Western Norway University of Applied Sciences

equinor

A Comparative Life Cycle Assessment of Additive and Conventionally Manufactured Cooling Fans

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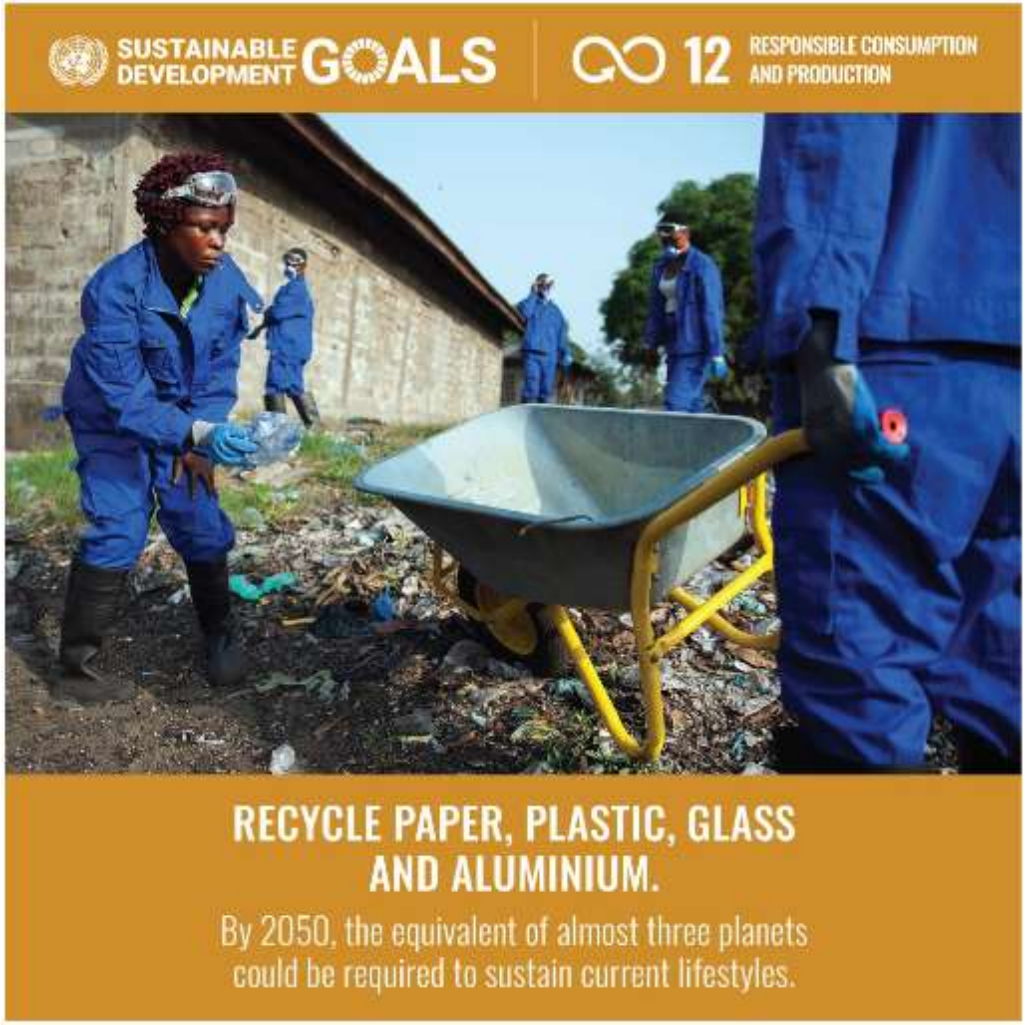
Energiteknologi / Undervannsteknologi
Institutt for Maskin- og Marinfag

