3D Printing & Sustainability at HP

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Bari, Nov 2023

Companies increase focus on Sustainability

Gartner: Sustainability emerges as top 10 business priority

CEOs' Top 10 Strategic Business Priority Areas for 2022-2023

Summary Top Three Mentions, Coded Responses

		Change From 2021
Growth	51%	▼ 8%
Tech-Related	34%	▼ 5%
Workforce	31%	▲ 32%
Corporate	29%	▼ 5%
Financial	20%	▼ 27%
Products and Services	15%	▲ 43%
Customer	15%	▲ 26%
Environmental Sustainability	9%	▲ 292%
Cost	9%	▼ 24%
Sales	6%	▲ 77%

Up from 20th in 2015 and 14th in 2019

Gartner

CO^2 footprint becomes the NorthStar metric

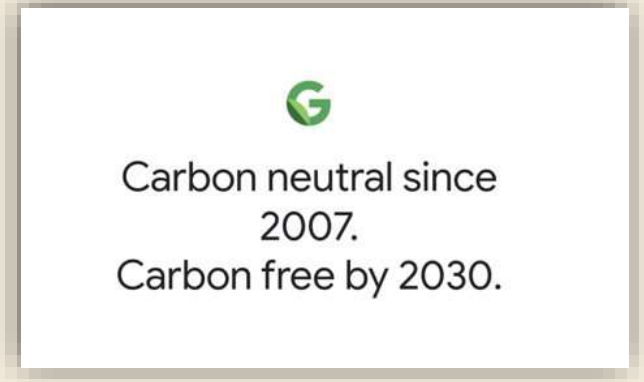
A single metric favors focus and alignment (internally and externally)

- Apple Inc.

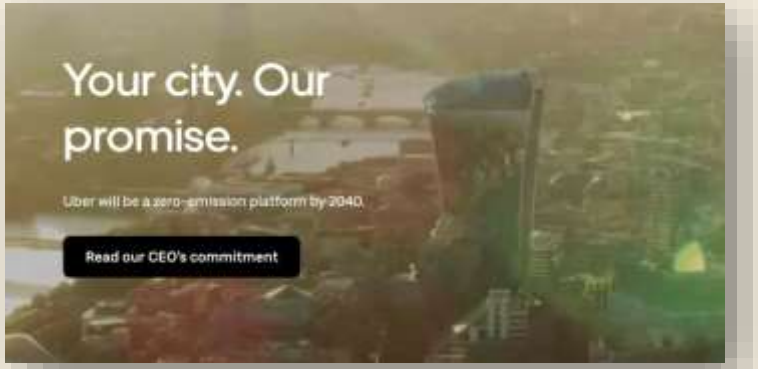
- Shell

- BP

- Netflix



- Google



- Uber

- United Airlines

- Nike

Why is 3D Printing more sustainable

- Lighter parts – Less energy to build/move/ship
- Material only where needed – Reduce waste and energy
- Assembly consolidation – Less extra components
- Localized production – Lower transportation cost
- Production on demand – No need to stock
- Digital spare parts inventory – Longer life cycle
- ……

