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Life Cycle Assessment of Novel Hybrid Glass-Metal Fibre Reinforced Polymer Composites – Comparing the Environmental Impact of Recycling Technologies with Conventional Disposal Routes

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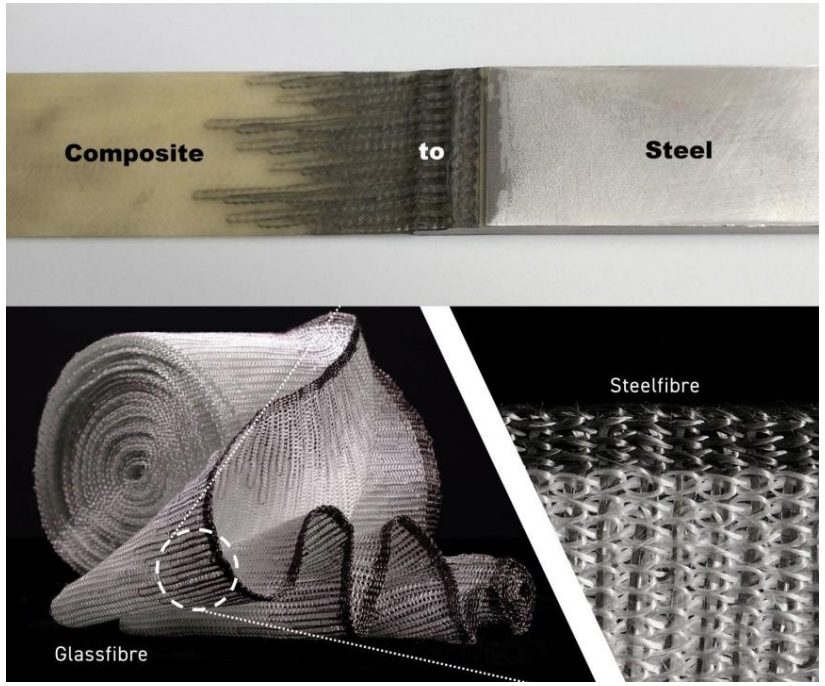
Hybrid Switch - Objectives

- Development of large-scale production technologies for lightweight ‘hybrid’ composite components

- 2x Technology Development tracks:
  - Truck side panels (Pultrusion)
    - Fuel savings during transport
  - Pipe connectors (Resin Transfer Moulding)
    - Reduce maintenance and extend service life



Project Details

Bundesministerium für Wirtschaft und Klimaschutz

- Funded by German Federal Ministry for Economic Affairs and Climate Action

- May 2022 - September 2025

- GreenDelta, Berlin
- Fraunhofer IWU, Chemnitz
- SKZ – KFE gGmbH, Halle
- FISCO GmbH, Kutzenhausen
- Suer Nutzfahrzeugtechnik GmbH & Co. KG, Wermelskirchen
- CeH4 technologies GmbH, Celle

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Background

- Composite materials provide opportunities for weight savings and improved mechanical properties

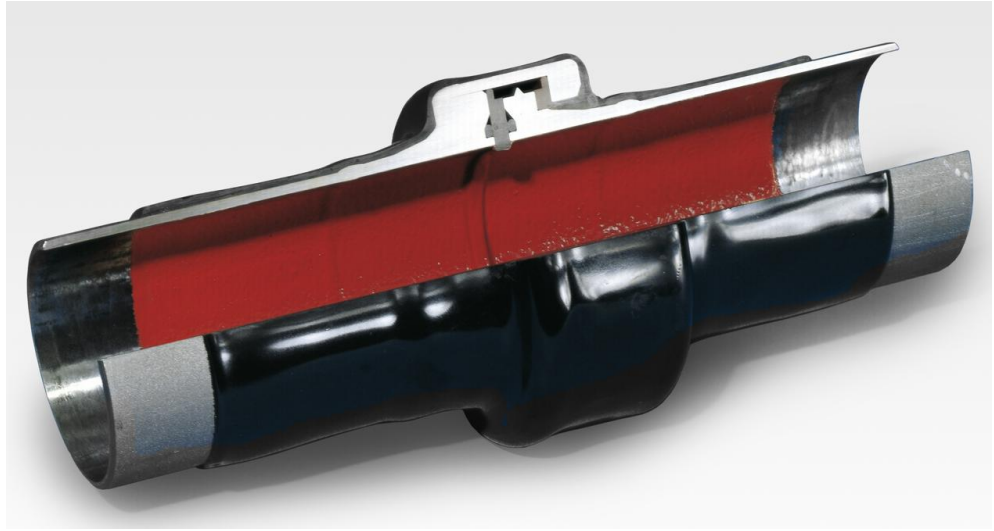
- FAUSST hybrid glass-steel FRP allows functional gradient between GFRP and steel components