Sustainable Development Goals

Goal 12: Responsible Consumption and Production

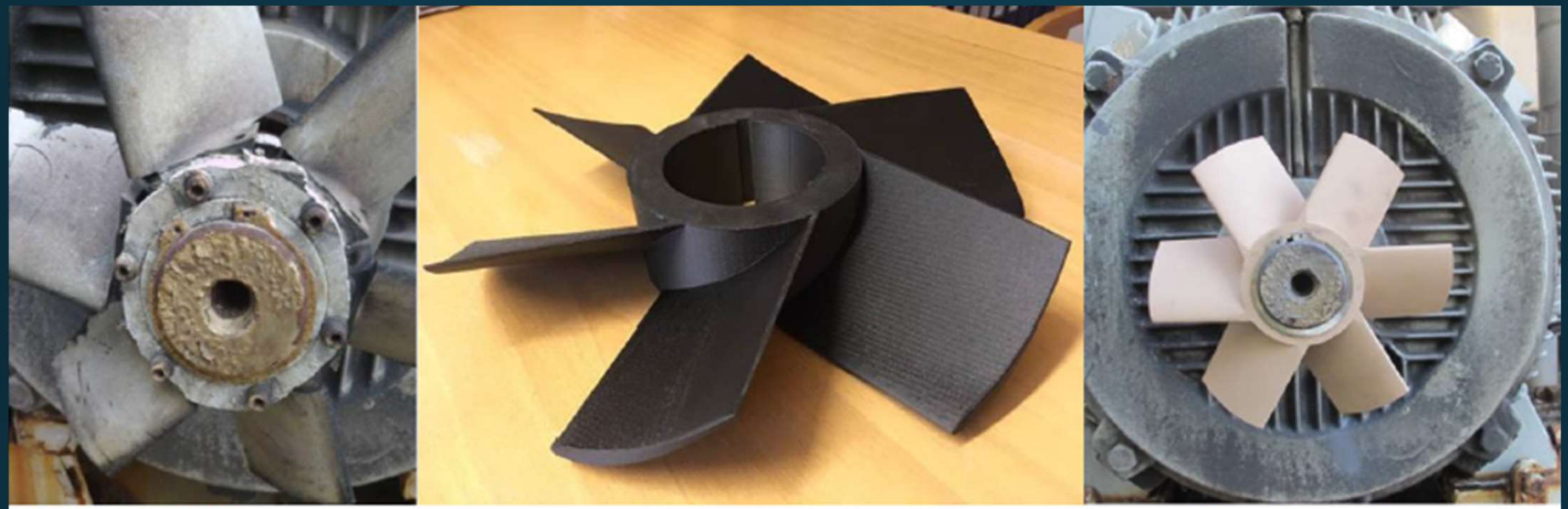


Sustainable Development Goals

Goal 13: Climate Action

Definitions

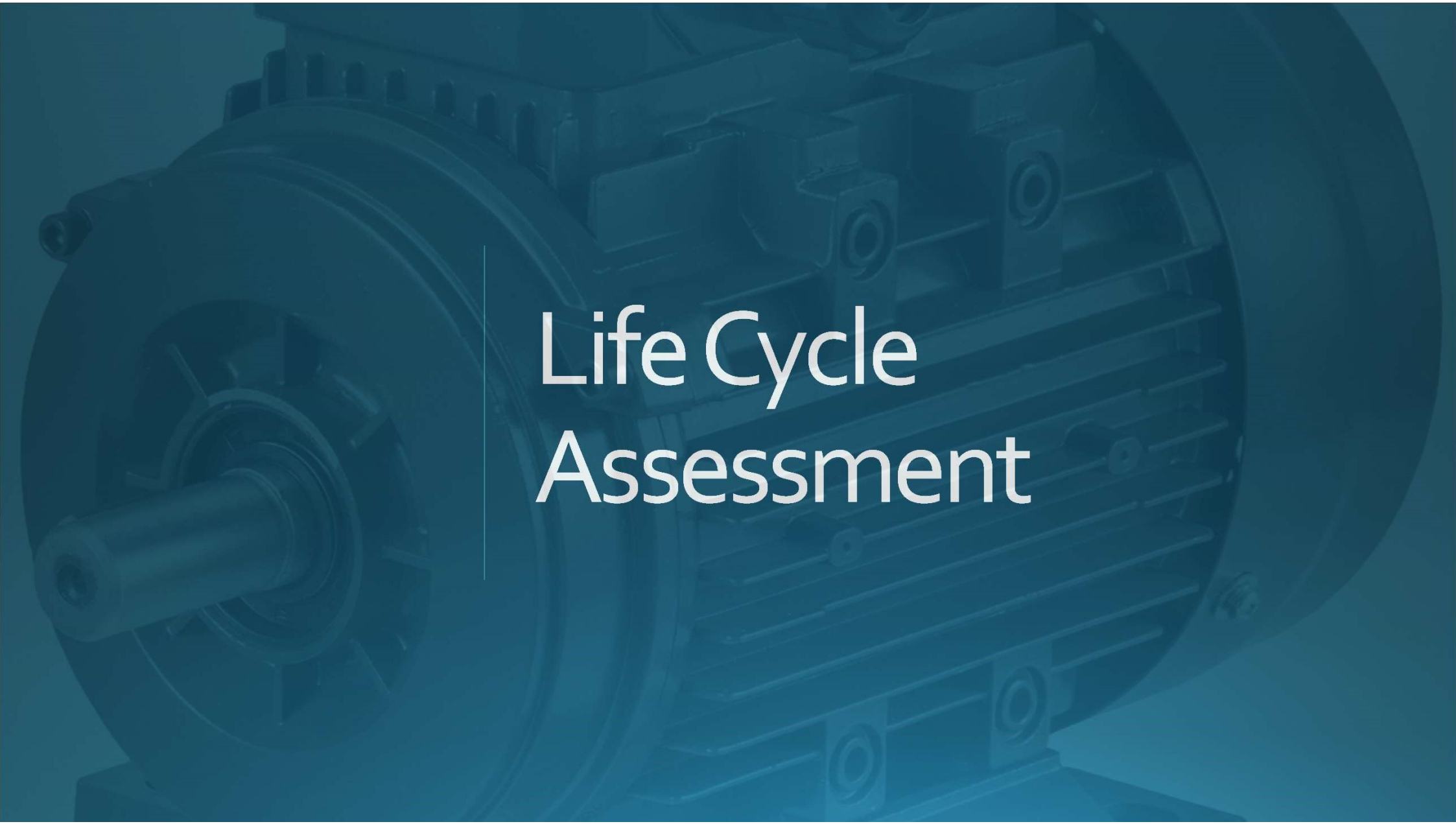
- **Life Cycle Assessment** (LCA): A management tool to examine the environmental impact of a product throughout its entire lifespan, from extraction of raw material to end of life
- **Cradle-to-grave:** All activities from virgin raw material extraction to waste disposal at end-of-life
- **Cradle-to-cradle**: Raw material is recycled at the end-of-life and is looped back into the early stage of a products Life Cycle
- **Global Warming Potential** (GWP): A unit where greenhouse gases are expressed as CO_2 equivalents over 100 years
- **Additive Manufacturing** (AM): The process of making a 3D object by adding material, usually layer upon layer.



Original fan, Tjeldbergodden | Printed fan before coating | Printed fan on site

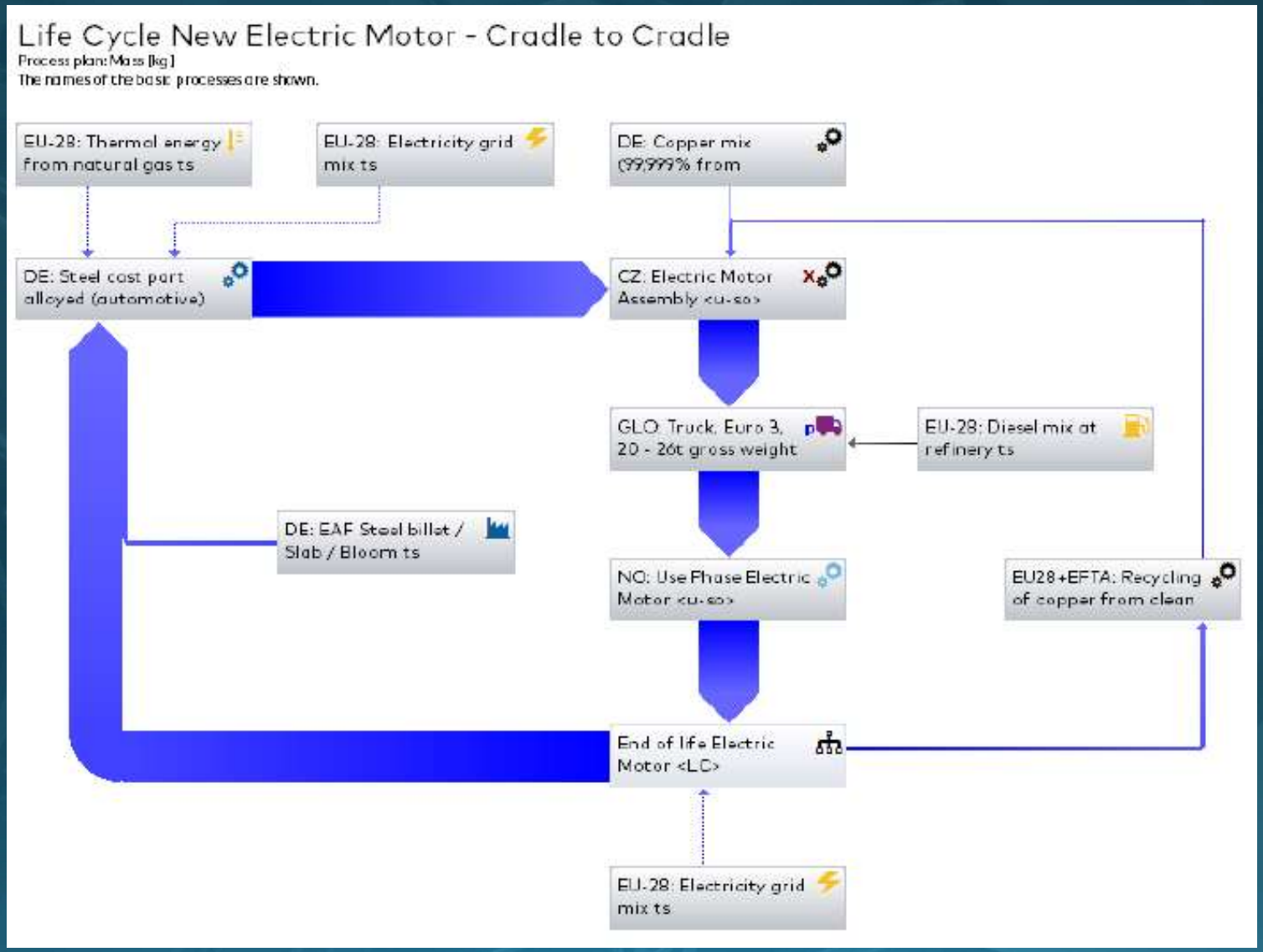
Case study

- A broken and obsolete cooling fan on an electric motor at Equinor Tjeldbergodden
- Supplier suggested to buy a new motor
- A new fan was «printed» using AM

