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

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Sustainable Development Goals

Goal 12: Responsible Consumption and Production

RECYCLE PAPER, PLASTIC, GLASS AND ALUMINIUM.

By 2050, the equivalent of almost three planets could be required to sustain current lifestyles.
Sustainable Development Goals

Goal 13: Climate Action

ACT NOW TO STOP GLOBAL WARMING.
Global emissions of carbon dioxide (CO2) have increased by almost 50% since 1990.
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 product's 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.
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
New Electric Motor
AM Cooling Fan
CM Aluminium Cooling Fan
Results and identification of hotspots
Hotspot-Electric Motor
AM Cooling Fan

Cradle-to-Grave

GWP 100 years

Cradle-to-Cradle

GWP 100 years
Hotspot-AM Cooling Fan
Hotspot CM Cooling Fan
GWP due to transportation

![Graph showing GWP (kg CO2-Equivalent) for Electric Motor, AM-Cooling Fan, and CM-Cooling Fan.]

- Electric Motor: 182.55 kg CO2-Equivalent
- AM-Cooling Fan: 1.02 kg CO2-Equivalent
- CM-Cooling Fan: 5.17 kg CO2-Equivalent
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

<table>
<thead>
<tr>
<th></th>
<th>Cradle to grave</th>
<th>Cradle to cradle</th>
<th>GWP from transportation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electro motor</td>
<td>4,509,456</td>
<td>2,071,218</td>
<td>182.55</td>
</tr>
<tr>
<td>AM cooling fan</td>
<td>3,773</td>
<td>1,702</td>
<td>1.02</td>
</tr>
<tr>
<td>CM cooling fan</td>
<td>15,436</td>
<td>8,353</td>
<td>5.17</td>
</tr>
</tbody>
</table>

Unit [kg/CO2e]
Discussion

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

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<thead>
<tr>
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<th>GWP reduction circular approach</th>
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</thead>
<tbody>
<tr>
<td><strong>Electric motor</strong></td>
<td>4509,456</td>
<td>2071,218</td>
<td>54,1%</td>
</tr>
<tr>
<td><strong>AM cooling fan</strong></td>
<td>3,773</td>
<td>1,702</td>
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<td><strong>GWP reduction</strong></td>
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<td><strong>AM vs. CM</strong></td>
<td>75,6%</td>
<td>79,6%</td>
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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.

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<td>8,353</td>
<td>45.89 %</td>
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<tr>
<td>GWP reduction AM vs CM</td>
<td>75,56 %</td>
<td>79,62 %</td>
<td></td>
</tr>
<tr>
<td>GWP reduction AM vs new motor</td>
<td>99.92 %</td>
<td>99.92 %</td>
<td></td>
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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