Cost of AM

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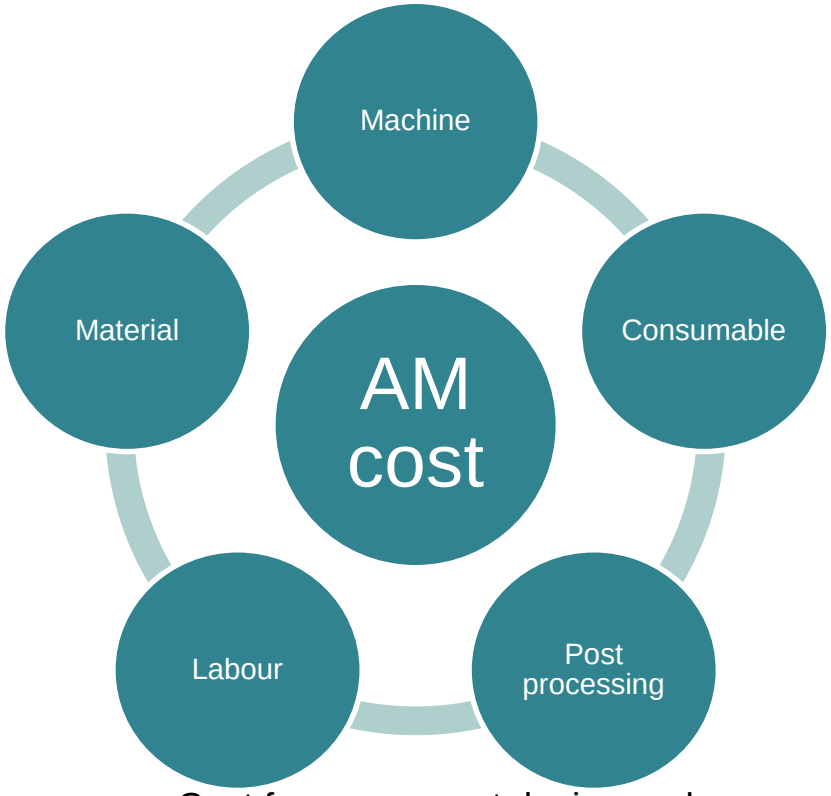
Cost Breakdown

- Machine
- Maintenance
- Consumables
- Overheads
- Labour
- Feedstock
- Build set up/removal
- Post-build curing
- Post Processing
  - Support removal
- Inspection



Cost for component design and quality control is not considered

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Materials

- AM materials are generally more expensive than for other processes.
- Materials can have a limited life span for printing, such as:
  - Set number of build cycles before degradation becomes too great.
  - Resins thicken over time due to small amounts of UV exposure.
  - 2 part resins set within ~12hrs once mixed.
- Reduce mass of parts to reduce material usage.
- Maximise build volume utilisation to minimise material wastage.

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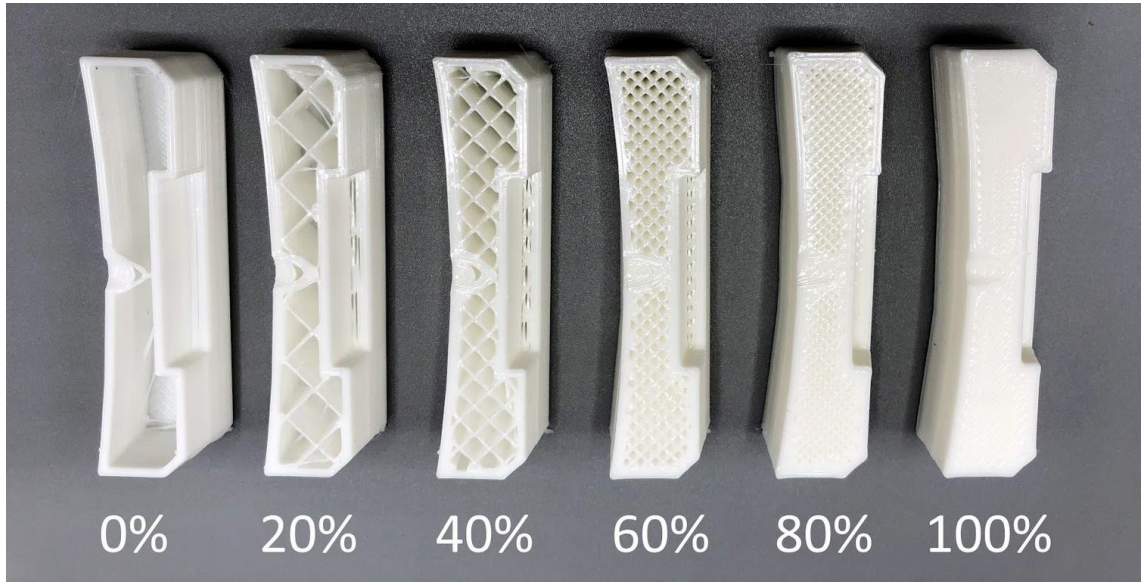
Infill