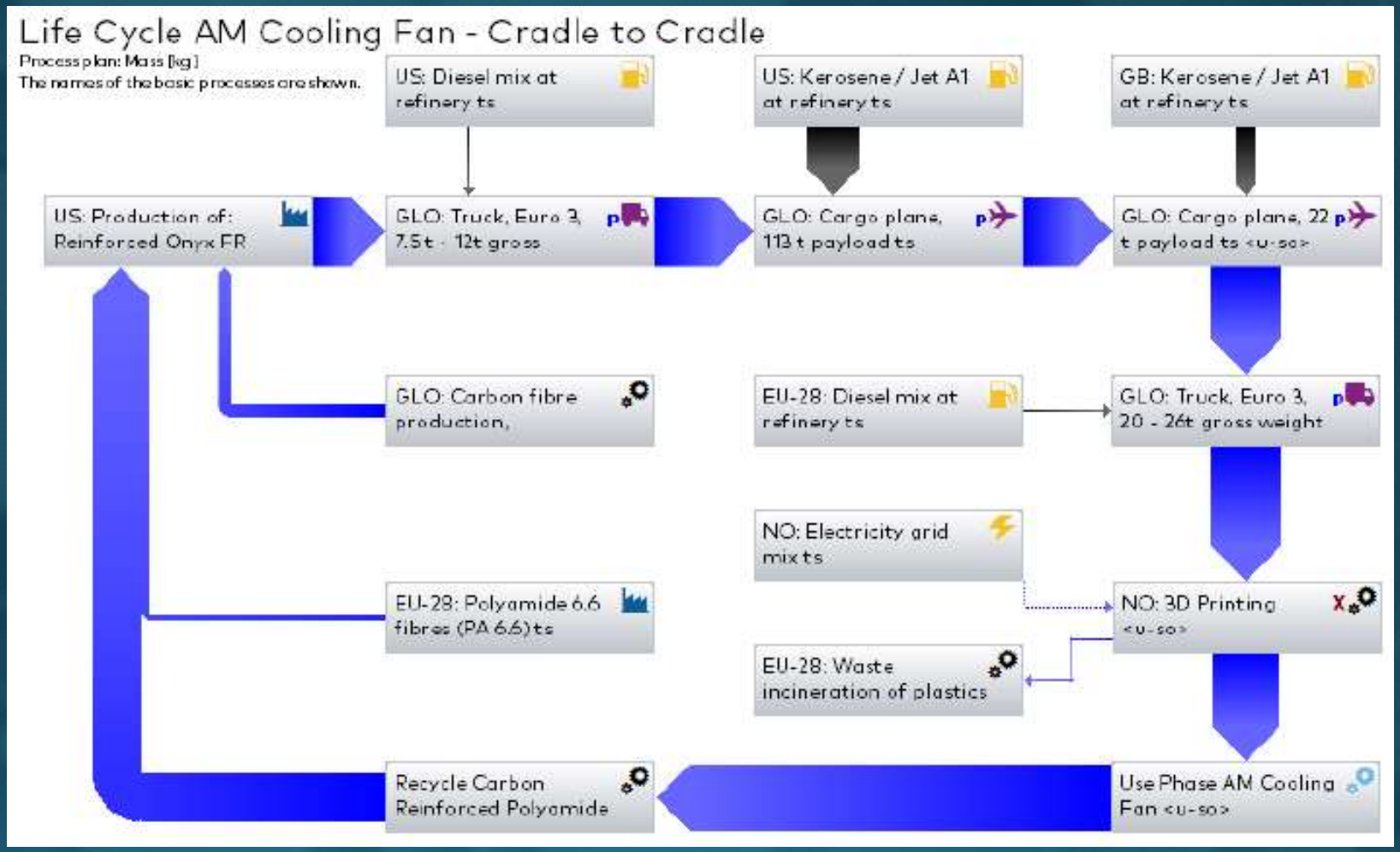


Life Cycle Assessment

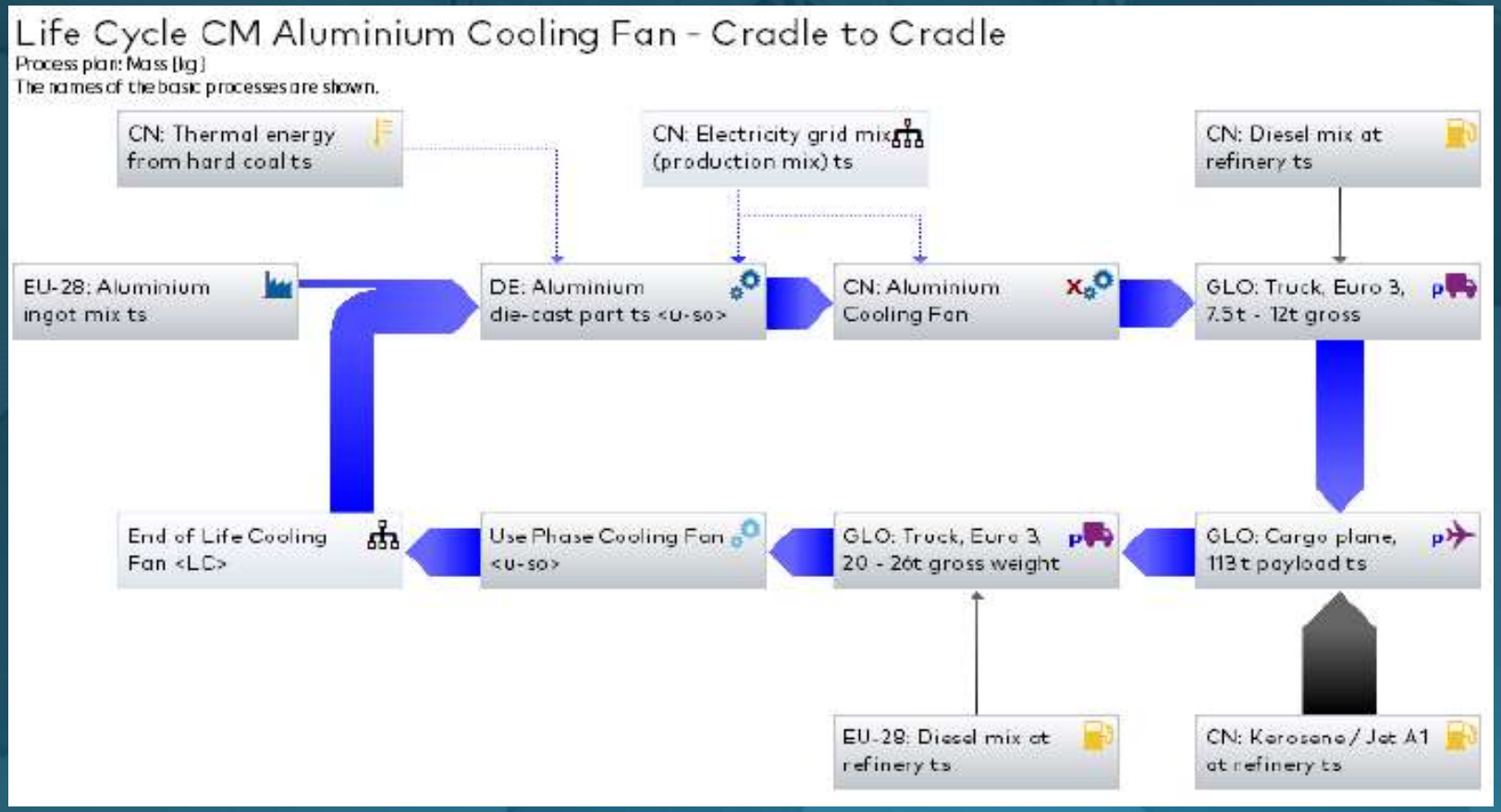
New Electric Motor



AM Cooling Fan

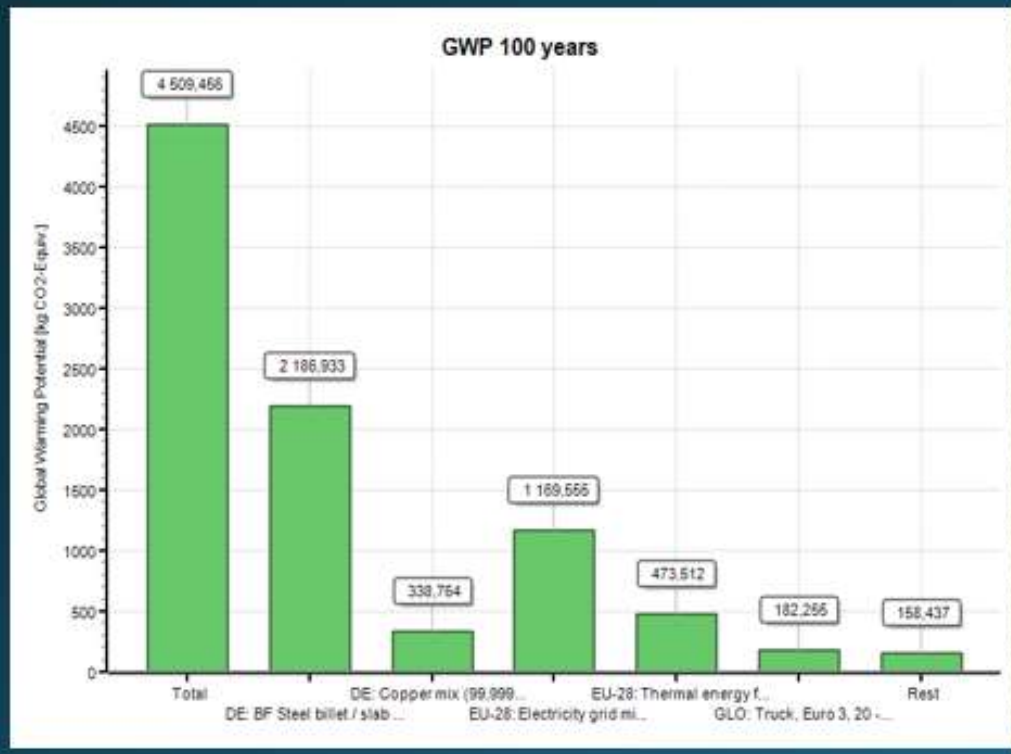


CM Aluminium Cooling Fan

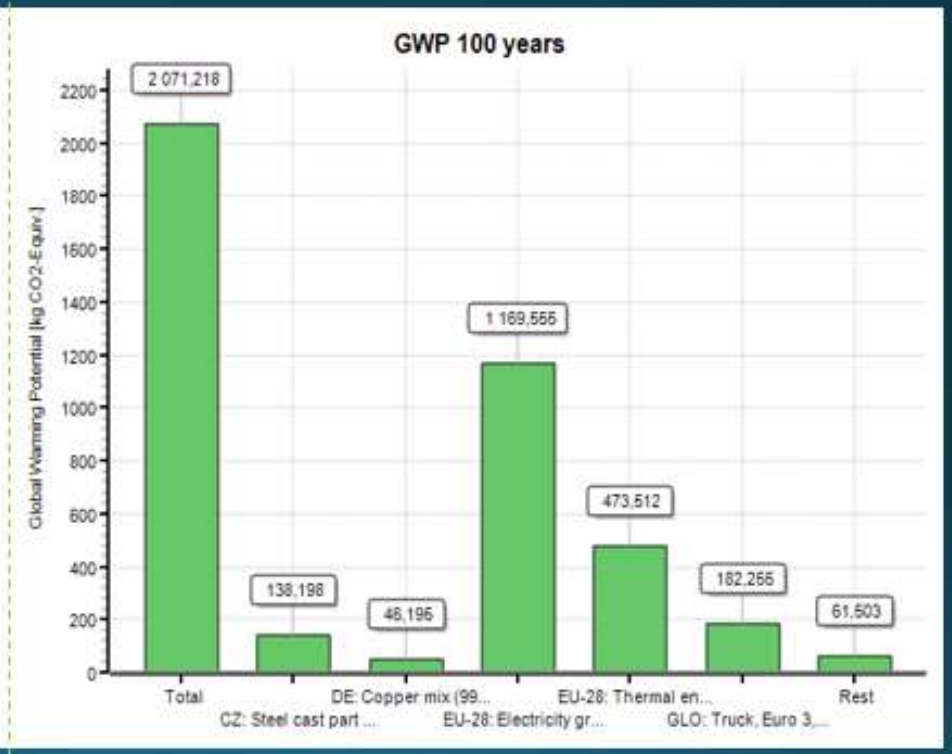


Results and identification of hotspots

Electric Motor

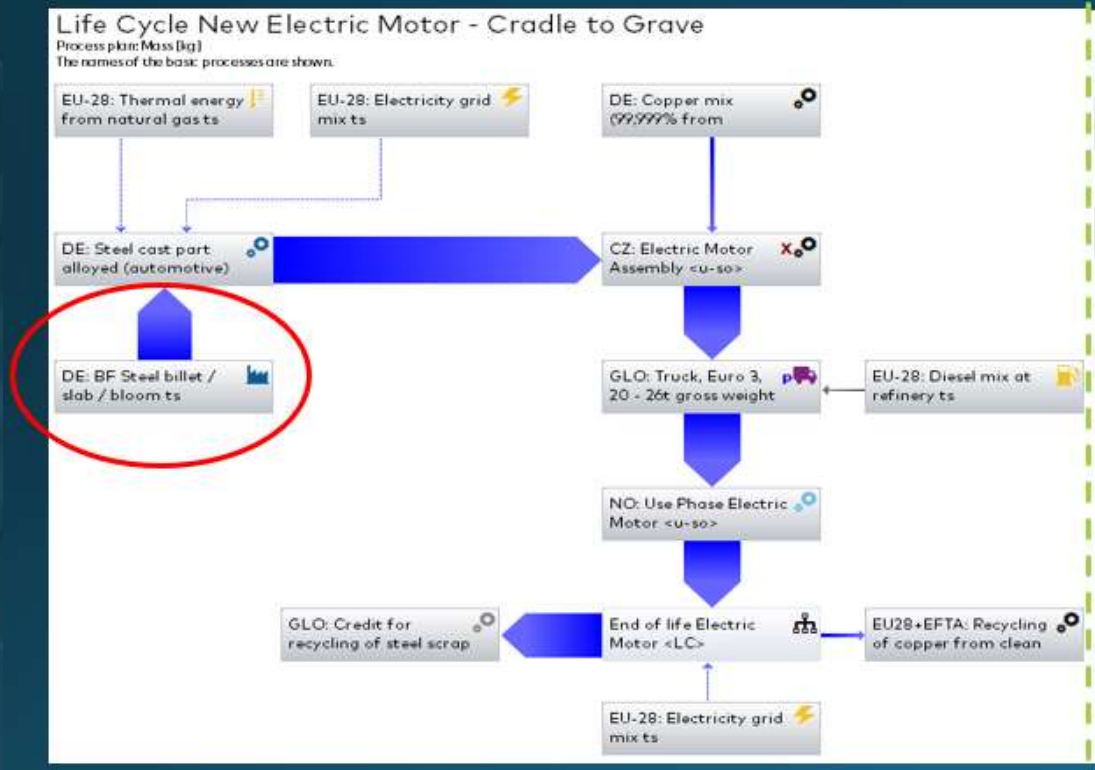


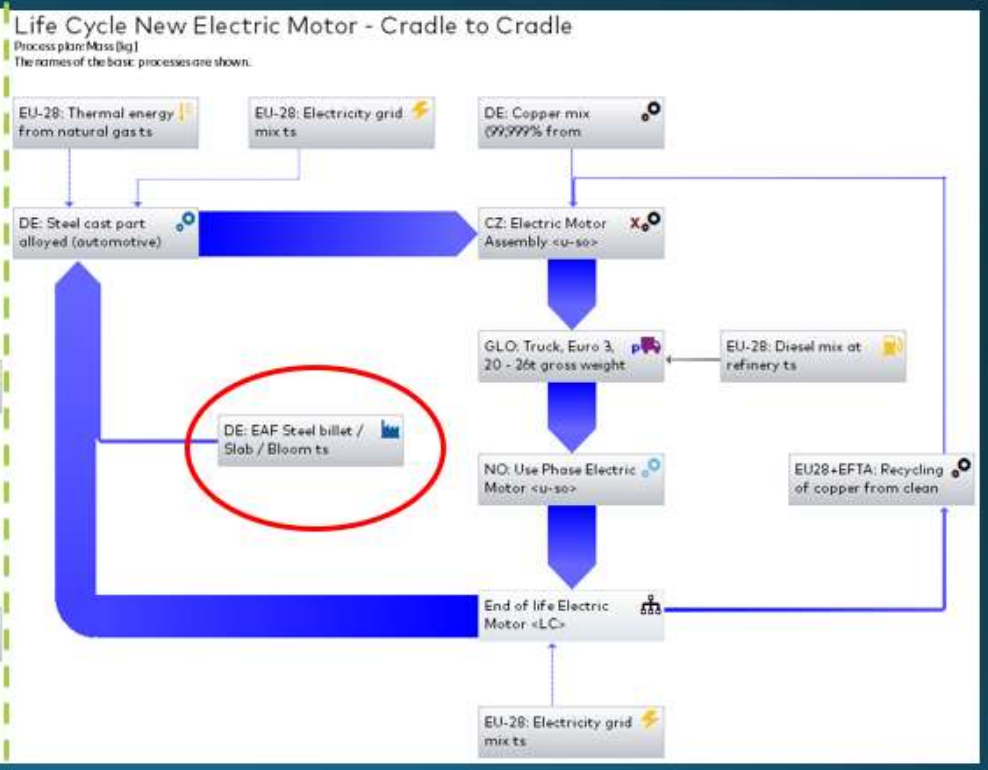
Cradle-to-Grave



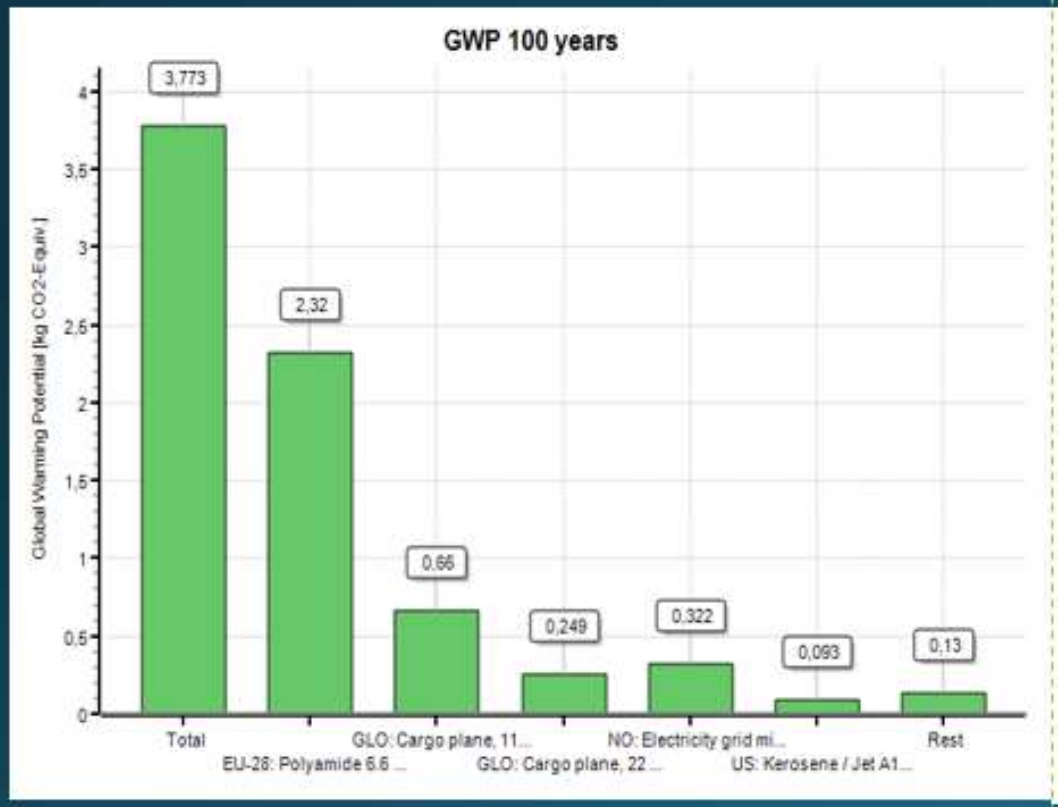
