The Revolutionof 3d Printing Technology And Analysis

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ABSTRACT

This 3-D prints a technology known as "additive manufacturing," which builds objects by adding successive layers of materials is having a tremendous impact on many industries. As the use of this technology grows, it is important to understand 3-D printing's social and environmental consequences, as well as the opportunities for its applications. This brief is intended to contribute to that discussion: What are the sustainability opportunities and challenges related to 3-D printing, and 3-D printing's main potential environmental impacts are linked to greenhouse gas (GHG) emissions, energy consumption, and resource efficiency, which the technology can affect in both positive and negative ways, The impact of 3-D printing will gradually increase in the future, leading to significant transformations, redefining our everyday life, economy and society.

KEY WORDS: *3-D printing technology, costs, impact.*

1.0 INTRODUCTION

The technology for 3D printing has roots that go back decades. The minds behind it were visionary. But for many years, 3D printing appeared at least in the mainstream view to be more of a novelty than a practical tool to advance commercial manufacturing. 3D printers created one-off trinkets, souvenirs and not much else and skeptical that 3D printing would ever advance enough to be an integral part of manufacturing. Nevertheless, the 3D printing has reached an inflection point as lower costs and technological advances have put it within reach of more people. That's the most common use because it allows for a more agile design process and rapid product iterations. Some of the more progressive users are exploring larger-scale parts production for existing products. This 3-D printing-a technology known as "additive manufacturing," which builds objects by adding successive layers of materials—is having a tremendous impact on many industries. In the private sector, industries ranging from aerospace and automotive to healthcare and consumer products are using the technology to do things like print tools on demand and create custom products, which can reduce costs related to time, resources, and inventory. In the nonprofit sector, organizations are finding applications in disaster relief and wildlife conservation by printing humanitarian supplies in the field or creating replicas of animal products to reduce the poaching of endangered species. It's clear that this technology has the potential to transform manufacturing supply chains, distribution channels, business models, and the use of resources across a range of sectors. But when it comes to sustainability, the impacts of 3-D printing are not yet well-known. As the use of this technology grows, it is important to understand 3-D printing's social and environmental consequences, as well as the opportunities for its applications. This brief is intended to contribute to that discussion: What are the sustainability opportunities and challenges related to 3-D printing, and 3-D printing's main potential environmental impacts are linked to greenhouse gas (GHG) emissions, energy consumption, and resource efficiency, which the technology can affect in both positive and negative ways, depending on its use. 3-D printing also has notable economic and social implications. In terms of work opportunities, it offers the potential for job creation and enhanced entrepreneurship, as well as increased efficiencies in manufacturing. There is a risk, however, that the technology will result in job loss and/or the relocation of jobs due to automation and localized production. Other opportunities related to social impacts include improved access to products and services, increased opportunities for social inclusion, and reductions in workplace accidents. Key social risks include health concerns from exposure to toxic substances used in printing, and increased access to 3-D-printed weapons. This paper proposes a framework that will help companies using 3-D printing understand these environmental and social impacts. Our framework, described in the "Recommendations" section of this brief, focuses on the importance of carrying out lifecycle assessments, considering the sustainability impacts of 3-D printing during the company's materiality review and strategic planning, and adopting a precautionary approach to 3-D printing that allows the company to account for the technology's potential risks and limitations. The applications of 3-D printing to consider how it might affect environmental, economic, and social issues, and incorporate those risks and opportunities into their planning analyses the evolution of 3D printing technology, its applications and numerous social, economic, geopolitical, security and environmental consequences. The impact of 3-D printing will gradually increase in the future, leading to significant transformations, redefining our everyday life, economy and society.