- Some technologies allow for non-solid parts.
- The infill percentage can be lowered, meaning:
  - Less material
  - Shorter build time
- Different styles of infill will also have an impact.
- Changes in infill need to be taken into consideration in the design.



Source: 3D Pros

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Build Time

- The build itself (physically running the machine) contributes considerably to the overall cost of a component.
- Depending on the technology the build time can be split into 2 factors:
  - Re-layering time – Changes with height of build and layer height
  - Consolidation time – Changes with part volume.

	Re-layering	Consolidation
MEX	✗	✓
VPP	✓	✓
PBF	✓	✓
BJT	✓	✓
MJT	✗	✓

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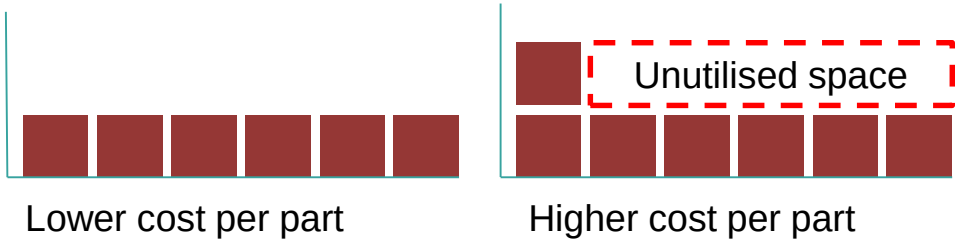
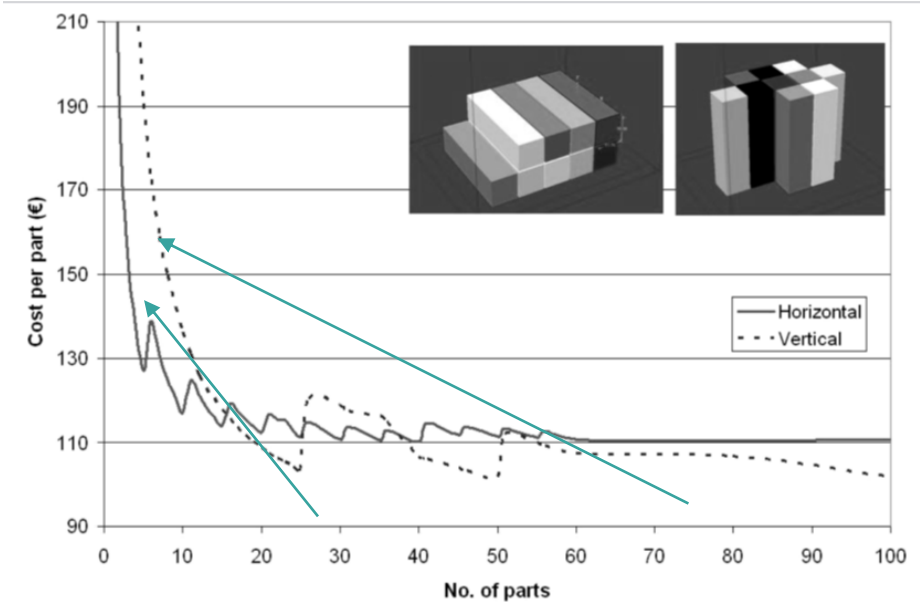
Build volume Utilisation

- Maximising build volume utilisation spreads the fixed costs.
- Orientation can have a big impact on possible build height and part nesting.