- EU composite recycling capacity limited - most end up in landfill [1]
  - Lack of available (scaled) technologies
  - Low market demand for recyclates (especially GFRP)

In this presentation…

- What End of Life routes are available for hybrid materials?
- How can we approach modelling recycling of hybrid materials?
- How do the environmental impacts of conventional disposal routes compare to recycling?

Hybrid Switch - Pipe Connector



State of the Art[2]

Hybrid Switch

HybridSwitch - Model Setup

- Scope:
  - Cradle to Grave
  - All factors that remain constant in the comparison are not considered

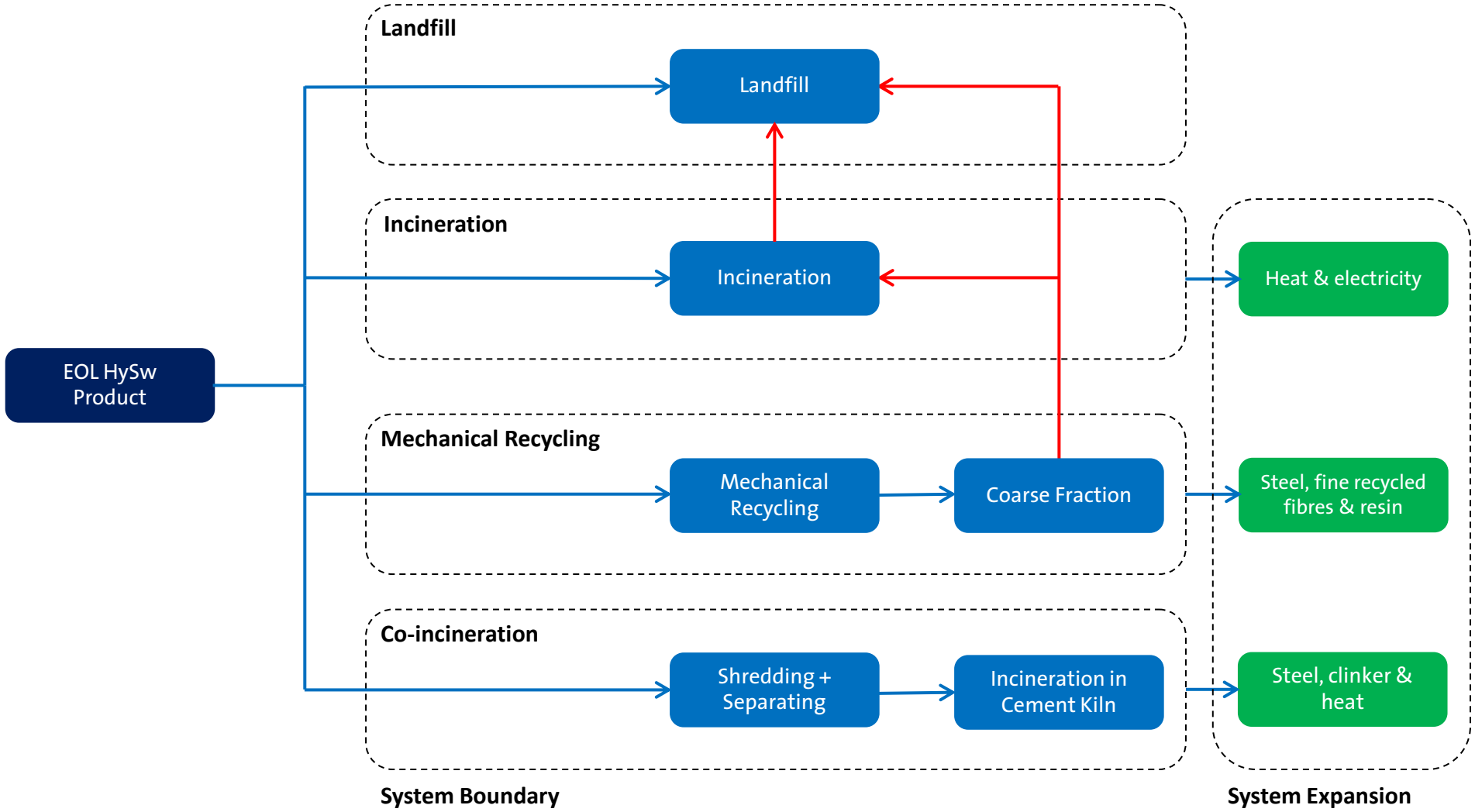
- Functional Unit:
  - Pipe Connector: transport of gas and electrical insulation of pipelines. Use phase of 20 years. 102 mm inner diameter

