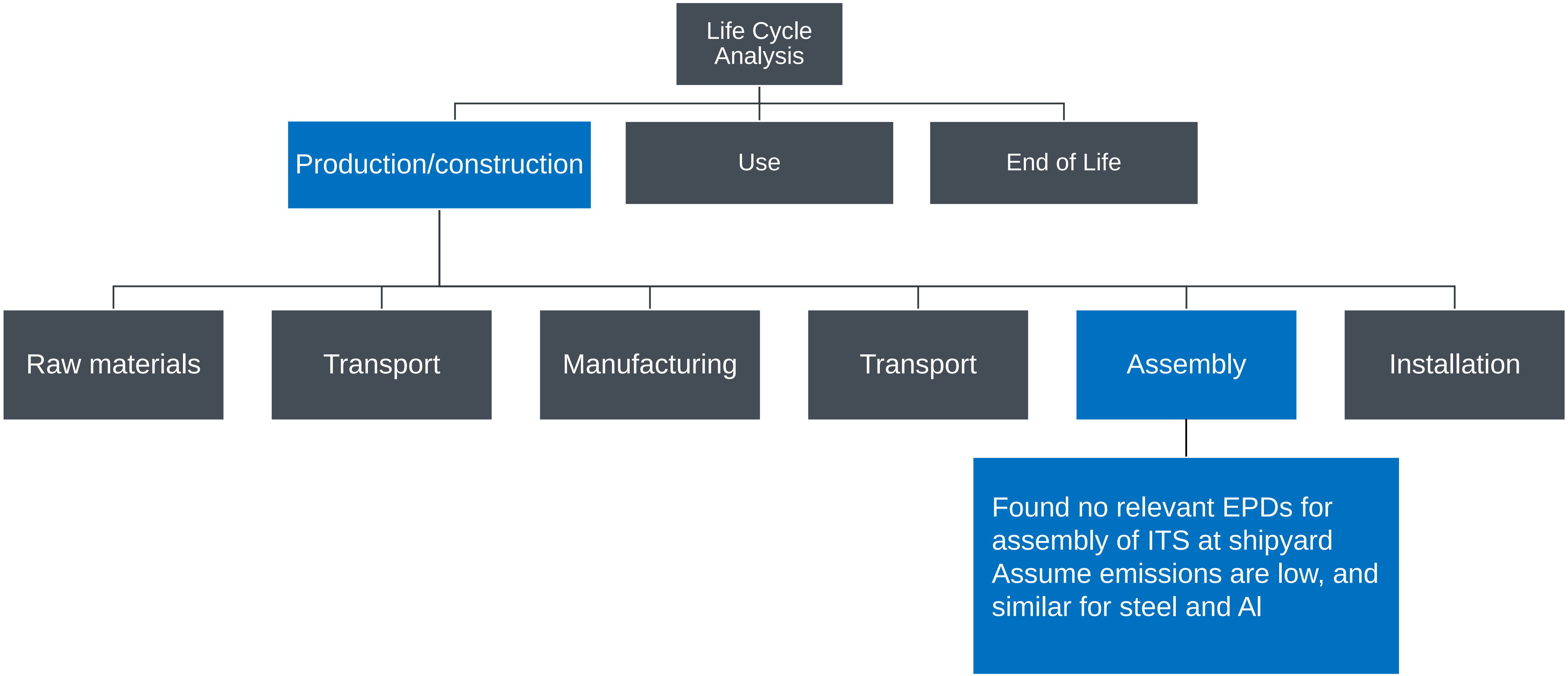
LCA methodology