Cradle-to-Cradle

Hotspot-Electric Motor

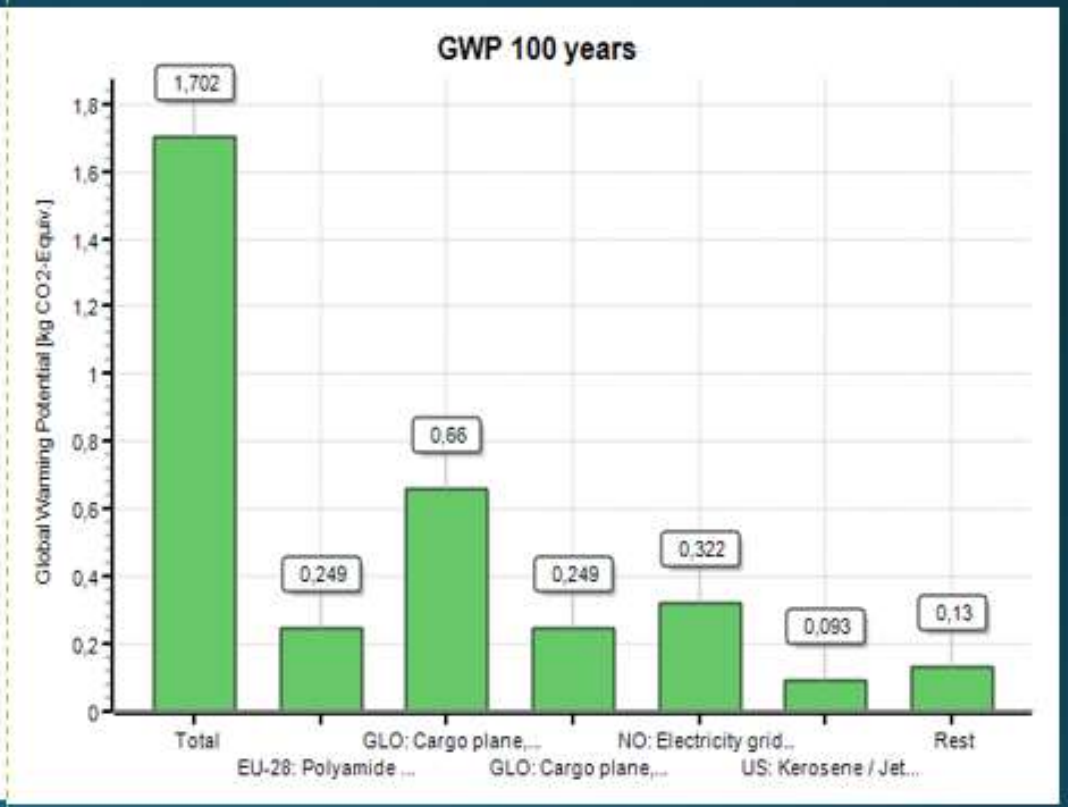




AM Cooling Fan

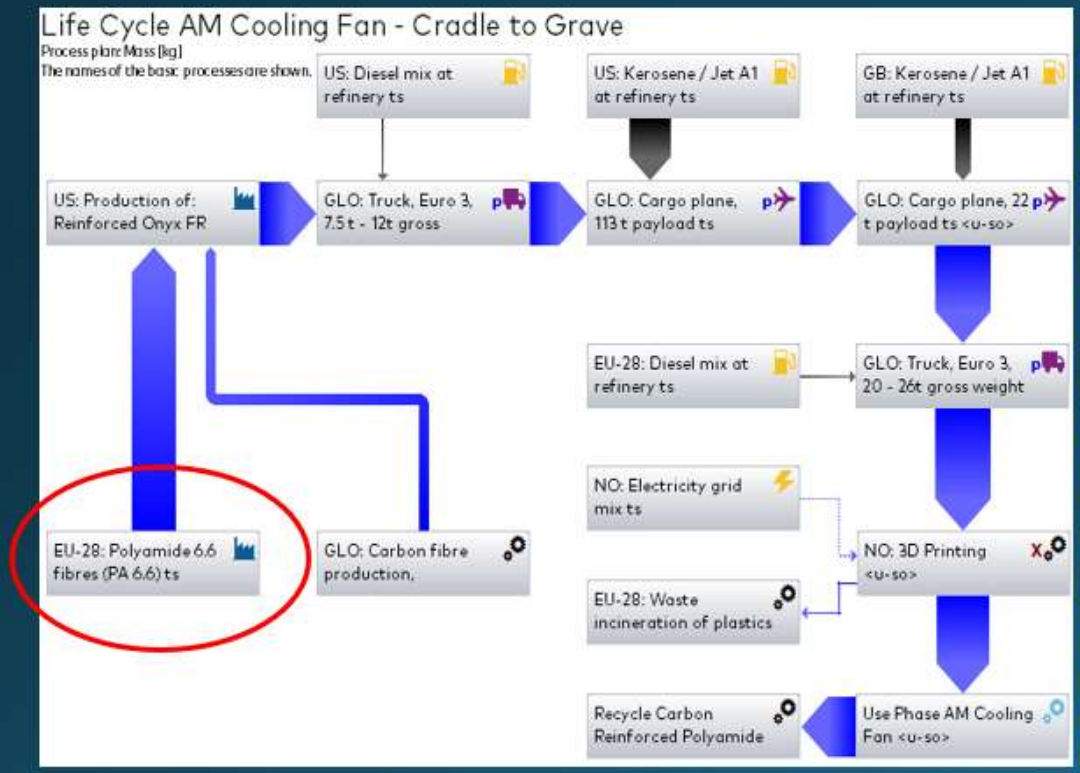


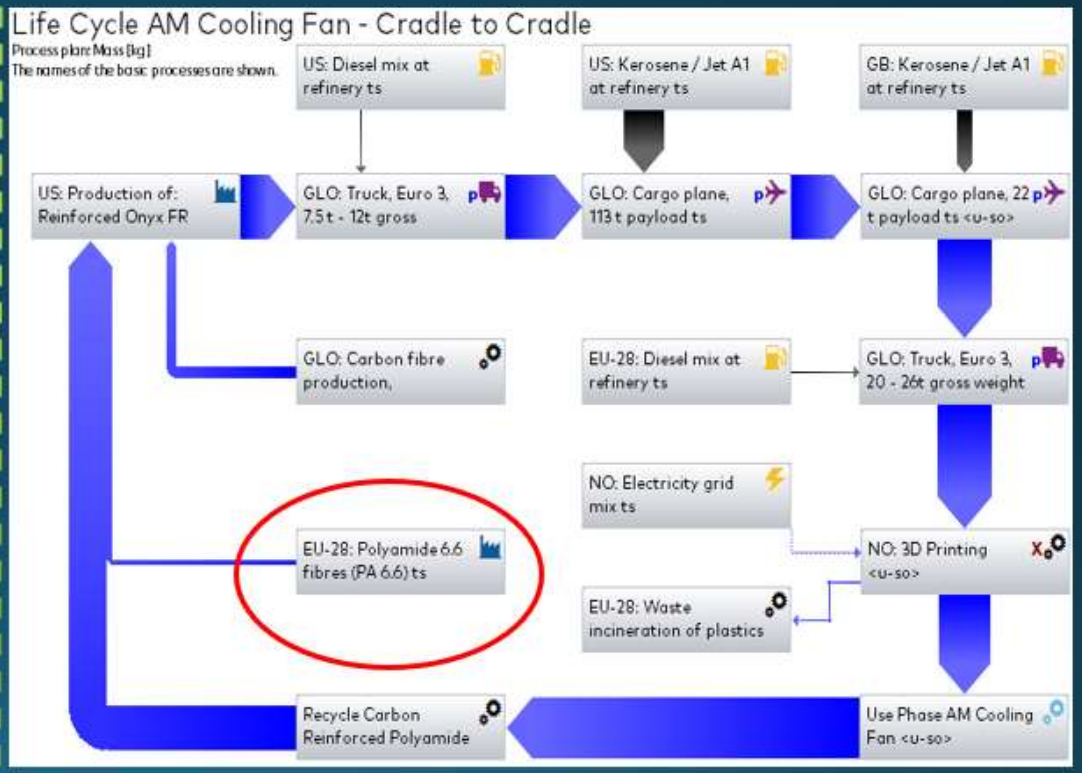
Cradle-to-Grave



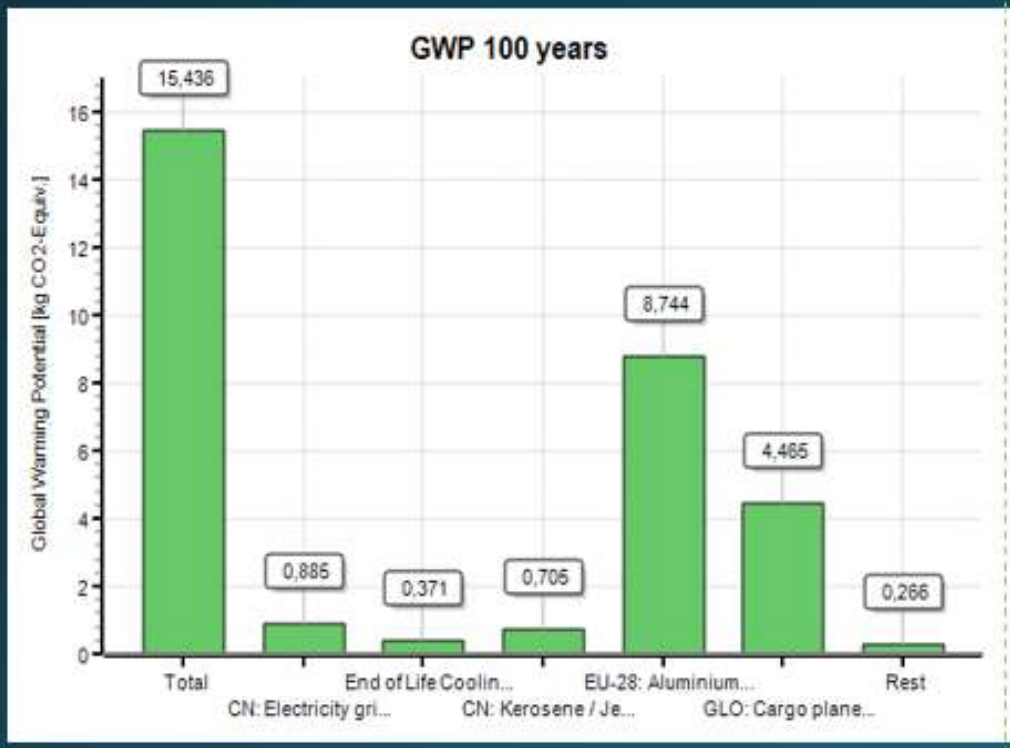
Cradle-to-Cradle

Hotspot-AM Cooling Fan

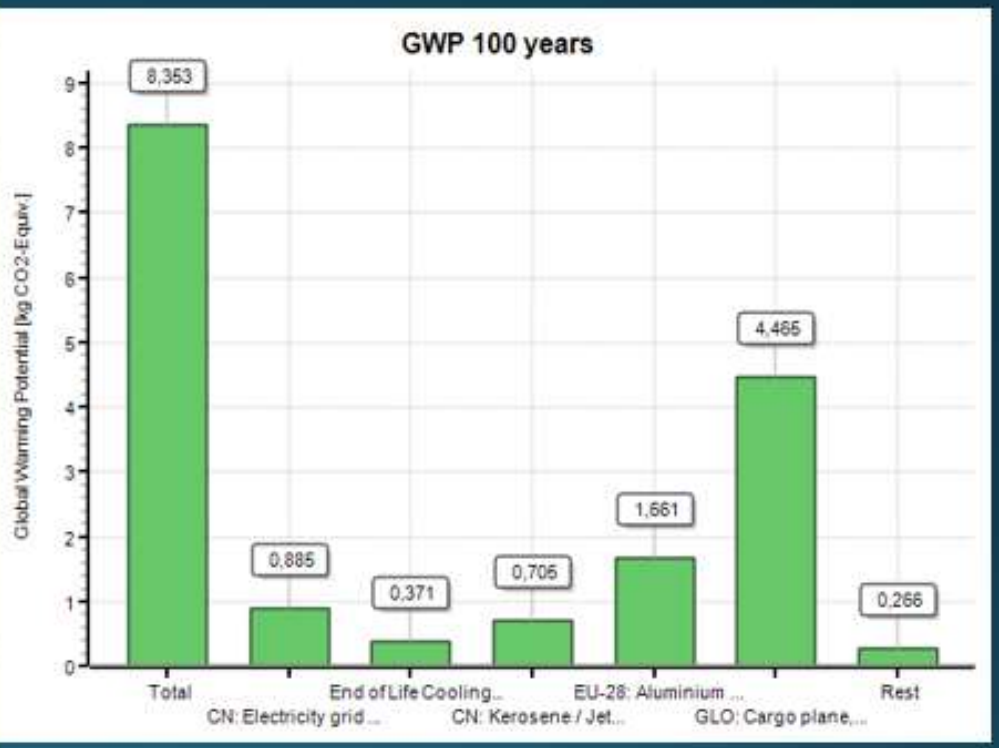




CM Cooling Fan

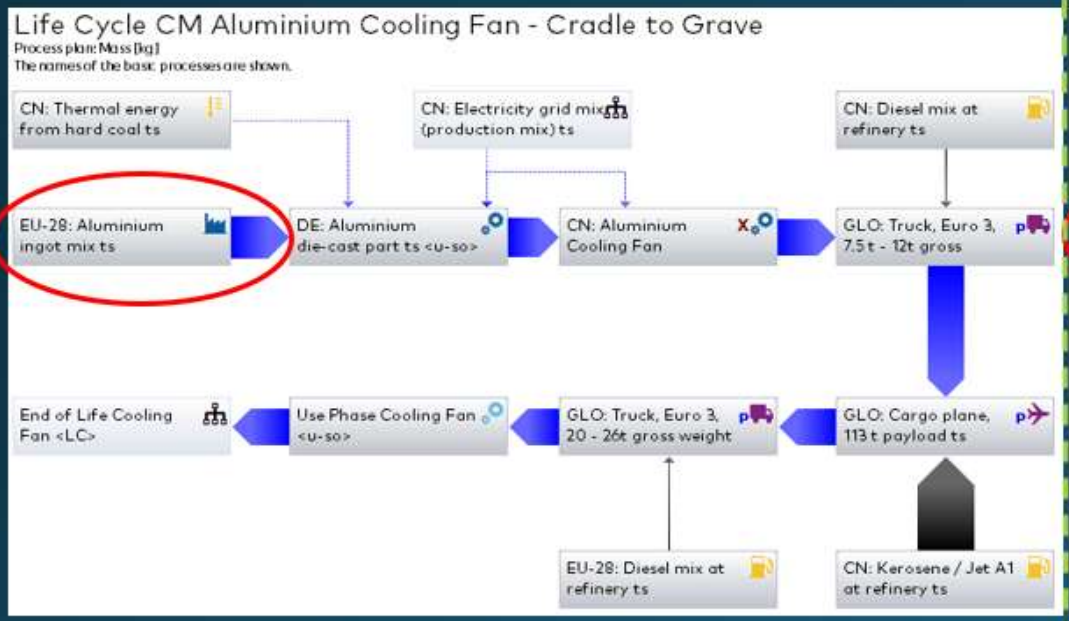


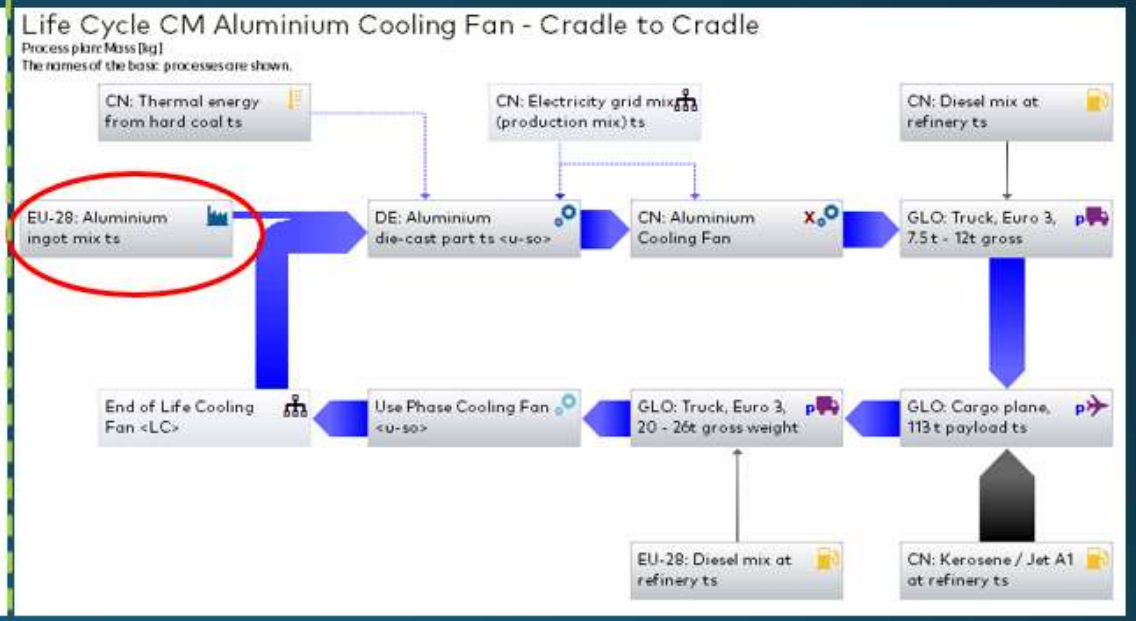
Cradle-to-Grave



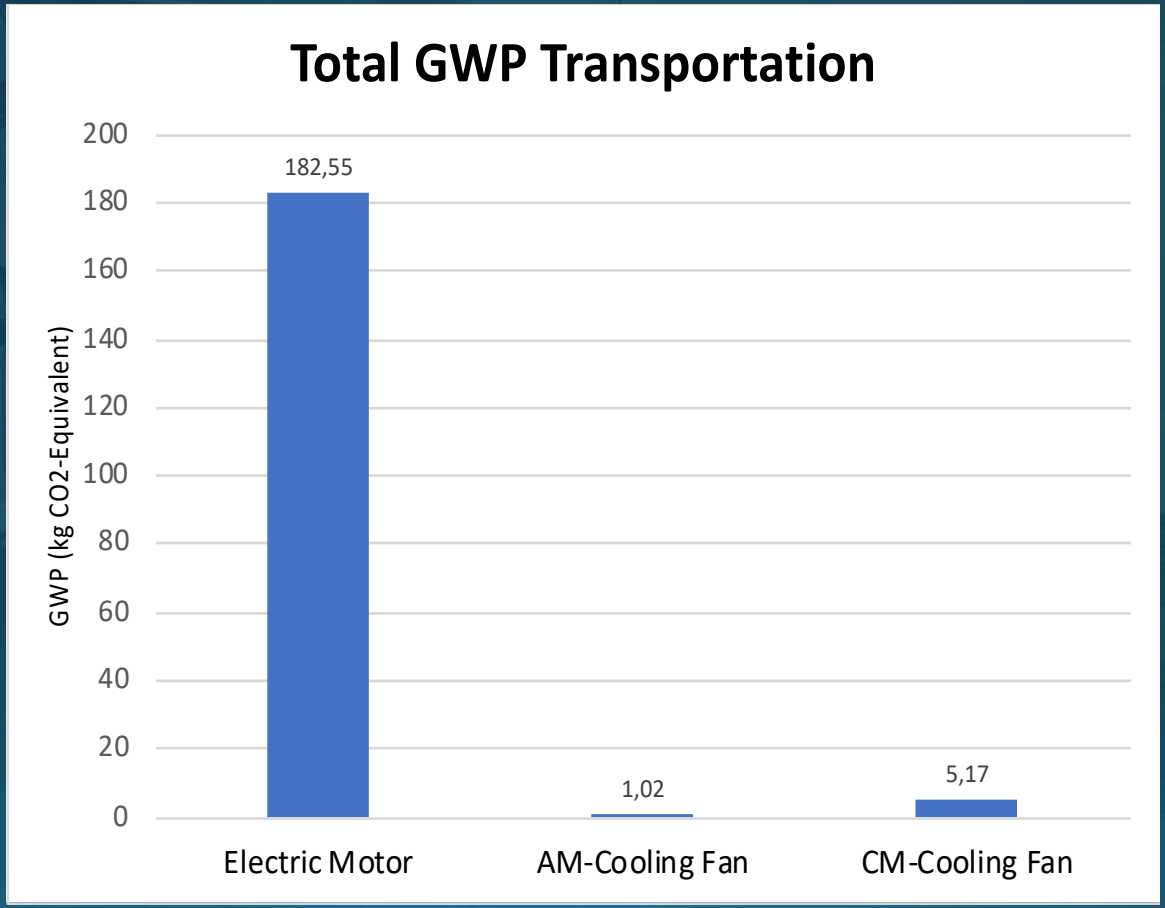