- Database: Ecoinvent 3.10 Unit Processes Cutoff
- LCIA Method: EF 3.1

- Key impact category: Climate Change

- Approach for avoided products:
  - Incineration: 1.39MJ/kg electric energy and 2.85MJ/kg thermal energy [3]
  - Mechanical Recycling: 1 kg rGF fine fibres replace 0.78 kg vGF, 1kg rGF fine powder fraction replaces 1 kg $CaCO_3$ [4]
  - Co-Incineration: 1 kg of GFRP waste replace 0.15 kg bauxite and 0.54 kg coal [5]

End of Life



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End of Life - Disposal Routes

- Landfill
  - Most common disposal route for composite waste globally [1]
  - Not permitted in Germany since 2005 for GFRP [6]

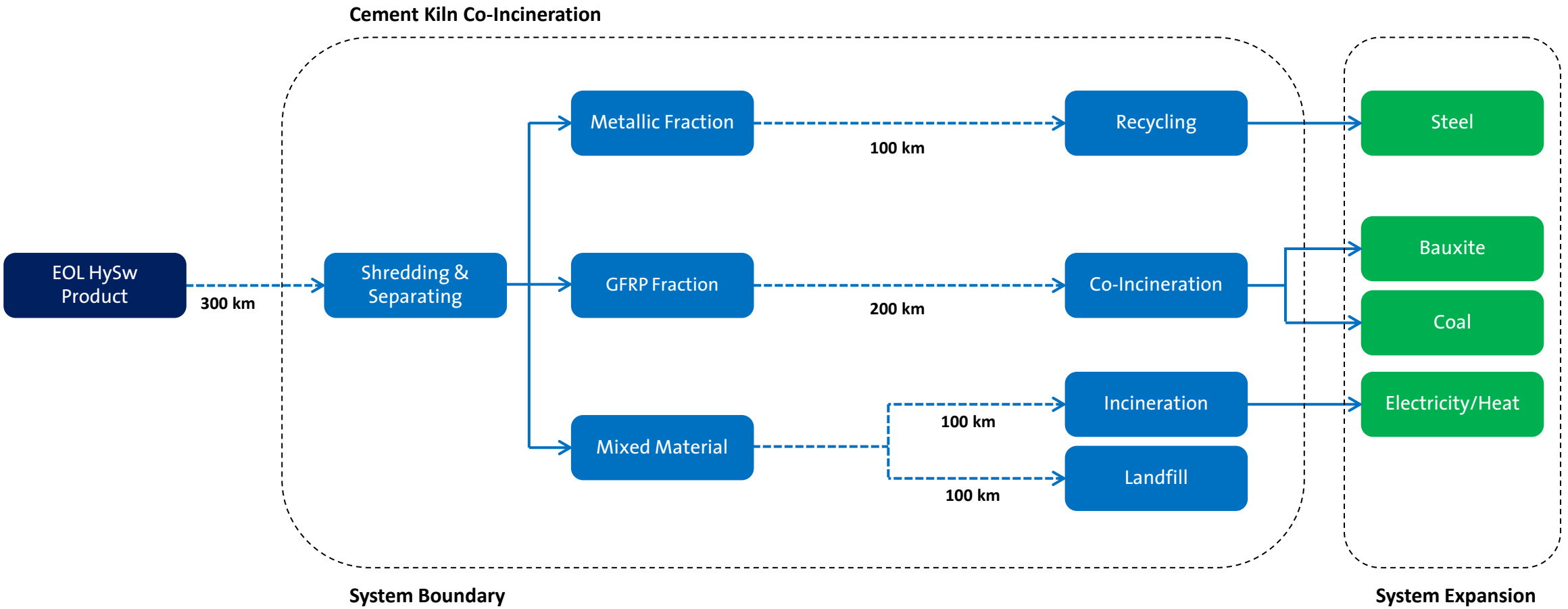
- Incineration (with energy recovery)
  - Toxic emissions can overload and clog filters
  - FRP materials contain high proportion of inorganic material that must be landfilled as ash [7]

