3D printing and sustainability

To what extent can 3D printing contribute to reducing the environmental impact of producing your parts?

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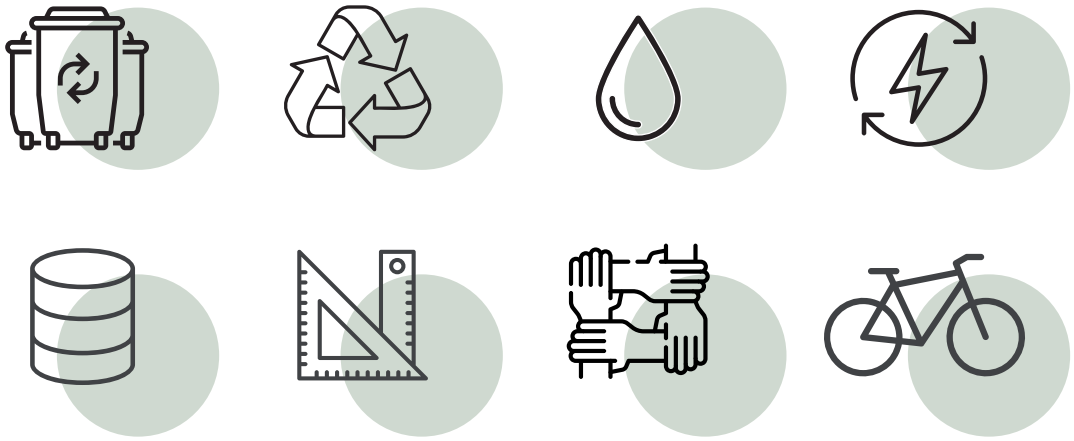
A brand of BASF - We create chemistry

Before we start

In this essay, we will attempt to provide you with information about the benefits of 3D printing in terms of reducing greenhouse gas emissions and, more generally, environmental impacts. We will present some best practices to achieve this. We hope that by reading it, you will be able to make an informed decision regarding the use of 3D printing to reduce your environmental footprint.

We will highlight the environmental advantages of 3D printing. We will also explore how to diminish the environmental footprint of your parts by focusing on optimized and shared production. You may even find some advice on how to eco-design your parts to enhance their performance and durability.

1 Reminder of the climate context and why it is important to reduce our impacts



The latest report from the IPCC emphasizes the urgency of taking strong measures to address anthropogenic climate change. It highlights the magnitude of the detrimental impacts on the environment, biodiversity, and human communities, some of which are already irreversible.

The intensive use of fossil fuels is causing an unprecedented increase in global temperatures. Indeed, the extraction, generation, and utilization of fossil energy are highly emitting in greenhouse gases (GHGs).

These GHGs, naturally present in the atmosphere, trap a portion of the heat received from solar energy. Among these gases, the well-known CO_2, water vapor, and also other gases resulting from human activities like fluorinated gases can be found. The increase in the concentration of GHGs - measured in «carbon equivalent» - in the atmosphere is responsible for this temperature rise.

In 2019, the concentration of CO_2 in the atmosphere reached an average of 410 ppm, a level that had not been reached in 2 million years.

Source: 2023 IPCC Report

For companies like Sculpteo, this represents a call to take action and reduce our environmental footprint, while simultaneously helping our clients do the same. By adopting more responsible practices, reducing greenhouse gas emissions, and optimizing the use of resources, companies can not only contribute to mitigating climate change but also enhance their resilience to face upcoming challenges.

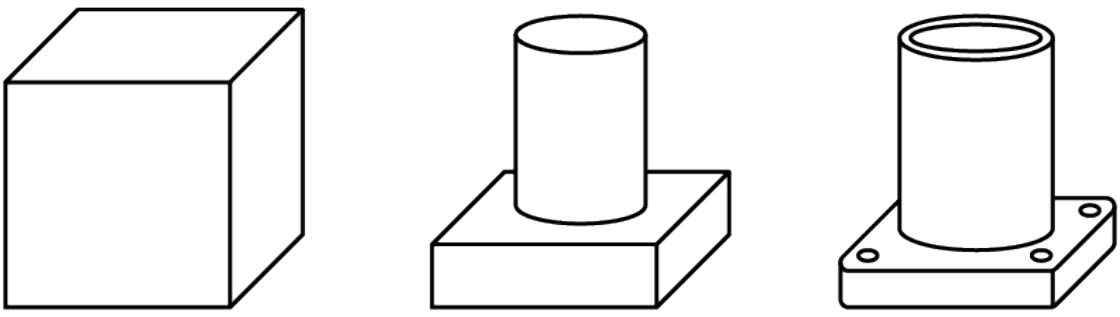
The transition to a low-carbon economy is inevitable, and proactive companies will be better prepared to ensure their long-term sustainability.