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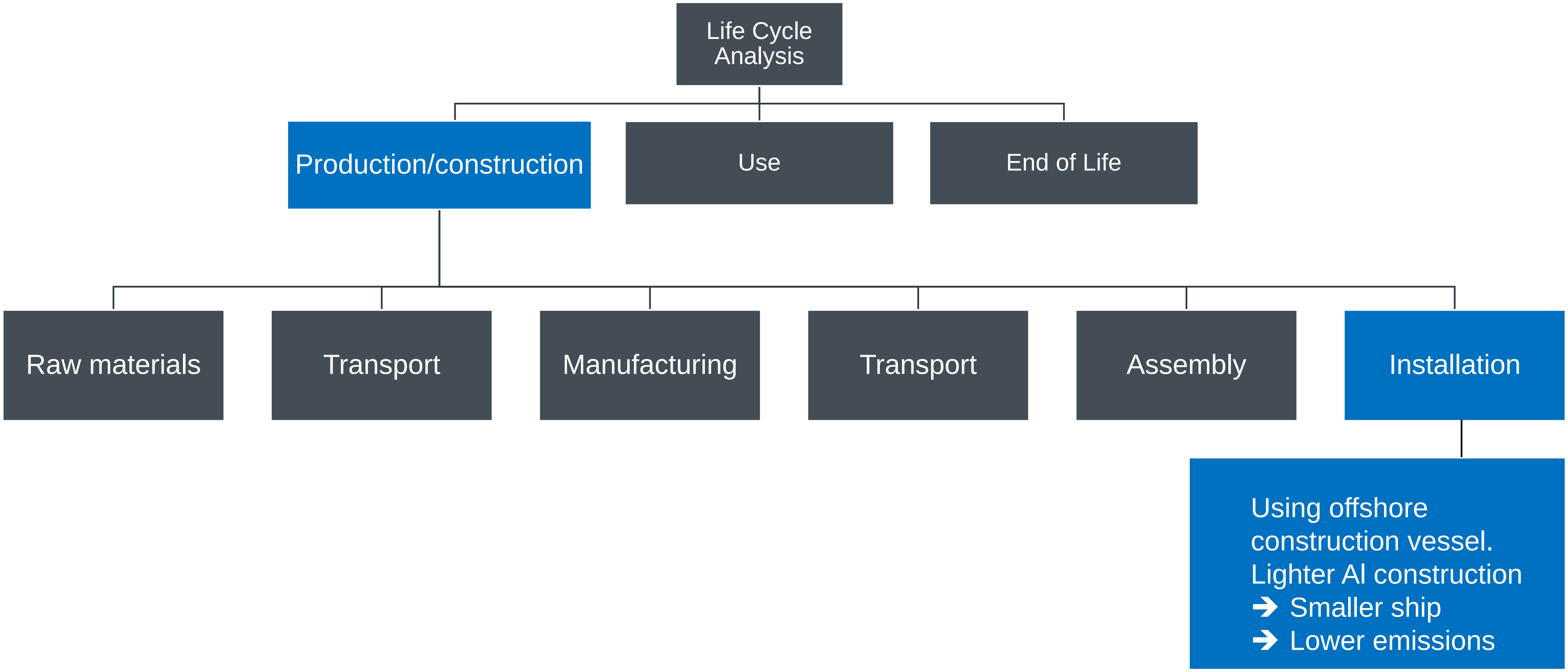