End of Life - Recycling Routes

- Mechanical Recycling
  - most commercially mature FRP recycling technology (since 1970s)
  - Low cost, high throughput rate, low value recyclates [8]

- Cement Kiln Co-Incineration
  - Specific to GFRP
  - organic fraction of GFRP waste (30%) converted to energy
  - inorganic fraction (30% filler, 40% fibre) is mixed into clinker [9]

System Boundary Diagram- Co-Incineration



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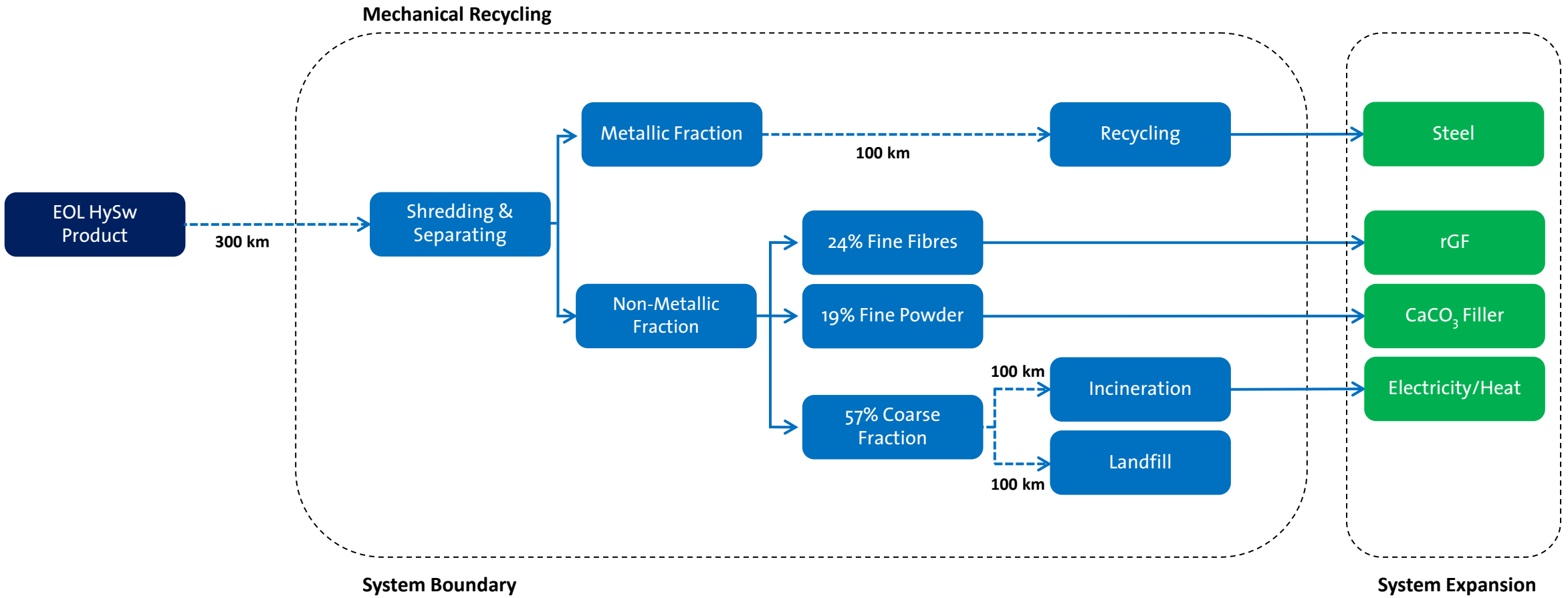
System Boundary Diagram- Mechanical Recycling