2 *Reminder of the environmental benefits of 3D printing*

In the manufacturing industry, the main issues of sustainability include energy consumption, waste production, water usage, and the environmental impact of the manufactured part in service. Producing parts using traditional methods can result in a significant amount of pollution and ecological damage. In comparison, 3D printing offers a number of environmental advantages (Huang, et. al.,2012).

MORE RESOURCE-EFFICIENT

This process only uses the amount of raw material required for manufacturing the parts. As a result, it generates much fewer production wastes compared to subtractive manufacturing methods (with limited support needs, in particular). This will reduce the «buy-to-fly» ratio, a frequently used indicator in aviation, which represents the ratio between the amount of material used to produce the part and the final mass of the object (Kobryn et al., 2006).



Starting billet | Rough machined | Final part

A DESIGN FLEXIBILITY SERVING ECO-DESIGN

3D printing offers design possibilities that were previously inconceivable. In this way, topological optimization or the integration of lattices (grid-like structures) into a part's design allows for a significant reduction in weight while maintaining its structural integrity (Gopal, M.; Lemu, H.G.; Gutema, E.M., 2023). (see image below).

In the case of a car or an airplane, for example, this weight reduction, in addition to saving raw materials, also reduces the carbon footprint of the operating vehicle. A lighter vehicle consumes less fuel and therefore emits less CO_2 (Tao Peng, 2016).

A 10% reduction in mass can lead to a **6% to 7% reduction in fuel consumption and CO_2 emissions** (Ricardo-AEA, 2015).

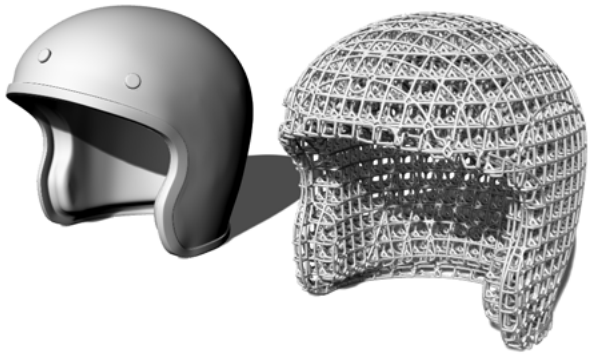
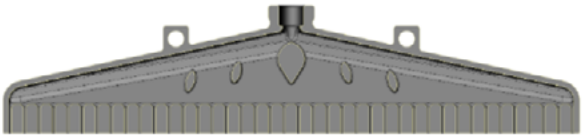
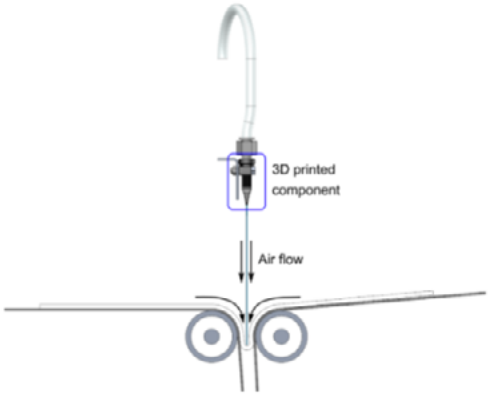


Image: *The weight of the helmet has been reduced by 87% through the addition of lattices. This results in less material being used. Source: Sculpteo*



Close up of the 3D printed part, front angle



Side view of the part attached to machine showing its function

Source: *Sculpteo x Girbau*

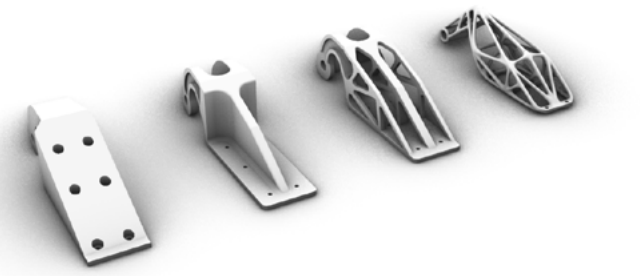
Another illustrative example comes from one of our clients, the laundry equipment manufacturer GIRBAU.