Cradle-to-Cradle

Hotspot CM Cooling Fan





GWP due to transportation



Discussion

Transportation

- AM fan is about 1/5th of CM
- AM has fewer transportation "steps"
- AM has lower weight

- Volume not considered

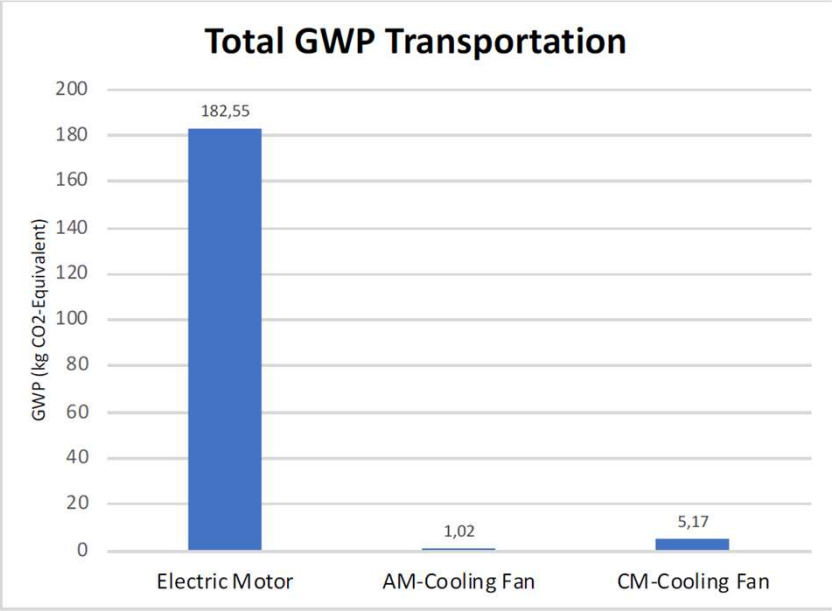


Figure 45: Total GWP Impact due to transportation

	Cradle to grave	Cradle to cradle	GWP from transportation
Electro motor	4509,456	2071,218	182,55
AM cooling fan	3,773	1,702	1,02