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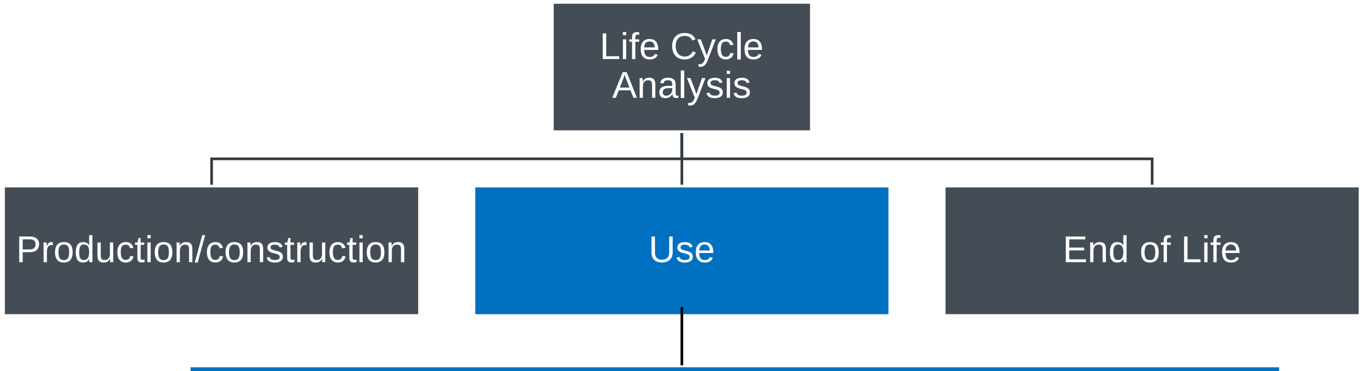
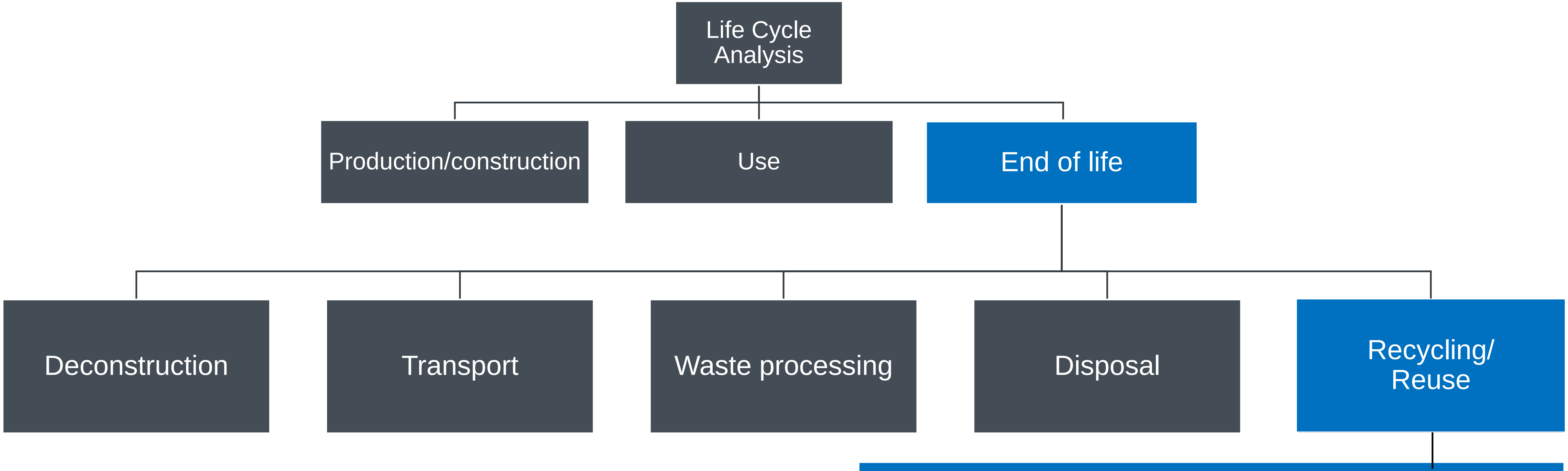


- Infrastructure housed in ITS and the wells they serve are outside the scope of this work.
- No maintenance done on subsea structures

➢ No emissions from the use-phase

LCA methodology



Environmental benefit from recycling can be calculated in several ways, potentially yielding very different results.
This is not necessarily relevant for the material choice of the structure, so is excluded from the scope of this work