They aimed to enhance the efficiency of their laundry folding machines using 3D printing to optimize the design of a critical component.

By optimizing the internal geometries of the part, the amount of compressed air required to fulfill its function was reduced from 5.5 bars to 4 bars. This air consumption reduction made the machine more efficient and durable. The small channels created within the part to direct the airflow also significantly reduced the machine's noise impact. With their original pierced tube design, the airflow lacked a precise direction, and the single tunnel structure echoed the sound of the air pressure (Learn more).

STREAMLINED AND SIMPLIFIED SUPPLY AND PRODUCTION CHAINS

Design freedom also enables a reduction in sourcing thanks to integrated functions (such as built-in fasteners, hinges) that would typically require additional components. This eliminates the need for metal supports, screws, and other accessories, therefore, **the requirement for extracting and processing raw resources is minimized**.



Source: *Sculpteo*

Original		**Optimized**
1h assembly		**30 min** assembly -50%
structure **225g**		structure **90g** -60%
wall thickness **6 mm**		wall thickness **0.8 mm** -87%
25 components		**7** components -70%

At Sculpteo, we enabled one of our clients to significantly reduce the weight of one of their parts by optimizing its design. This resulted in savings of resources, money, and assembly time.

AN ASSET IN THE FIGHT AGAINST OBSOLESCENCE

You've probably found yourself thinking about discarding a device simply because you couldn't replace a broken part. In France alone, 28 million large household appliances are discarded each year, while only 5 million are repaired. This generates nearly 4 million tons of CO_2 equivalent (Source: Ademe - May 2019).

Spare parts often end up leaving manufacturers' production lines and stocks due to space limitations and the constant renewal of product ranges. This hinders the refurbishment of numerous machines that are still repairable. Additive manufacturing can address this need by printing on-demand, eliminating the need for storage warehouses and the utilization of a traditional production line. This, in turn, combats the obsolescence of our devices.

Source : SEB

Many well-known professionals are utilizing 3D printing to offer their customers products with a higher reparability index.
This is the case with the SEB Group - Rowenta, for example. Since 2020, more than 150 references of functional and technical 3D-printed parts are available to all authorized repairers within the SEB Group worldwide, labeled as «3D printed part certified by the manufacturer» (Source).

Considering the carbon footprint of a bagless vacuum cleaner, as per data published by Ademe, the CO_2 footprint would be around 43 kg of CO_2, encompassing the impact from manufacturing to product commercialization. The production of a spare part that doesn't exceed 100 grams of material has **a carbon footprint that does not exceed 500 g of CO_2**, across all polymer-based additive manufacturing technologies that we use. It's thus evident that repairing, especially through additive manufacturing, is significantly more ecologically friendly.

SOURCES OF POLLUTION AVOIDED

Conventional subtractive manufacturing techniques such as CNC machining require the use of cutting fluids like coolant to manage heat emissions during product machining. These fluids are considered toxic both for human health (prolonged worker exposure to these substances) and the environment (YC Luo, ZM Ji, Leu, et al., 1999).

A MORE LOCALIZED, ON-DEMAND PRODUCTION

By manufacturing parts closer to their distribution points, a portion of emissions related to goods transport and logistics is eliminated (Tao Peng, 2016). For instance, bringing 1 ton of manufactured parts from China via cargo plane generates 8.6 tons of emitted CO2 due to contrails, which can be avoided by producing more locally (Emission factor used in the calculation: 1.58 kgCO2e/ton.km).

On-demand production also avoids the need for storage infrastructure. If we push the reflection further, this contributes on a small scale to reducing soil sealing and the destruction of biodiversity for the construction of hangars.

