3D Printing and Environmental Sustainability

There is a perpetual love and hate relationship that occurs between technology and the environment. In some cases, technology is a beautiful thing, which allows people to better take care of their environment. In other cases, technology is the tool that allows people to become harbingers of death and destruction—to both themselves and the environment.

3D printing is an up and coming disruptive technology that is gaining increasing prevalence and attention. However, it is important to be informed as to how such technology will affect the world around us in the long run. 3D printing is continuously heralded in the design world, but, because of its association with plastic, it often bears negative connotations in regards to the environment.

However, there are many possible ways that 3D printing could be beneficial towards environmental sustainability, and this article aims to explore a few of them.

Emissions

Carbon dioxide (also known as CO2) is often demonized, but it is actually a naturally occurring gas and one of the many greenhouse gases that are present in the atmosphere. CO2 itself is not inherently bad, as its production was once managed and maintained by the planet's naturally occurring systems. The main purpose of CO2, as well as other "greenhouse" gases, was to assist in regulating the planet's temperature. However, this changed significantly during the Industrial Revolution, which introduced new manufacturing processes as well as the urbanization and industrialization of once rural societies.

This change in history led to increased CO2 emissions, which is heavily produced by human activity at significant degrees. Electricity usage, transportation, industrial processes, and more all contribute to CO2 emissions. CO2 is trapping gases within the atmosphere, increasing the temperature, and causing the oceans to become more acidic. This issue still plagues the world today—and more than ever before.

3D printing (which will be henceforth referred to as "3DP") presents a possible opportunity to significantly decrease CO2 emissions—at least in regards to industrial and manufacturing processes.

When factories manufacture and ship goods it emits great levels of CO2. Shipping and transportation of the goods especially contribute to this issue, as many North American companies outsource production to overseas factories. However, as 3D printing becomes even more prominent, corporations could see it as an even cheaper, more viable means of production. As a result, manufacturing efforts could be refocused back to North America, and the environmental effects of this would be greatly beneficial.

3DP could also potentially lower CO2 emission by streamlining the manufacturing process. Currently, when complex forms are produced, they have to be created separated and then assembled. However, 3DP makes it possible to print complicated forms directly—making designs that once required high waste output more "lightweight". Studies have shows that, in regards to CO2 emissions, there could be a decrease of up to 75%.

Less Waste/Additive Manufacturing

A major aspect of 3DP is a process called "Additive Manufacturing". Additive Manufacturing is the process of executing a 3D design by depositing material, layer by layer, in order to build up a product. This is essentially the "printing" that occurs during the 3DP process.

This is a major revision of what usually occurs during the traditional manufacturing procedure. During traditional manufacturing, material is removed until the desired shape is achieved. For example (and this is only for example purposes, it does not reflect what actually occurs when manufacturing this specific item), if a company manufactured solid gold, real life sized statues, they would start out with 10 ft. tall blocks of gold and then break it down until they reached the wanted shape. Another example of traditional manufacturing is injecting material into a mold, in which case the company would melt down the 10 ft. block of gold and inject it into the mold of the desired shape until it was full. Both cases create large amounts of raw material waste.

Additive manufacturing, conversely, offers a much more efficient alternative—where only the amount that is needed to print the object is used. In comparison to traditional manufacturing methods, additive manufacturing has little waste. If this replaced standard processes and became the primary method for

manufacturing, there would be a reduction of material waste and landfill amounts.

Product "End of Life"/Reusability

Imagine this scenario: You have leftovers from last night's dinner. It's a macaroni casserole, and while you typically enjoy them, you are not currently interested in eating one. So you pop it back into the microwave, push a couple of buttons, and once you open the microwave door, you are greeted with a pizza.

Now, this was a highly exaggerated example of the effect of 3DP on a product's "end of life" and reusability. A product's "end of life" refers to exactly what it sounds like—when a product reaches a stage where it is no longer useful or needed. Reusability, likewise, is the degree at which a product can be reused. Currently, a product's EOL, much like last night's leftovers, is relatively firm. Once it is no longer useful, needed, or wanted, a product heads towards trashes and landfills. Reusability may be an option, but it is often expensive and inadequate. It is an especially difficult option for plastic based goods. However, with the introduction of 3DP, "EOL" and "Reusability" can mirror the shown above scenario.

Plastic products can be very controversial, as plastics are seen as a direct threat towards the environment. Most plastics are not biodegradable, and their waste often results in garbage and pollution. Recycling ordinary plastics attempts to resolve the issue, but it is time consuming, expensive, and there is often not much output for reuse.

Many 3DP processes use a material called "PLA", otherwise known as "Polylactic Acid". PLA is a polymer that is derived from sugar, and is biodegradable because it is made from renewable resources. It can be obtained from plant-based sources, such as tapioca roots and sugar cane, but it is most commonly made from cornstarch.

Not only is it biodegradable, but also it can be reused as new objects multiple times. What does this mean? Well, when an object is 3D printed from PLA, and then reaches a point where it is no longer needed or useful—its "end of life"—it can then be re-melted and reprinted as a new object. This not only puts an end to costly recycling chains, but also extends the period of time before a product

truly reaches its EOL, effectively combatting the wasteful habits of modern society.

A great example of this is the "Filabot", which is a small machine created by Tyler McNaney which is able to melt existing plastic waste into filament that is then used by 3D printers.

Energy Demand

During the traditional manufacturing process of complex forms, there is normally a large amount of energy that is demanded. As previously stated, when a factory needs to assemble a complicated, for example, piece of machinery, all parts need to be separately created. Then, those parts have to be assembled. Overall, there is a lot of energy that is being directly and indirectly used—from creating and assembling the actual machinery, to transporting its parts for assembly.

Fortunately, 3DP may become a viable option for the amount of energy required during this process. 3DP streamlines the process, and makes complex designs more "lightweight" in terms of resource input and waste output. Cases have shown that there may be usage savings up to 63% in energy.

An example of this is a study that was conducting using the "RepRap". The RepRap is an open source, self0replicating rapid prototype system. It demonstrates viability of 3DP as of form of manufacturing of polymer-based products. Results from the study demonstrate that the energy demand of manufactured polymer products can be reduced by up to 65% compared to traditional methods (and even up to more than 70% if the RepRap used solar power).

Conclusion

Overall, there are many ways that 3DP could be potentially beneficial towards environmental sustainability. However, it cannot be said for certain how 3DP, an incredibly disruptive technology, could affect the future. 3DP, like most other forms of technology, can be used in both detrimental and beneficial ways, but it is much too early to tell in which way it will primarily skew.

While this article may focus on the positives, it is important to remember that 3DP is not magic, and that people should also inform themselves of the negatives as well. As David Dornfield, professor of mechanical engineering at the University of California, Berkeley says,

> "It may very well be the greatest thing for the environment since slide bread, but you have to think about the energy that comes in the door with every kilogram of metal or material that you're using. We don't yet have the numbers for that on the powders and extruded pastes used in additive manufacturing"

However, being aware of the positives is the first step towards putting them in action. 3DP could lower the amount of energy demanded in the production process, as well as decrease outsourcing and therefore reduce CO2 emissions. Process related waste would also decrease as a result of additive manufacturing, and the use of PLA would change plastic products' EOL period, as well as making reusability more feasible. Although all these possibilities cannot be made certain, it can be said that 3D Printing may affect the landscape of not only the design world, but also change more than people had ever thought possible in the coming years.