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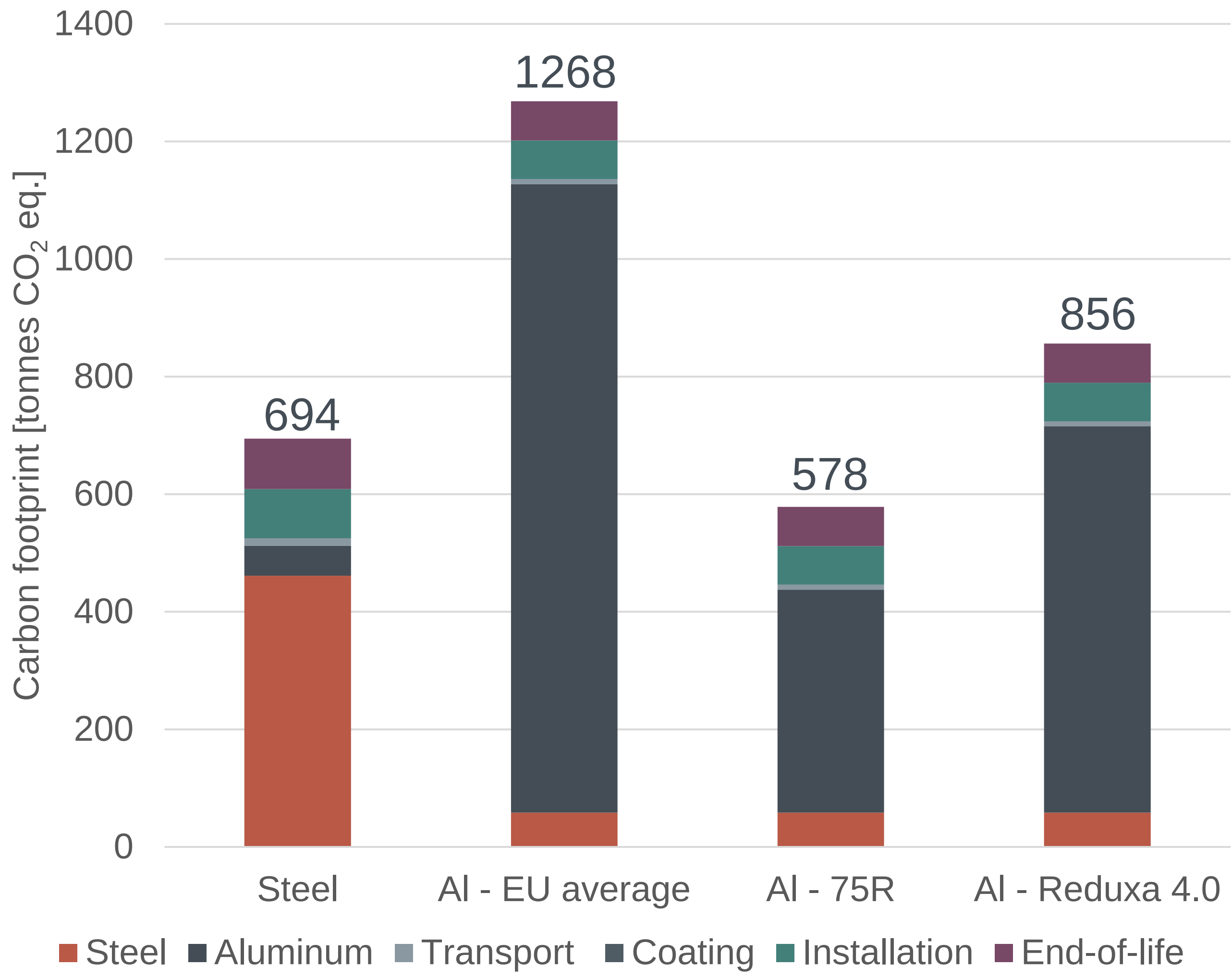
Total Global Warming Potential