Source: C. T. R. J. H. M. Ruffov (2006)

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Post Processing

- De-build and support removal are labour intensive processes.
  - Minimise use of supports
  - Design with ease of de-build in mind
- Minimising supports also reduced the time needed to remove witness marks or use soluble supports where available.
- Some processes require further curing or thermal processing after the build, adding cost and equipment.

Source: 3D Hubs

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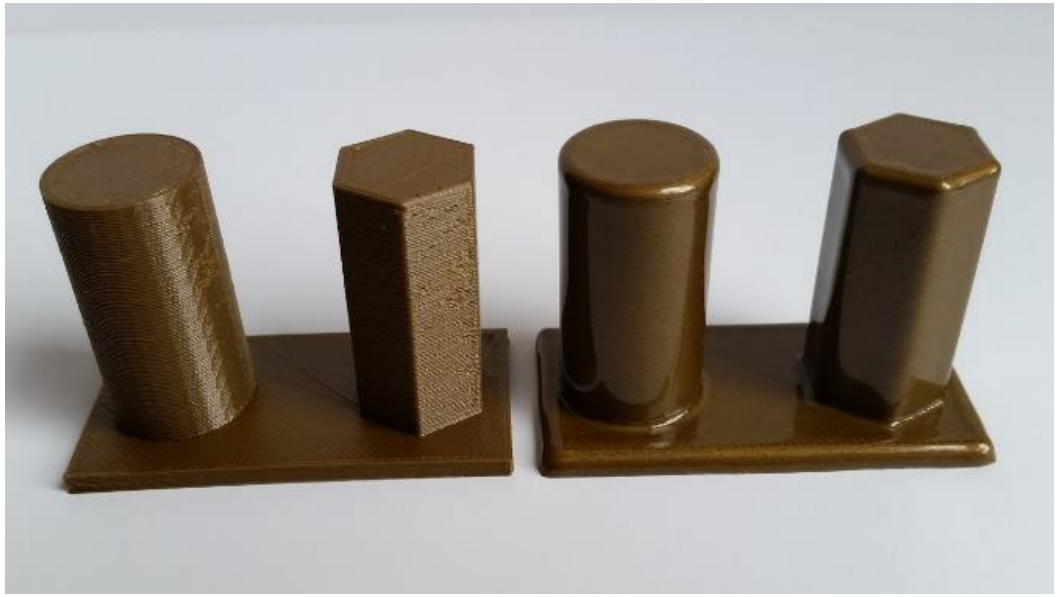
Post Processing

- Surface finishing requirements add to the overall cost of parts. In some cases the parts can be oriented to remove the need.
- Where possible avoid the need for manual finishing such as polishing.



Source: All3dp

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Inspection

- Metrology
- X-ray CT
- Defect investigation
- Geometrical tolerance
- Surface texture

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Additional Costs

- Ancillary equipment
  - Curing chambers
  - Washing facilities
  - Mixers
  - Powder sieves
  - Cool down stations
- Powder/Resin handling and characterisation
- Build failures

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In House vs. Bureau

- 3D printing bureaus can be a good way to get parts printed without the large upfront costs.
- Access to a variety of process and materials.
- More expensive in the long term.
- Guarded about their IP.
  - This can make it difficult if eventually wanting to bring work in house.
  - Wont always be clear what has been required to get a successful print.