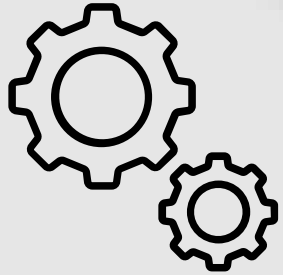
HP 3D printing technology

Multi Jet Fusion: Design Parameters

SPEED 1

Process **layers** in **one pass**

PART PERFORMANCE 2

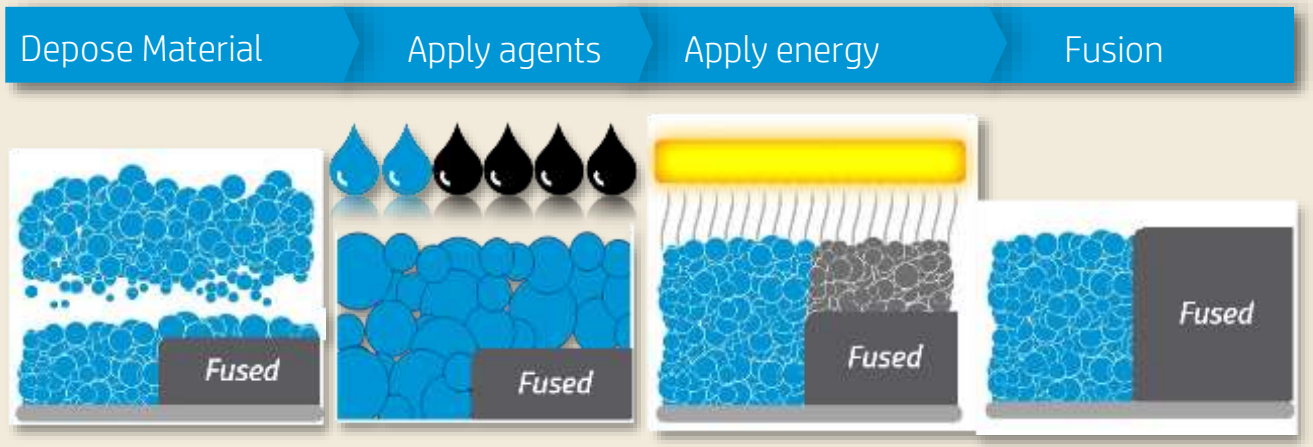


Build **functional** parts

ECONOMICS 3

Cut **running costs**

HP Multi Jet Fusion Technology



HP 3D Sustainability Strategy

1 Reduce Carbon Emissions

- Reduce material carbon footprint
- High reusability materials

2 Enable Circularity

- Recycling programs

3 Drive Awareness

- Materials LCA under
- HP Carbon calculator


How are we reducing MJF CO^2 today?
High reusability materials
PA12 switch to renewable energy
PA11 bio-based and use of renewable energy

High reusability

Industry-leading surplus powder reusability

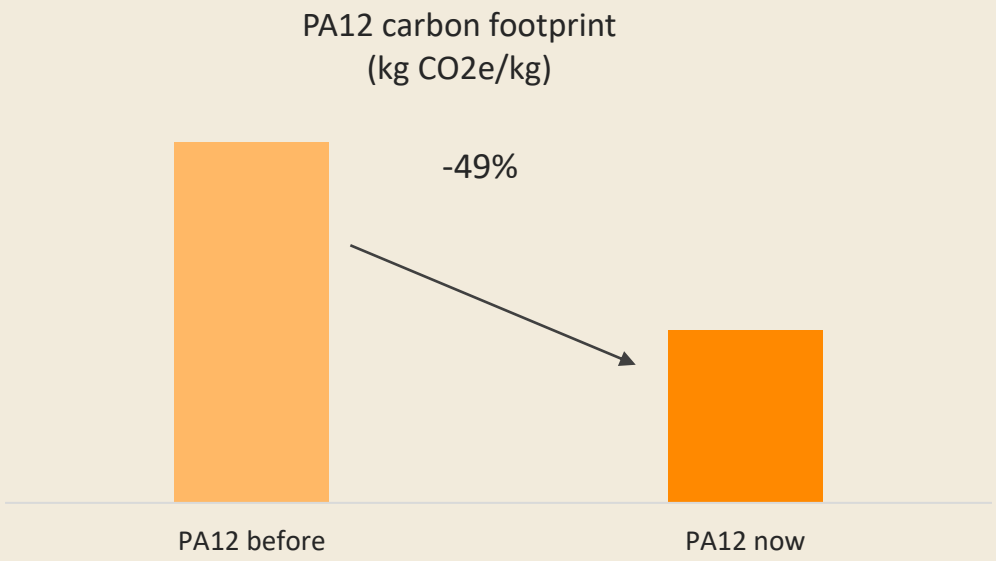
Moving from 50 to 80% reusability ratio has an impact of ~70% in the carbon footprint of a printed part

Material	Reusability ratio
PA12	80%
PA11	70%
PA12 GB	70%
PP	90%
PA12 W	75%
TPU	80%
TPA	80%

Assumptions: based on PA12, full builds at 8% PD and 40cc parts

PA12 switch to renewable energy

49% reduction in the carbon footprint (compared to its previous iteration)



Full switch of all PA12 purchases

- Lower carbon footprint
- = Same price for our end users
- = Same exact material formulation, performance, SKU…

