MFG501099

How Can Sustainable Manufacturing Save You Money and Help the Planet

Matt Oosthuizen
Autodesk

Robert Bowerman
Autodesk

Learning Objectives

- Compare different metal additive, subtractive. and hybrid workflows.
- Learn about sustainability metrics within manufacturing and how they impact the embodied carbon of manufactured components.
- Learn about applying sustainability metrics to assess three manufacturing workflows to select the most sustainable methodology.
  Evaluate how sustainability metrics can be predicted to enable the decision-making process within the design phase.

Description

Modern manufacturing technology has given designers a large selection of possible avenues for the manufacturing of a component. However, with this variety, it's difficult to know which method would provide the most-sustainable results. By maximizing manufacturing sustainability metrics, in this session, we'll showcase how Autodesk Fusion 360 users can select a manufacturing workflow to ensure a reduced impact for their manufactured component. Focusing on additive, subtractive, and hybrid manufacturing workflows, our case study will highlight how to use manufacturing energy consumption and waste metrics to select the most sustainable manufacturing method for designs. Furthermore, this session will dive into ongoing research on how these decisions can be made within the design phase of product development, through maximizing predictive manufacturing energy and waste models.

Speaker(s)

Matt Oosthuizen

Sustainable Manufacturing Specialist
Autodesk - Impact and ESG Organisation

Matt Oosthuizen is the Sustainable Manufacturing Specialist within Autodesk's Impact Organization. With an undergraduate and master's in mechanical & Manufacturing Engineering from the University of Warwick. Now being responsible for the Sustainable Manufacturing strategy at Autodesk he is now focused on understanding and developing the next wave of technology to provide manufacturing impact visibility. Currently Matt is exploring and creating tools for accurately predicting energy consumption of various manufacturing methods, to influence more sustainable design and product manufacturing decisions of customers.

Rob Bowerman

Senior Technology Consultant
Autodesk - Customer Engagement Organisation

Robert Bowerman is a Technology Consultant within Autodesk's Fusion 360 family's Customer Engagement Organization. Working within the field of Additive Manufacturing, on collaborative projects and with industrial partners to develop the future tools for Additive Manufacturing processes. Of particular interest are the design freedoms that AM offers and the exploration of new design methodologies. My experience spans 8 years of working with Additive processes, starting as a Researcher at the UK's National Centre for AM, looking into Powder Bed Fusion Processes. To my current role at Autodesk, investigating and developing tool for driving DED and Hybrid processes.

Manufacturing's Impact

The manufacturing industry is a key contributor to the worlds carbon emissions, with around 9 billion metric tons of CO2 being emitted during metallurgy, machining and manufacturing operations. This provides a big opportunity for small changes to make big differences. Therefore we want you as our customers and the worlds engineers to think about how you can make small changes within your design and manufacturing workflows.