CM cooling fan	15,436	8,353	5,17

Unit [kg/CO2e]

Discussion

- Recycling!
- AM significant in favour
- 54.9% reduction
- Aluminium vs nylon
- Increased recycling?

	Cradle to grave	Cradle to cradle	GWP reduction circular approach
Electric motor	*4500,456*	*2071,218*	*54,1 %*
AM cooling fan	3,773	1,702	54,9 %
CM cooling fan	15,436	8,353	45,9 %
GWP reduction AM vs. CM	75,6 %	79,6 %	

Unit GWP 100 [kg CO_2e]

Table 2: The potential reduction of GWP

Conclusion

The carbon footprint of an electric motor, a conventionally- and an additive manufactured cooling fan has been evaluated in regards to the GWP over 100 years. Results are in significant favour to the AM nylon fan, both compared to the CM aluminium fan and compared to the replacement of the electric motor. Recycling of raw material reduces the GWP from 45% to 54% in the three respective scenarios.

	Cradle to grave	Cradle to cradle	GWP reduction circular approach
Electro motor	4509,456	2071,218	54,07 %
AM cooling fan	3,773	1,702	54,89 %
CM cooling fan	15,436	8,353	45,89 %
GWP reduction AM vs CM	75,56 %	79,62 %	
GWP reduction AM vs new motor	99,92 %	99,92 %	

Further conclusions

- LCA: a useful tool to measure GWP
- Recycling
  - Gives significant reduction of GWP
  - Requires design for recycling, pure materials and labelling
  - Increased recycling rate?
- AM enables extension of the lifespan of products
- Circular economy