REDUCING THE FOOTPRINT OF YOUR PARTS BY POOLING ECOLOGICAL IMPACTS

When you choose to print your parts with a service bureau like Sculpteo, you give yourself the opportunity to share the environmental footprint of your parts with those of other clients produced in the same manufacturing batch.

Instead of solely bearing the environmental impact of sintering an entire powder batch on your parts, the impact is spread over a larger number of pieces.

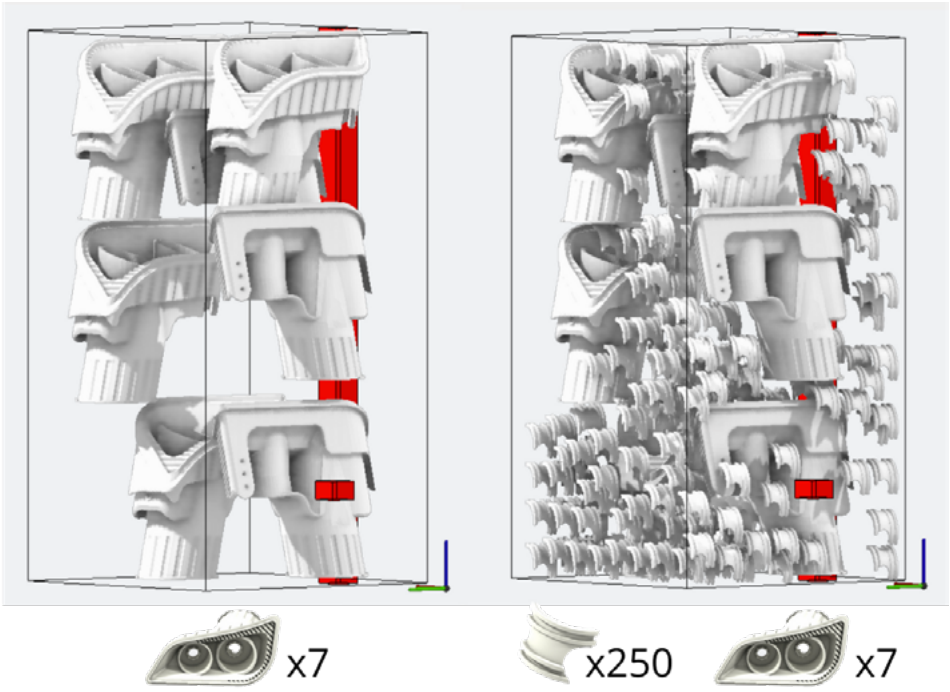
You can think of this like a car. The more passengers there are in it, the lower the per-person impact of the journey will be. The same principle applies to the printing of your parts.

The fuller the print batch, the lower the individual impact of manufacturing your parts will be.

Let's take an example: You want to produce 7 car headlights in Nylon PA11. Your part has a volume of 438 cm^3, making it quite bulky. It takes space in the printer, but there is still unoccupied space left in the print batch.

On the left, the nesting (arrangement of parts in a print batch in a three-dimensional Tetris-like manner) of your parts in scenario #1, where your parts are the only ones in the print batch.

On the right, scenario #2, you've chosen to go through a service bureau like Sculpteo, and our technicians take care of optimizing the printing process by maximizing the nesting of parts awaiting printing.



Source: *Sculpteo nesting, machine EOS, dimensions: 340×340×608mm*

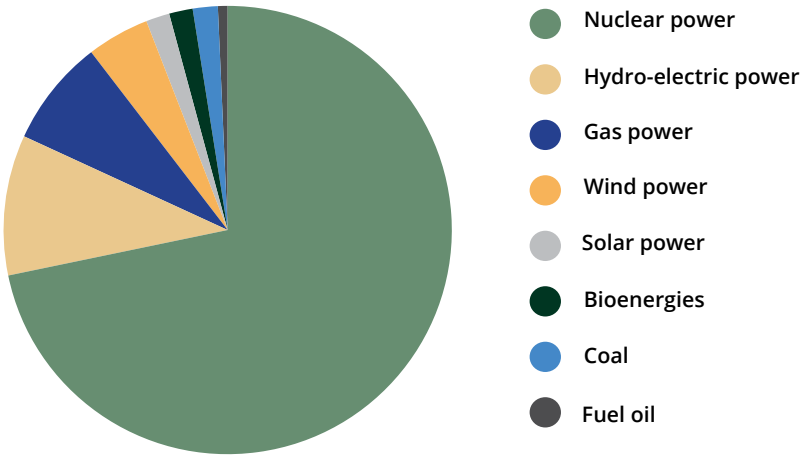
This way, your parts are printed alongside smaller parts from other Sculpteo customers. In this case, 250 additional parts have been added. The nesting is optimized, and more items are printed simultaneously in a single batch.