Global greenhouse gas emissions by sector
This is shown for the year 2016 – global greenhouse gas emissions were 49.4 billion tonnes CO₂eq.
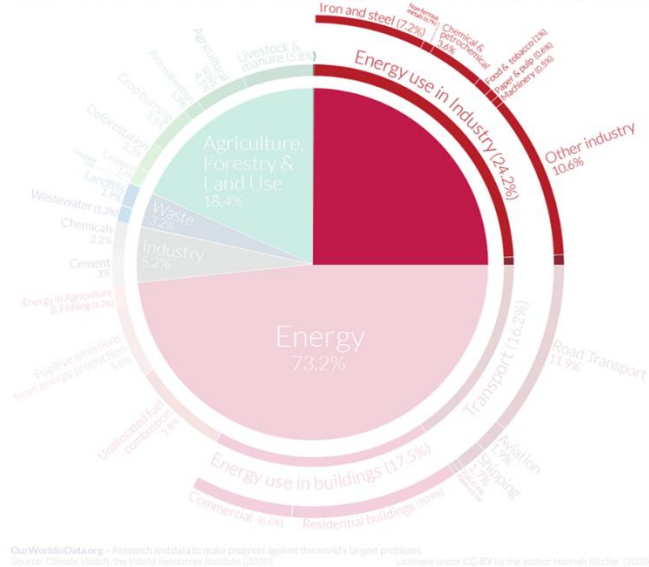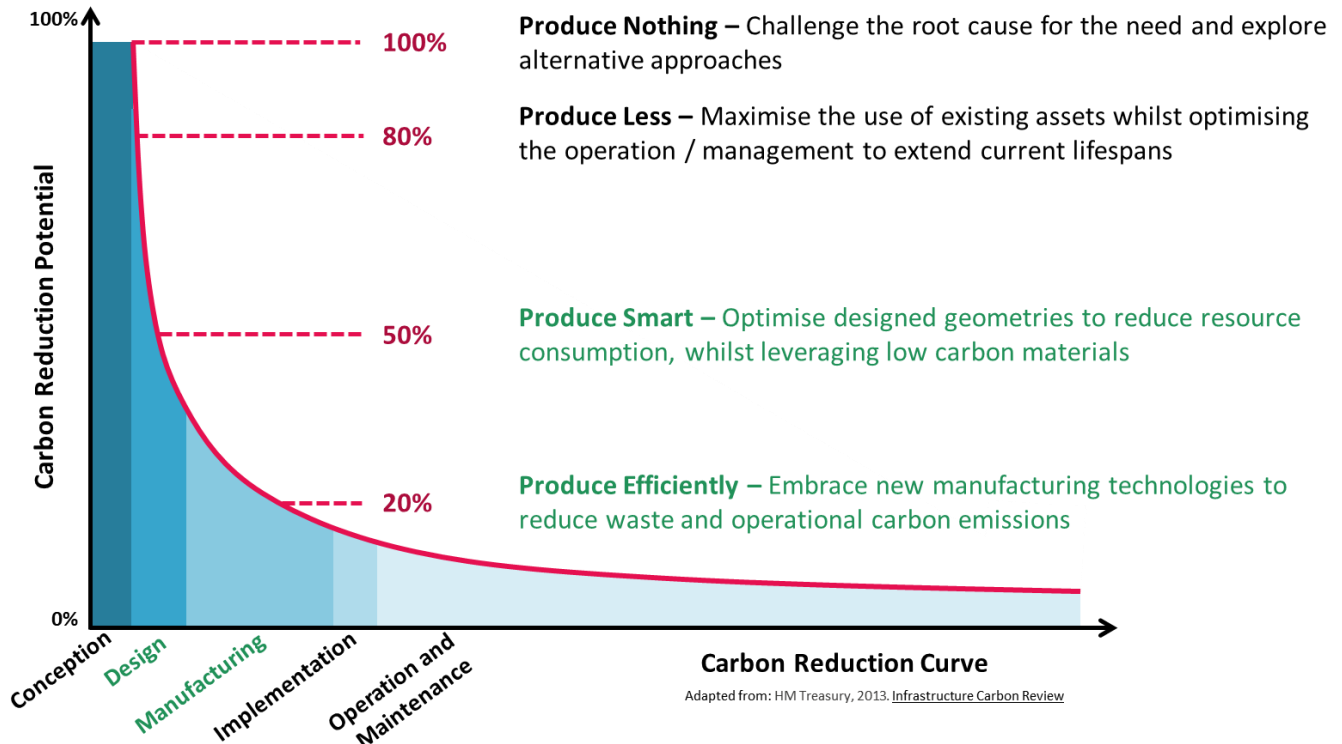
Life cycle analysis and defining a 'scope'
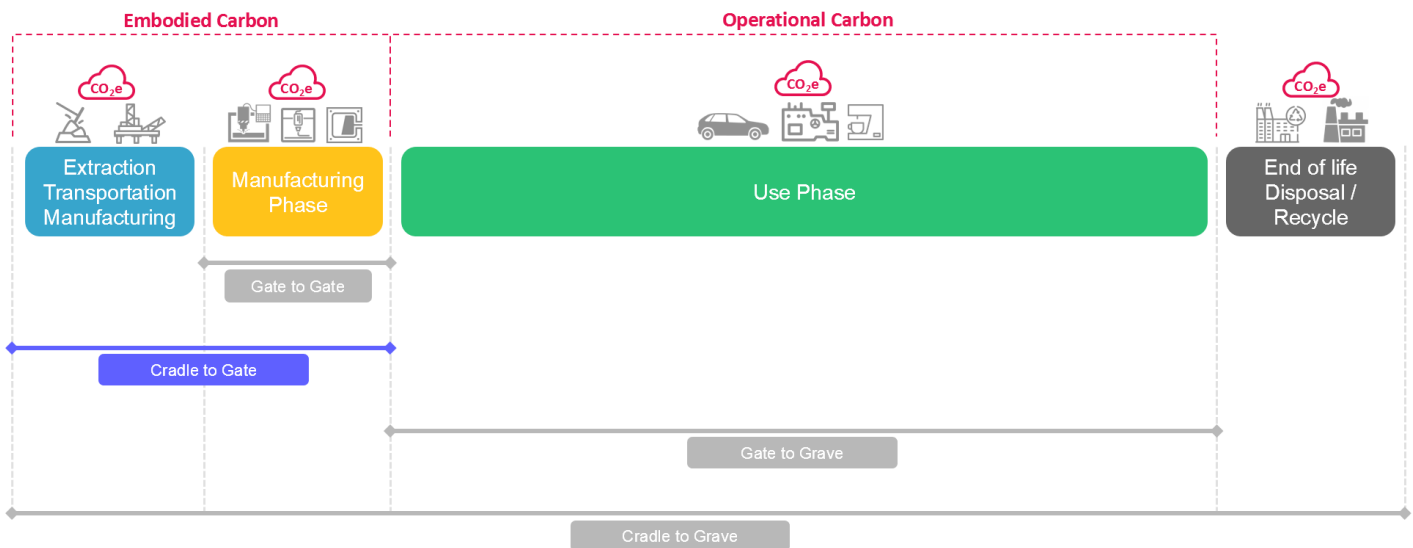
- A Life cycle analysis (LCA) is the methodology for assessing environmental impacts associated with the phases of the life of a commercial product.
- The Scope of an LCA is used to isolate the areas of interest and ensure the research and calculations are focused on important areas. Ensuring that the analysis within the scope is thorough.
- Embodied carbon is the CO_2 emissions associated with the materials extraction, processing, transport and manufacturing process of a designed component.