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Sustainability in AM

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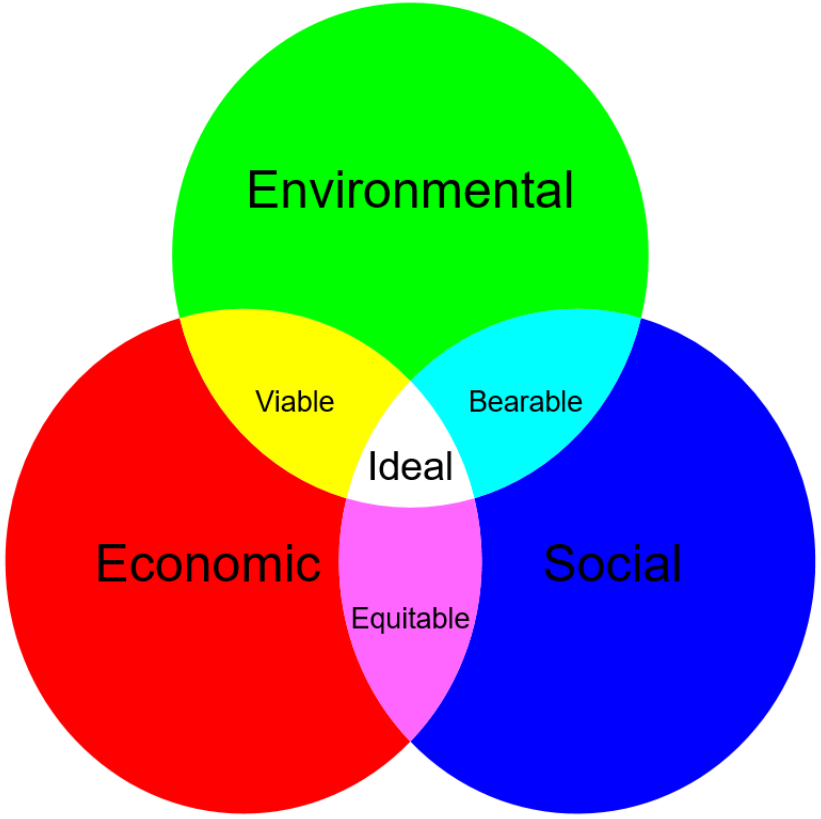
Sustainability

- There are three fundamental pillars on which the concept of sustainability is built upon, known as the 3 Ps:
  - Environmental (Planet)
    - Minimising the impact a product, service or process has on the environment through the entire lifecycle.
  - Social (People)
    - Ensuring decisions are made that benefit a wide population and not solely focused on one individual or group.
  - Economic (Profit)
    - Delivering profitable outcomes



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Sustainability of AM

- Components should be designed to avoid waste (energy or feedstock) occurring.
  - Minimise part mass.
  - Reduce feedstock wastage during manufacture.
- Can it be designed such that it is possible to repair or refurbish?
- Can it be turned into something else?
- Are we using materials that are easy to recycle?
- Is other waste being created, i.e. water, chemicals, consumables?

Source: The Department for Environment, Food and Rural Affairs

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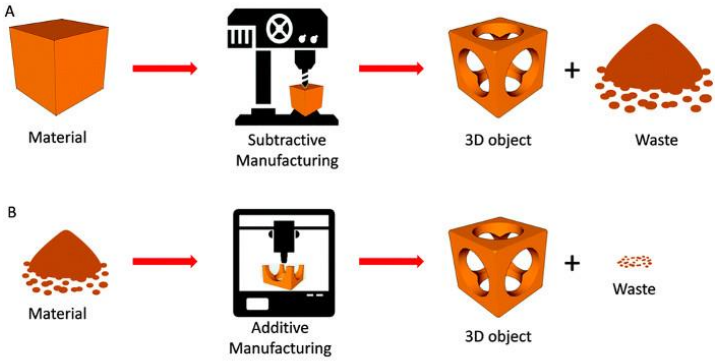
Improving Sustainability Through AM

