Capture the variance of resource intensity estimates for solid freeform fabrication processes based on inherent parameter, model selection, and data source effects.

Conduct a case study to verify results for the Fused Deposition Modeling (FDM) process using a Life Cycle Assessment approach (LCA).

Develop a set of recommendations for further research & development.

Increasing concern about product effects on the environment and society require a more holistic accounting of the impacts of manufacturing operations. LCA is a common tool for estimating the resource consumption and impacts of processes and process chains, but was quoted with uncertainty in current literature. The intersection of these areas is first addressed here with a novel methodology in a case study on FDM.

The combined effects of process (researcher choices of how parameters combine and interact) and scenario (geographic, temporal, or technological) effects contribute largely to uncertainty. Figure description:

- **B**: target machine, area HVAC allocation, uniform treatment
- **C**: proxy machine, target area HVAC allocation, uniform treatment
- **D**: proxy machine and HVAC area allocation, lognormal treatment

Simple Effects

Aggregated Results

Conclusions

Point estimates are poor references for decision makers.

Process LCAs lend themselves to iterative assessment allowing arbitrarily detailed process chain estimates.

Studies should report basic statistics on their results for improved interpretation and comparison.

Proxy estimates, even with the same technology reduce the accuracy significantly.

Model choices should be strongly scrutinized.

Error and uncertainty in resource intensity estimates are poorly recorded in the literature, particularly for rapid prototyping, rapid manufacturing, aka solid freeform fabrication processes.

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<tr>
<th>Source</th>
<th>Study Details</th>
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<td>Lloyd &amp; Reap, et al. (2007)</td>
<td>Developed a set of recommendations for further research &amp; development</td>
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Global warming potential (left) and energy consumption (right) estimates for all sets of conditions by frequency of value estimate.

Measured energy consumption during printing for various random parts on 3 machines with HVAC and lighting.

Conducted a Monte Carlo simulation including various energy consumption assumptions, different geographical locations, and data sets for environmental impacts.

Recorded 2304 sets of conditions.