The benefit of tackelling carbon early

Produce Nothing – Challenge the root cause for the need and explore alternative approaches

Produce Less – Maximise the use of existing assets whilst optimising the operation / management to extend current lifespans

Produce Smart – Optimise designed geometries to reduce resource consumption, whilst leveraging low carbon materials

Produce Efficiently – Embrace new manufacturing technologies to reduce waste and operational carbon emissions

Carbon Reduction Curve

Adapted from: HM Treasury, 2013. Infrastructure Carbon Review

80% of environmental impact of a products life cycle is locked in during the design phase, with manufacturing decisions also having a big influence. Therefore, if we can design products for extended lifespans and optimize these products to be designed and manufactured in more smart and efficient ways.
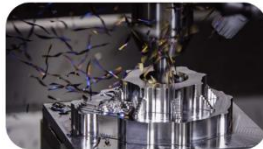
Evaulating different manufacturing methods

Manufacturing Machines Used

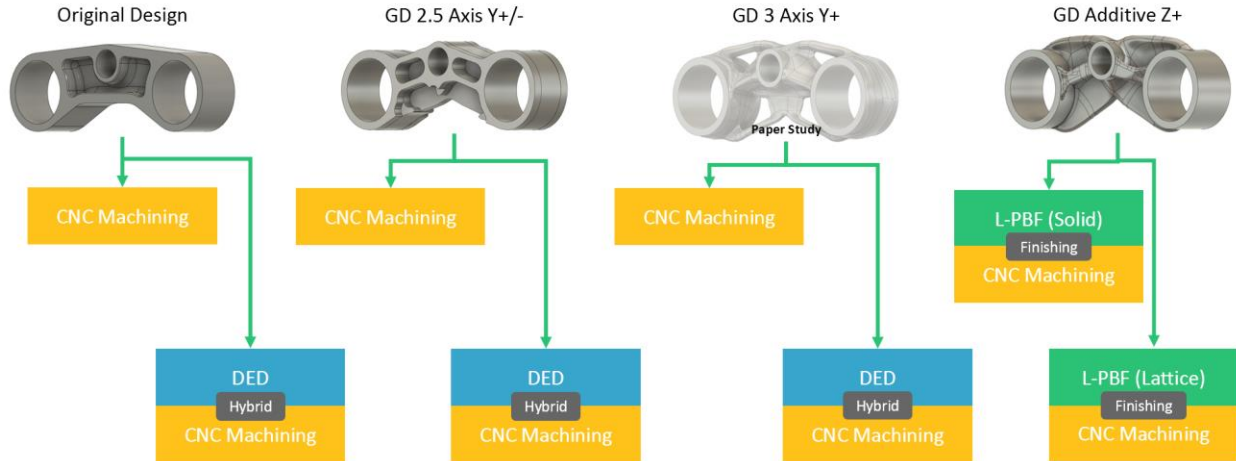**Additive Manufacturing**
Laser Powder Bed Fusion (L-PBF)

Subtractive Manufacturing
CNC Milling
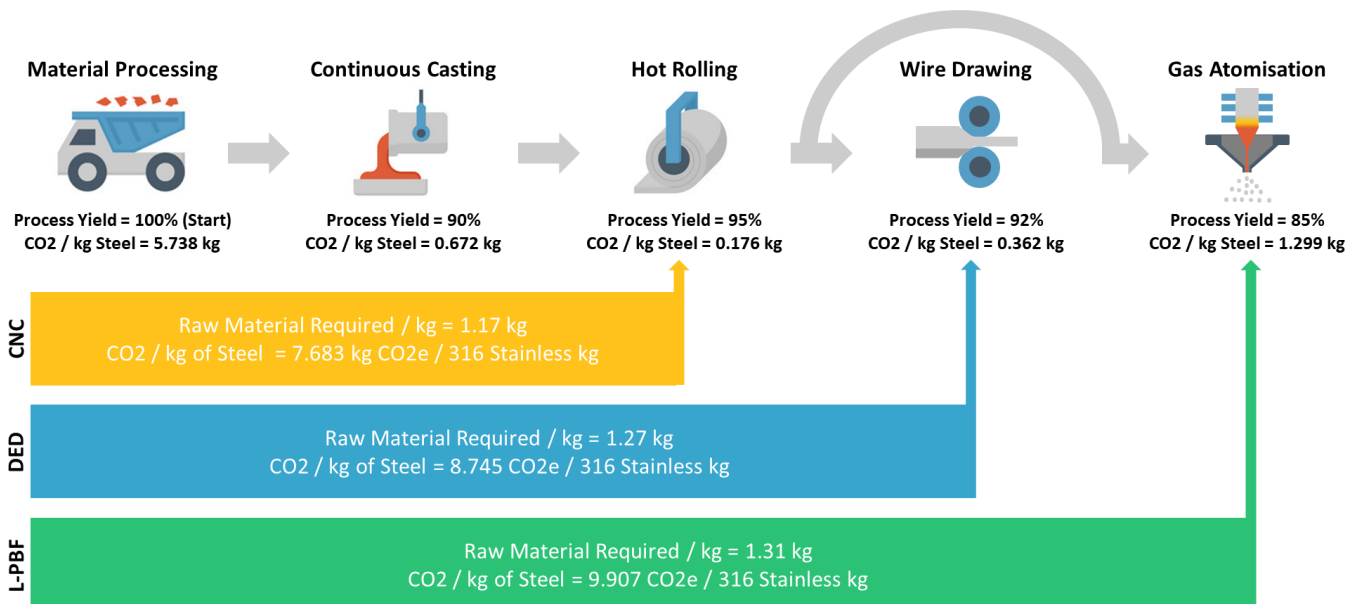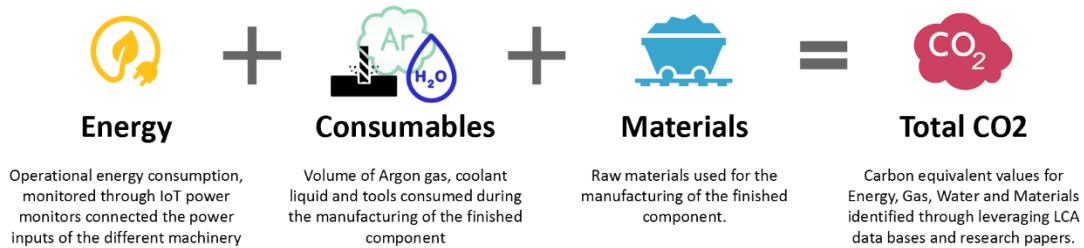
Hybrid Manufacturing
Direct Energy Deposition + CNC Milling