- Light weighting
  - AM allow parts to be lighter, with less material and less parts (through consolidation).
- Reduced Waste
  - AM produces near net shapes, minimising the material used during machining
- Distributed Manufacturing
  - Part files can be sent to local manufacturing facilities, rather than whole parts being shipped long distances

Source: additivemanufacturing.media



Source: 3dnatives

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Recycling of Materials

- Thermoplastics used in AM processes generally produce recyclable end products.
  - Additives to the materials can affect this.
- Thermosets are not currently recyclable.
  - Typically photosensitive resins come under this category.
- Filled polymers are not current recyclable due to the difficulty in separating the different materials.
- If using a recyclable feedstock, you could add the appropriate icon somewhere on the part.

Source: All3dp

Source: RepRap

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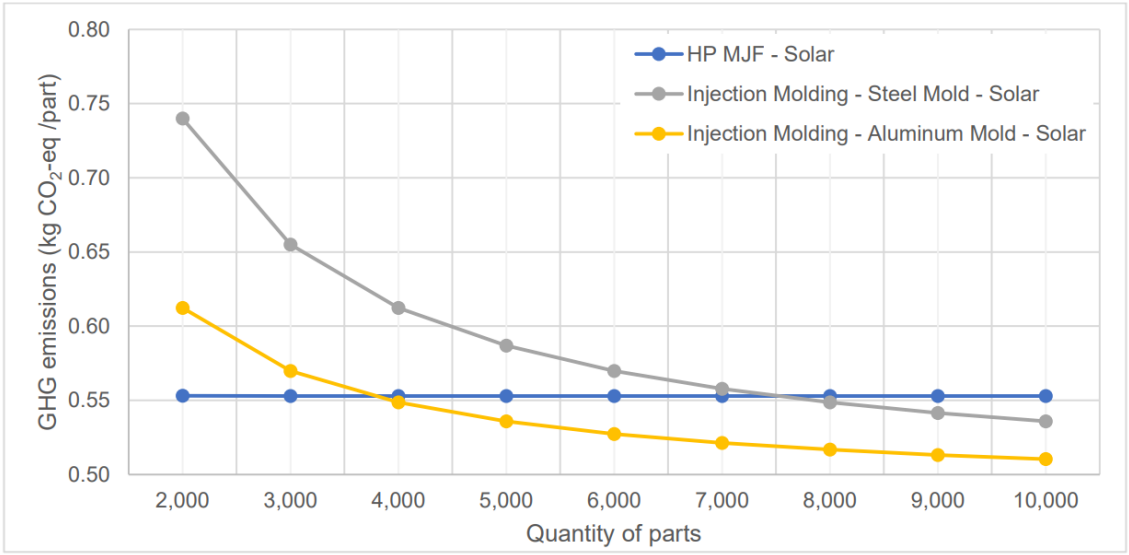
Emissions

- The energy required to create the raw feedstock for AM can be higher than for other processes.
- This can sometimes be offset by the parts needing less feedstock to produce.
- Data is limited on embodied energy and carbon but studies show that for small numbers of parts the emissions per part are lower the other processes.
- The CO_2-eq and economic break even points do not always line up.



Source: London, Michael (2020)