Analogous to installation and transport

Larger crane vessel required for steel design

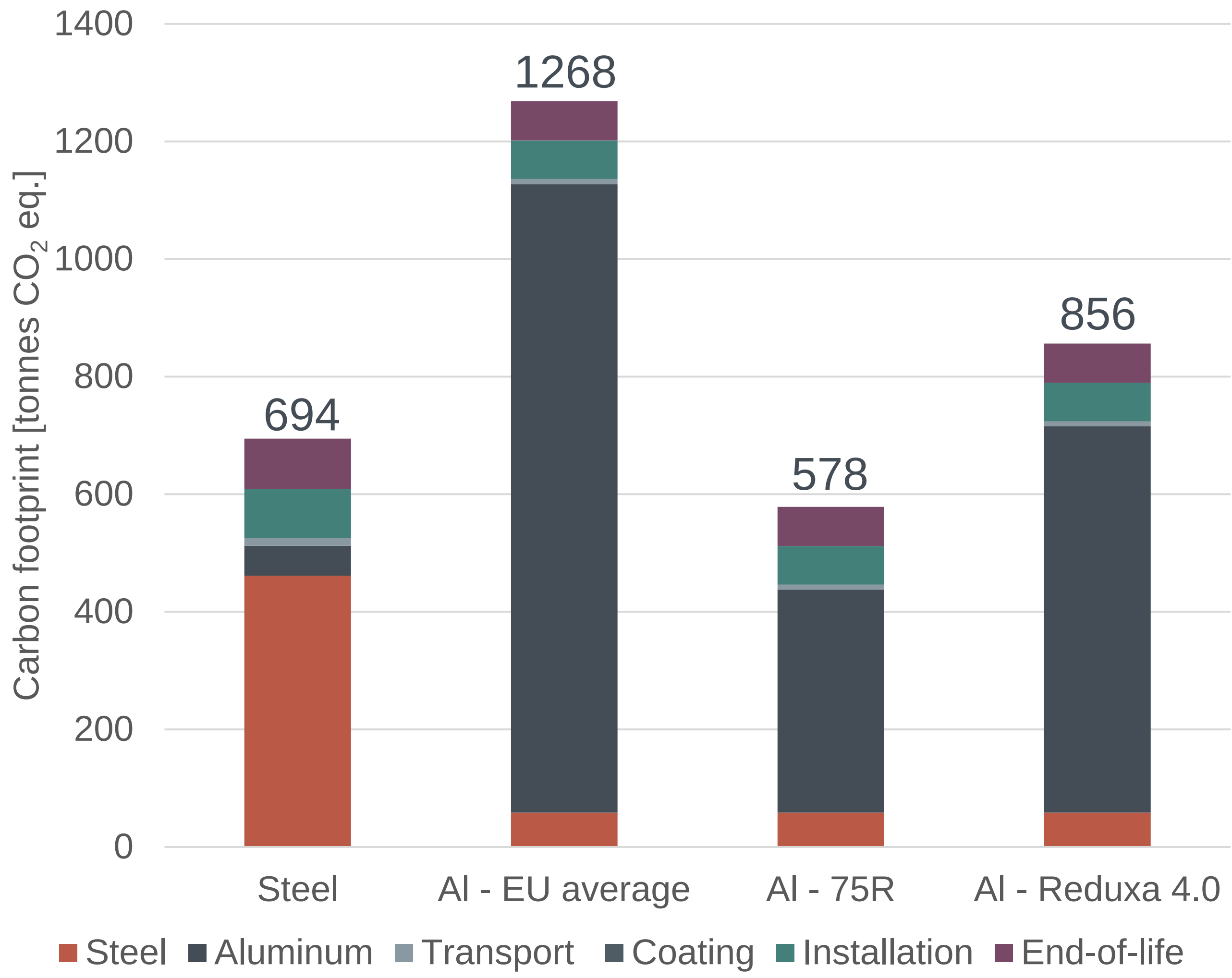
Impact of coating is very low

Transport emissions increased by higher weight of steel design

Al sacrificial anode is used in both steel and aluminium design

Some steel parts are still used in the aluminium design

Conclusions



Uncertainties in method

- Al design not professionally evaluated
- Assumptions in value chain
- Environmental data difficult to find for some parts of process

Main takeaways

- Metal production is the dominant contribution. Using recycled or low-carbon aluminium has a large impact on overall footprint
- A cost-competetive aluminium redesign can have a similar or lower environmental impact as the current steel solution

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Acknowledgements

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