Pairing generative design with additive and subtractive manufacturing

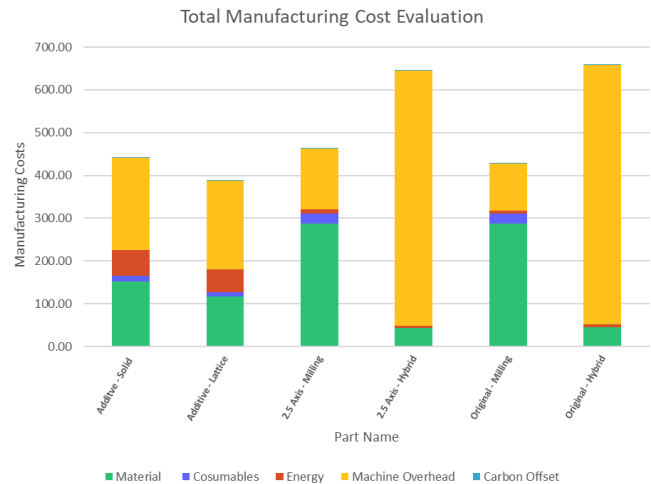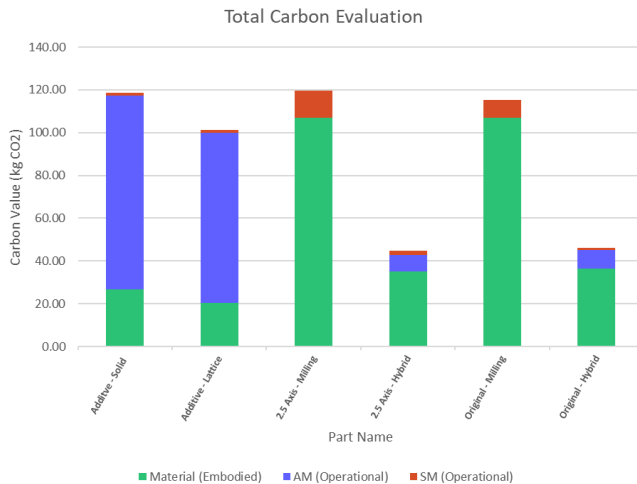| Original Design	GD 2.5 Axis Y+/-	GD 3 Axis Y+	GD Additive Z+
CNC Machining	CNC Machining	CNC Machining	L-PBF (Solid) / Finishing / CNC Machining
DED / Hybrid / CNC Machining	DED / Hybrid / CNC Machining	DED / Hybrid / CNC Machining	L-PBF (Lattice) / Finishing / CNC Machining

To ensure the designs were optimized for the manufacturing method, we leveraged generative design to create design outcomes with the manufacturing constraints being considered.

Evaluating the manufactured outcomes

Energy + **Consumables** + **Materials** = **Total CO2**

Energy
Operational energy consumption, monitored through IoT power monitors connected the power inputs of the different machinery

Consumables
Volume of Argon gas, coolant liquid and tools consumed during the manufacturing of the finished component

Materials
Raw materials used for the manufacturing of the finished component.

Total CO2
Carbon equivalent values for Energy, Gas, Water and Materials identified through leveraging LCA data bases and research papers.