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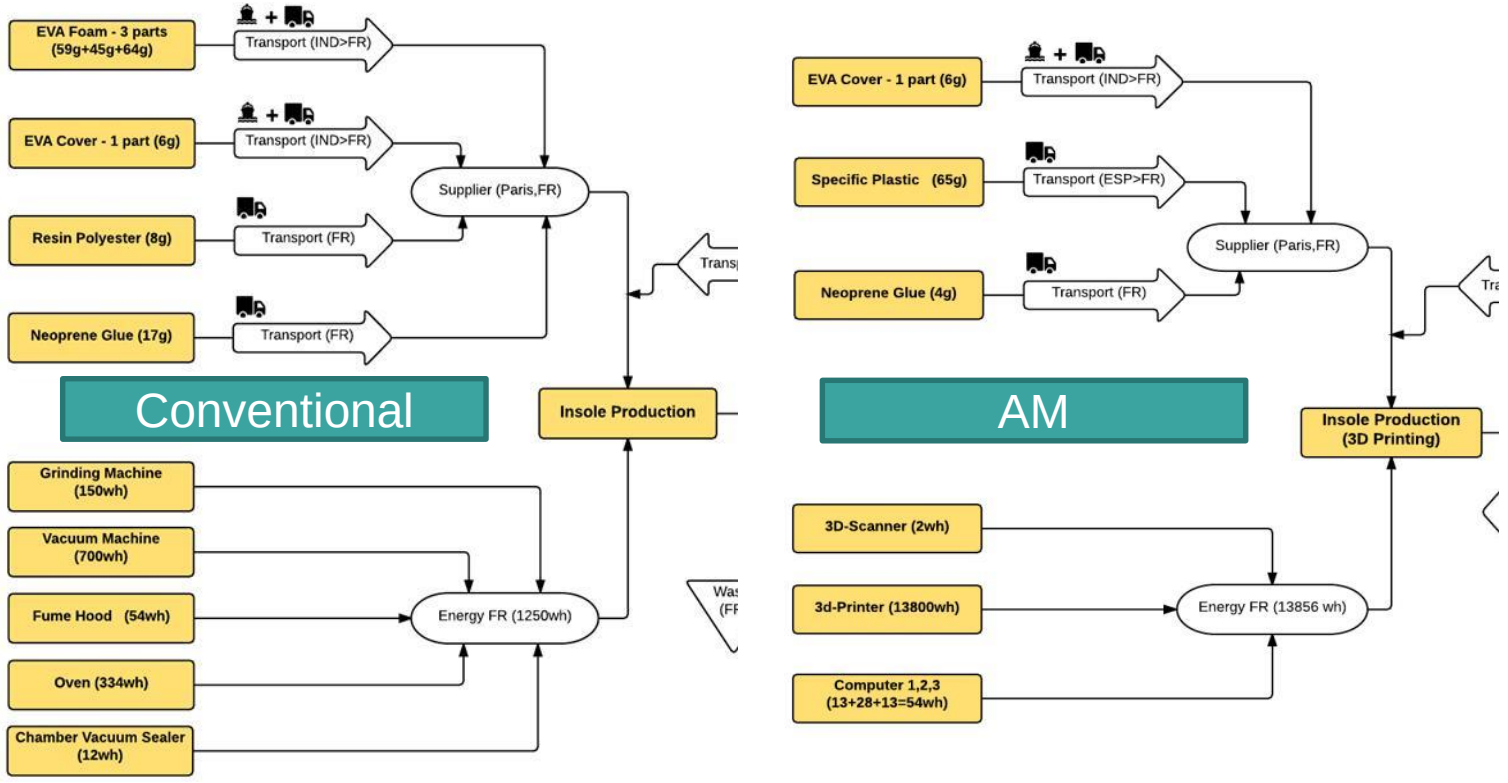
Life Cycle Analysis

- Life Cycle Analysis can be used to assess the overall environmental impact of a part though its life.
- There are a growing number of studies looking at the LCA of AM processes.
- Studies show the energy consumption per part changes substantially with machine utilisation.