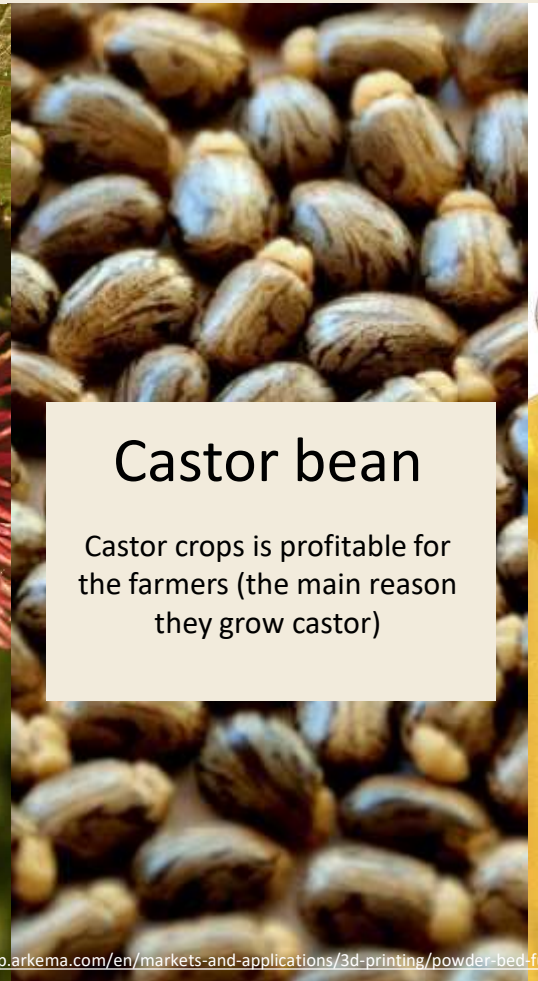
PA11 – 100% bio based

Life-cycle HP 3D High Reusability PA 11[1]

From castor bean to advanced polymers

Castor plant

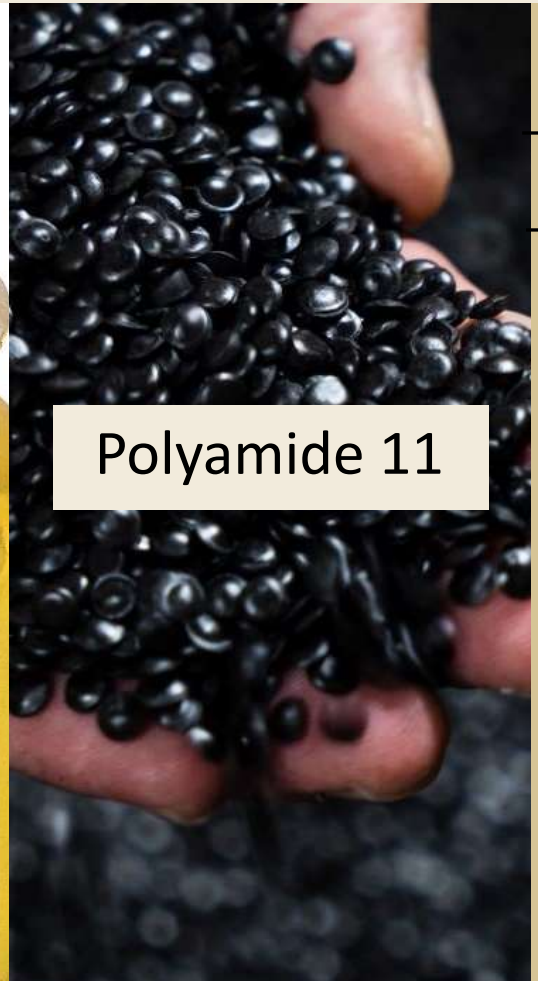
Castor grows where nothing else can grow – it does not compete with food and does not cause deforestation



Castor bean

Castor crops is profitable for the farmers (the main reason they grow castor)