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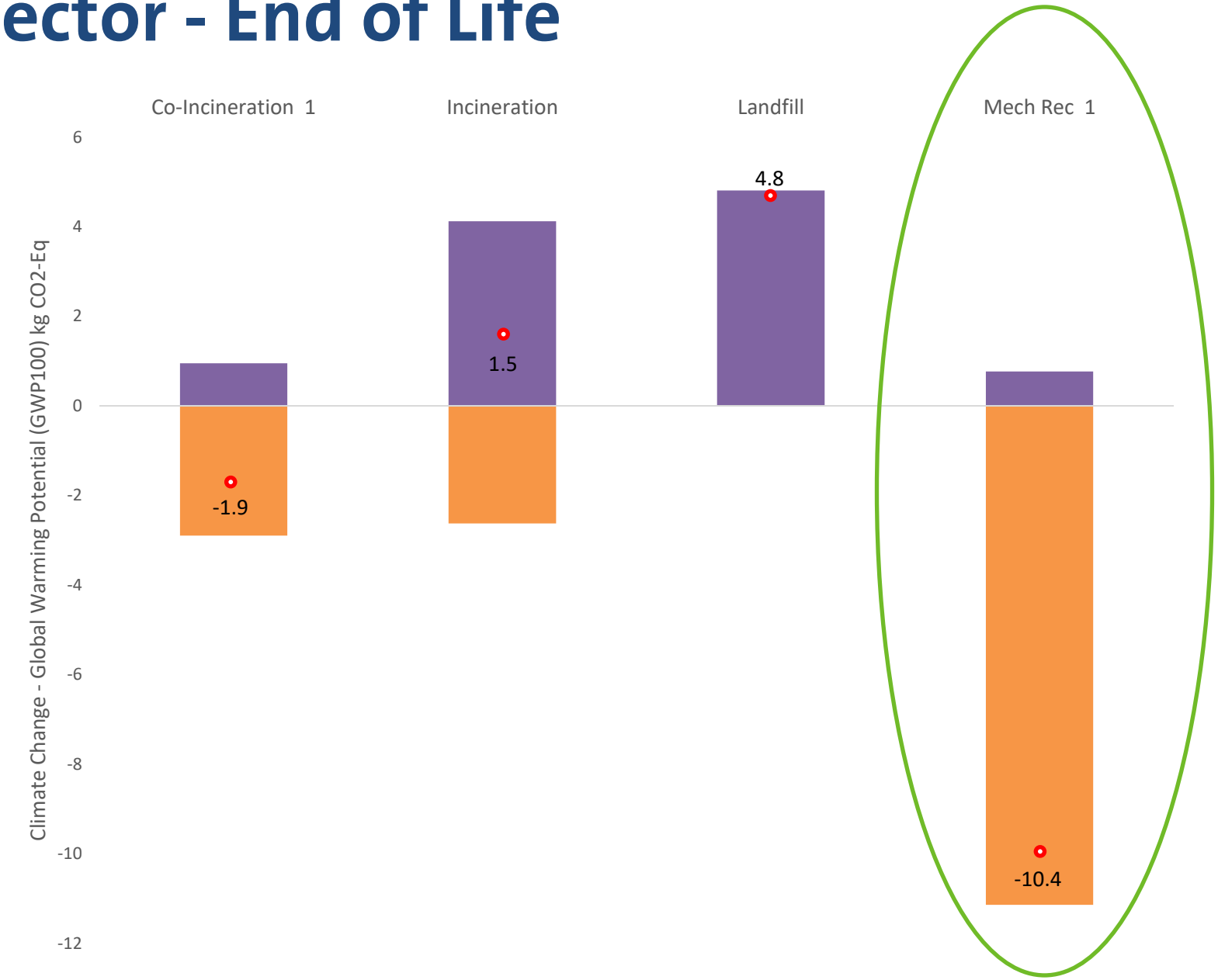
Pipe Connector - End of Life