Source: 3D Printing Industry

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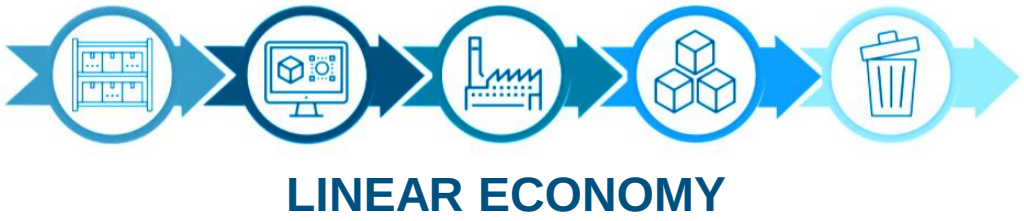
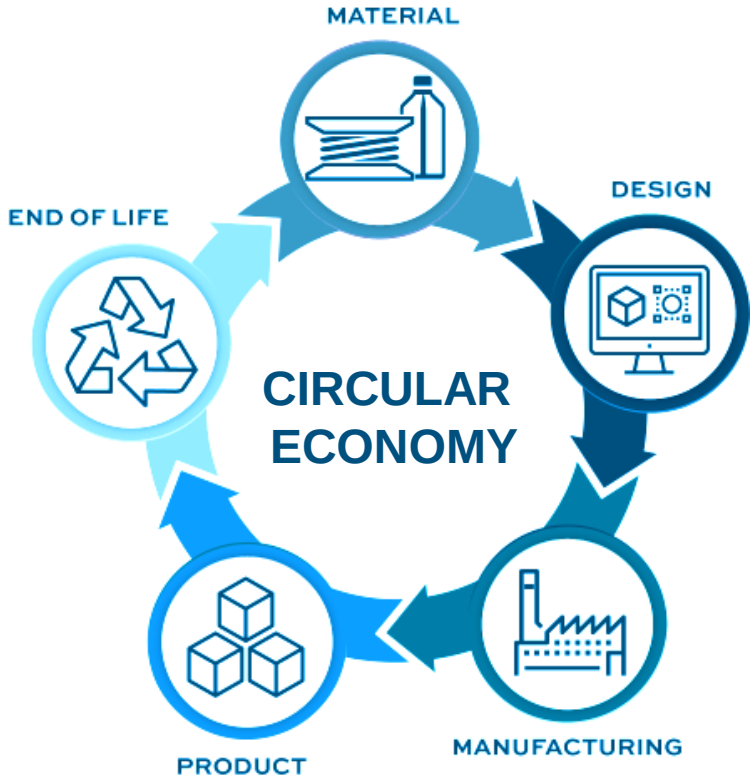
Improved Sustainability

Linear vs Circular Economy

- Increasing sustainability awareness mean companies are looking to go from a linear to circular economy model



LINEAR ECONOMY



Source: additivemanufacturing.media

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Improved Sustainability

Through Materials

- A growing number of manufacturers are providing recycled and bio-degradable polymers (like PLA as opposed to ABS/PET)
- Companies are converting their post-production plastic waste into filaments to be used by 3D printers
- The focus now is to recycle waste from the customers to close the circular loop on plastic production

Source: additivemanufacturing.media

Source: Dezeen

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Improved Sustainability

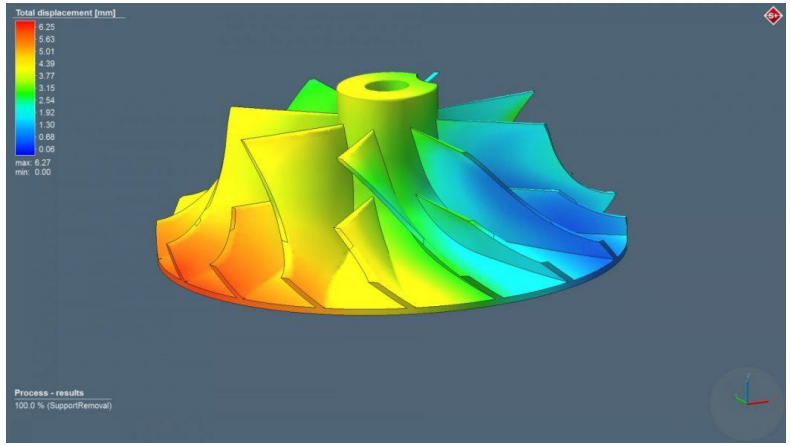
Through Software

- AM tailored software tools are becoming increasingly more advanced:
  - Topology optimisation
  - Generative design
  - Build preparation

- Ability to create complex structures

- Rapid prototyping is being replaced with digital prototyping through process (or build) simulation software

Source: Generate



Source: Simufact Additive

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