Castor oil



Polyamide 11

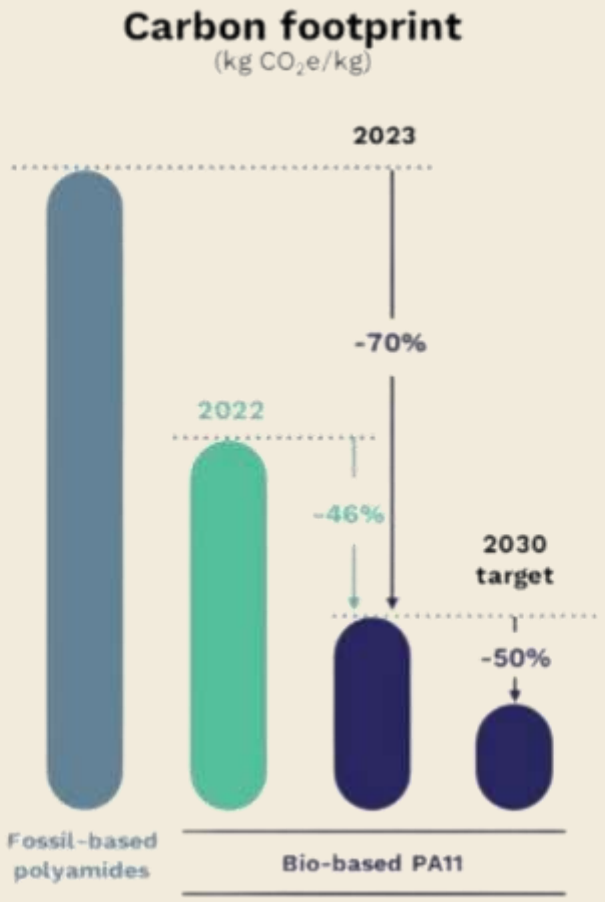
Castor:

"the magic bean"

- No competition with food/feed
- Grows in marginal soil
- Limited water use (takes advantage of natural monsoons)
- No deforestation
- Profitable for the 700,000 farmers who grow it

Note: 1. Per material supplier public documentation https://hpp.arkema.com/en/markets-and-applications/3d-printing/powder-bed-fusion/#pa11

PA11 renewable energy use



46% reduction in the carbon footprint of our PA 11 material compared to its previous iteration

~30% reduction on the part carbon footprint

PA11 has the lowest material carbon footprint among HP portfolio

Starting in January 2023, Arkema has partnered with Engie to introduce renewable biomethane into the production process

This change has no impact on the product performance, cost or SKU

Source: https://www.arkema.com/global/en/media/newslist/news/global/investorrelations/2023/20231009-lower-carbon-footprint-bio-based-rilsan/

Circularity

HP 3D Sustainability Strategy

Enable circularity

Working with our partners to enable our customers to recycle MJF printed parts and powder

HP Take Back program

Arkema Virtucycle

Forward AM TPU01 Second Life

Source: https://hpp.arkema.com/en/sustainability/virtucycle/

Arkema

The Virtucycle® Program

Arkema's proposal for HP's customers

→ Arkema can help HP's customers to recycle used MJF polyamides used powders and printed parts **instead of costly and environmentally-unfriendly landfilling or burning**

Virtucycle® ARKEMA

→ Arkema is **reengineering and recompounding high performance long-chain polyamides** at its **Agiplast plant in Italy** for example in pellets for injection molding applications like automotive, sports, consumer market, etc

HP, Lavergne, Ford HP PA12 Pilot Take Back and Reuse Program

Small volume, proof of concept project

5. Ford qualified recycled resin in F-250 trucks

4. Reformulated and pelletized for use in plastics injection molding

LAVERGNE

3. Select US customers recycle through HP Planet Partners

1. Customers buy Original HP 3D MJF materials

2. Customers use Original HP materials to make products

https://media.ford.com/content/fordmedia/fna/us/en/permalink.html?VideoId=6243441479001#

Drive Awareness

HP 3D Sustainability Strategy

Drive awareness

Be more transparent about our environmental impact	Work together with customers to help them measuring and reducing their carbon emissions	Provide materials LCA to end customers and the carbon footprint of parts printed with MJF

Next step:

LCA comparison vs traditional Manufacturing Processes

HP Carbon Calculator

› We have developed a tool that is able to calculate the carbon footprint of a MJF printed part

› The tool only considers the carbon footprint of the printing process, so everything that happens inside the printer.

$$\text{CF of a part} = \frac{\text{kg fresh powder} * \text{LCA material} + \text{electricity consumption} * \text{country's grid emission factor} + \text{L agents used} * \text{LCA agents}}{\text{\# parts in a job}}$$