For each car headlight manufactured, about 440 cm^3* of material is sintered, totaling 3080 cm^3* for all 7 headlights. The added 250 pieces represent an additional 875 cm^3 of sintered material in the same print batch. If we use a logic of mass allocation, this results in **a decrease of approximately -22% in the overall environmental impact of your parts**.
(*indicative data)

ADDITIONAL MITIGATION OF IMPACTS THROUGH THE USE OF RENEWABLE ENERGY

At Sculpteo, even in the current context of rising energy prices, we have chosen to power 3 out of our 4 production sites with green energy. The transition of the 4th site to green energy is underway. This choice directly influences the environmental impact of the parts we produce. Electricity production in France is generally considered low in CO2 emissions because 80 to 90% of the electricity produced in France comes from low-carbon sources (source). This is partly due to the fact that nuclear power, which accounts for 72% of electricity production in France (as shown in the graph on the following page), has low CO2 emissions.

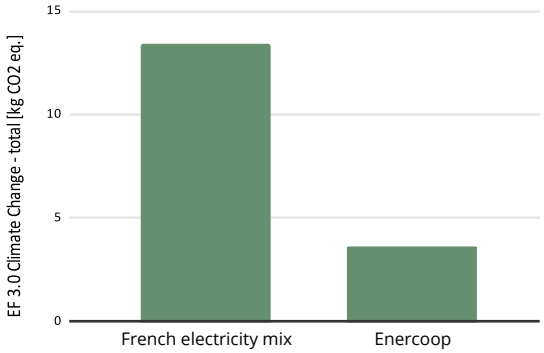
Breakdown of the French electricity mix



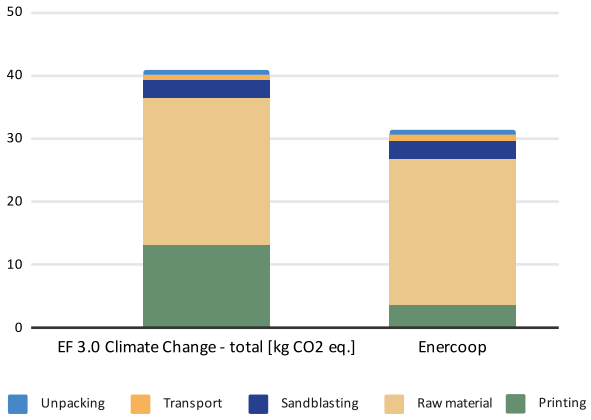
Source: *French Ministry of Ecological Transition and Territorial Cohesion, data from 2022.*

The choice to rely solely on renewable energies to ensure our production further decreases the environmental impact of the printing process. We observe a 72% reduction in contribution to climate change when using renewable energy sources for the printing of a PA11 MJF print batch (see graph #1). More generally, **the use of renewable energy results in an overall impact reduction of 24% on a PA11 MJF job** (see graph #2).

Reduction in the contribution to global warming (during the printing process only) by switching from the French electricity mix to the Enercoop supplier



Reduction in the contribution to global warming (all manufacturing processes included) by switching from the French electricity mix to the Enercoop supplier



Source: *Enercoop and Sphera*

Conclusion

Limiting our emissions and, more generally, our environmental impacts is crucial to mitigating the effects of climate change. Many companies worldwide have set goals in this direction. In this context, 3D printing can assist manufacturing companies in achieving these objectives. To transition production processes toward a more environmentally friendly model, 3D printing stands out as an interesting alternative. We appreciate your interest in reducing your environmental footprint through 3D printing and look forward to assisting you in achieving it! We wish you great success in your journey toward sustainability.

How you can reduce your carbon footprint?

Find out more

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