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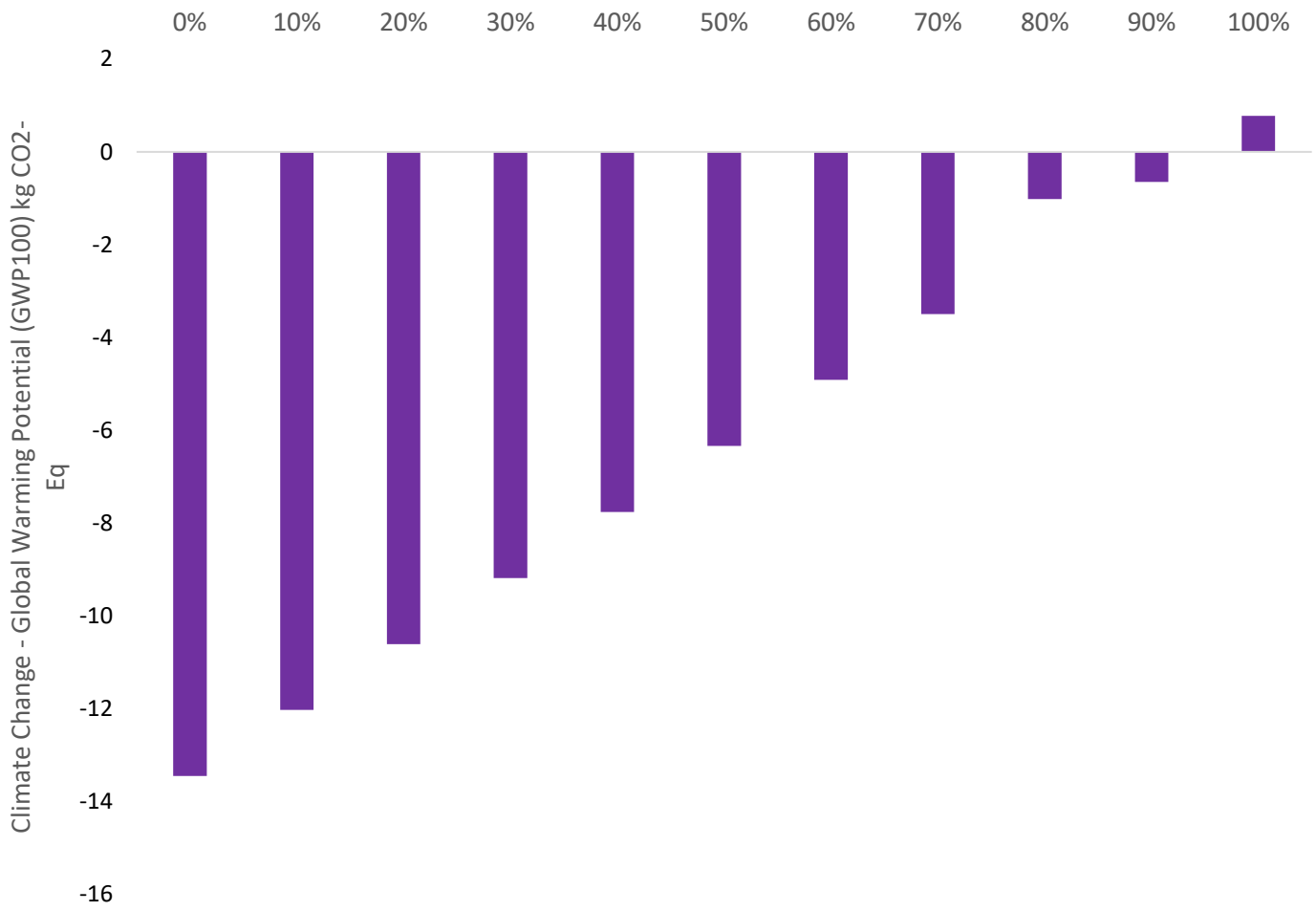
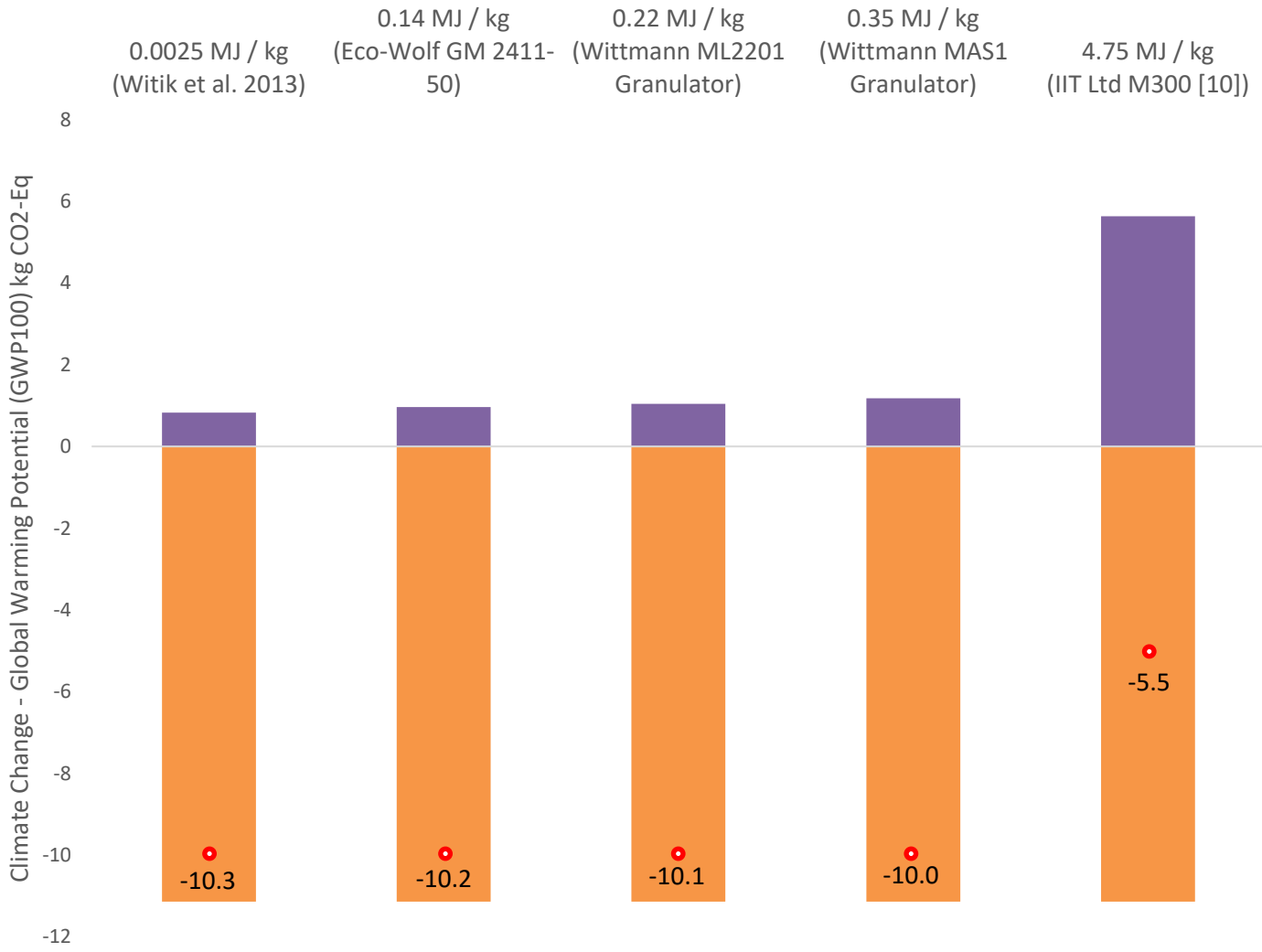
Mechanical Recycling - Sensitivity Analysis (rGF Substitution)



Mechanical Recycling - Sensitivity Analysis (Processing Energy)



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Summary & Next Steps

- Lowest impact (climate change) EOL process - Mechanical recycling
  - Even at low substitution of vGF with rGF
  - Clean supply of waste required for recycling facilities to operate at scale
- Co-Incineration also promising but dependent on re-establishment of infrastructure in Germany and ability to separate waste fractions

- Life Cycle Costing Assessment (in progress)
- Data Quality Assessment
- Updating model to represent scale-up

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Danke!

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