Material Processing
Process Yield = 100% (Start)
CO_2 / kg Steel = 5.738 kg

Continuous Casting
Process Yield = 90%
CO_2 / kg Steel = 0.672 kg

Hot Rolling
Process Yield = 95%
CO_2 / kg Steel = 0.176 kg

Wire Drawing
Process Yield = 92%
CO_2 / kg Steel = 0.362 kg

Gas Atomisation
Process Yield = 85%
CO_2 / kg Steel = 1.299 kg

CNC
Raw Material Required / kg = 1.17 kg
CO_2 / kg of Steel = 7.683 kg CO2e / 316 Stainless kg

DED
Raw Material Required / kg = 1.27 kg
CO_2 / kg of Steel = 8.745 CO2e / 316 Stainless kg

L-PBF
Raw Material Required / kg = 1.31 kg
CO_2 / kg of Steel = 9.907 CO2e / 316 Stainless kg

## Which was outcome was most sustainable and cost effective?

The 2.5 Axis outcome, manufactured through a hybrid workflow was the least impactful, with only 44.74 kg of CO2eq. This was due to the pairing of low operational energy consumption and efficient buy to fly ratio. However, due to the cost of the machine, the hybrid workflow was a more costly method for manufacturing a component.

If circular economy practices are introduced, the pure subtractive manufacturing processes see a 60% reduction in total product impact, making the process significantly more sustainable.

If the scope is extended and the mass of the final part is considered, then the Addtive – Latticed outcome will have the lowest total carbon impact. A 42% mass reduction compared to the original design could lead to significant fuel savings when utilized on a combustion powered vehicle.

Predicting future impact within Fusion 360 D&M workspaces
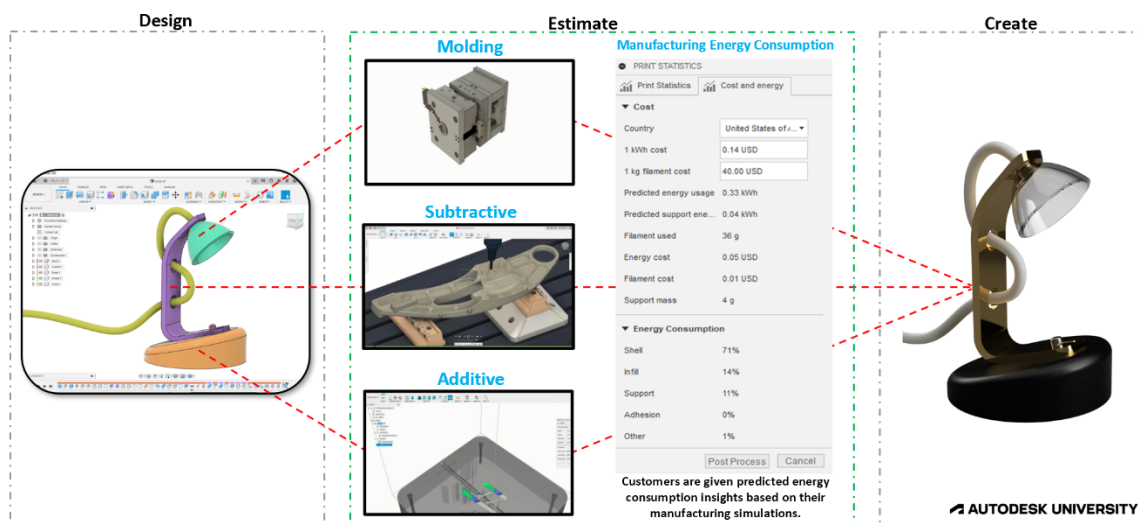
We want you to make more sustainable design and manufacturing choices, therefore we want to develop tools which enable you to have this level of impact visibility between your design and create workflows.

Therefore please think about the following:

- What would you do with this level of impact insight?
- Would you change your design and manufacturing workflows to reduce production impact?
- What small changes in your daily operations could you make to reduce your impact?
- Have you explored new technologies, materials for workflows?