2.0 LITERATURE REVIEW

In 1943 Thomas Watson, the founder of IBM, reputedly stated that there would be 'a world market for about five computers'. If this is what he actually said, then to date he has been caught out by a factor of at least a billion. And even if it is not exactly what he said, the belief of so many in the 1950s, 60s and 70s that computers would always be a minority, industrial technology has clearly been proved plain wrong. Today, a great many commentators seem to be of the opinion that very few people will ever want a 3D printer, and hence that the demand for them will remain very limited. As I have argued in this chapter, it is quite possible that only a minority of us will ever have a personal 3D printer at home purely because the most useful and sophisticated models will be shared online or in retail outlets. Even so, I would speculate that within 20 years, and perhaps in less than 10, most people in developed nations will regularly make use of a 3D printer to 'materialize' a digital design, or will be regularly purchasing products or spare parts that others materialize for them. It may also turn out that most people will have at least a little 3D printer at home, if only as a hobbyist tool or educational device. In 1981, Hideo Kodama of the Nagoya Municipal Industrial Research Institute (Nagoya, Japan) has studied and published for the first time the manufacturing of a printed solid model, the starting point of the "additive manufacturing", "rapid prototyping" or "3D printing technology" [1]. In the next decades, this technology has been substantially improved and has evolved into a useful tool for researchers, manufacturers, designers, engineers and scientists. As the term suggests, "additive manufacturing" is based on creating materials and objects, starting from a digital model, using an additive process of layering, in a sequential manner. Most of the traditional manufacturing processes are based on subtractive techniques: starting from an object having an initial shape, the material is removed (cut, drilled) until the desired shape is obtained. Unlike the above-mentioned technique, the 3D printing is based on adding successive material layers in order to obtain the desired shape. Since 1984, when the first 3D printer was designed and realized by Charles W. Hull from 3D Systems Corp. [2], the technology has evolved and these machines have become more and more useful, while their price points lowered, thus becoming more affordable. Nowadays, rapid prototyping has a wide range of applications in various fields of human activity: research, engineering, medical industry, military, construction, architecture, fashion, education, computer industry and many others. The 3D printing technology consists of three main phases - the modeling, the printing and the finishing of the product. In the modeling phase, in order to obtain the printing model, the machine uses virtual blueprints of the object and processes them in a series of thin cross-sections that are being used successively. The virtual model is identical to the physical one.

• In the printing phase, the 3D printer reads the design (consisting of cross-sections) and deposits the layers of material, in order to build the product. Each layer, based on a virtual cross section, fuses with the previous ones and, finally, after printing all these layers, the desired object has been obtained. Through this technique, one can create different objects of various shapes, built from a variety of materials (thermoplastic, metal, powder, ceramic, paper, photopolymer, liquid). • The final phase consists in the finishing of the product. In many cases, in order to obtain an increased precision, it is more advantageous to print the object at a higher size than the final desired one, using a standard resolution and to remove then the supplementary material using a subtractive process at a higher resolution.

Depending on the employed manufacturing technique, the 3D printing could offer additional improvements. Thus, in the printing process, one can use multiple materials in manufacturing different parts of the same object or one can use multiple colors. If necessary, when printing the objects, one can use certain supports that are being removed or dissolved when finishing the product. Taking into account the importance of the 3D printing technology, we have decided to analyses further the main available additive processes, the advantages and limitations of this technology, to compare the most significant existing 3D printing solutions. We have also decided to study the usefulness, the implications and the future evolution that the 3D printing technology brings into the modern society, economy and everyday life.

3.0 3D- PRINTING WORKS &METHODS

3D printers manufacture objects by controlling the placement and adhesion of a 'build material' in 3D space. To 3D print an object, a digital model first needs to exist in a computer. This may be fashioned by hand using a computer aided design (CAD) application, or some other variety of 3D modeling software. Alternatively, a digital model may be created by scanning a real object with a 3D scanner, or perhaps by taking a scan of something and then tweaking it with software tools. However the digital model is created, once it is ready to be fabricated some additional computer software needs to slice it up into a great many cross sectional layers only a fraction of a millimeter thick. These object layers can then be sent to a 3D printer that will print them out, one on top of the other, until they are built up into a complete 3D printed object. Exactly how a 3D printer outputs an object one thin layer at a time depends on the particular technology on which it is based. As we shall see in chapter 2, already there are more than a dozen viable 3D printing technologies. This said, almost all of them work in one of three basic ways. Firstly, there are 3D printers that create objects by extruding a molten or otherwise semi-liquid material from a print head nozzle. Most commonly this involves extruding a continuous stream of hot thermoplastic that very rapidly sets after it has left the print head. Other extrusion-based 3D printers manufacture objects by outputting a molten metal, or by extruding chocolate, cheese or cake frosting (icing sugar) to 3D print culinary creations. There are even experimental 3D printers that output a computer-controlled flow of liquid concrete, and which may in the future allow whole buildings to be 3D printed.

A second category of 3D printer creates object layers by selectively solidifying a liquid – known as a 'photopolymer' – that hardens when exposed to a laser or other light source. Some such 'photo polymerization' 3D printers build object layers within a tank of liquid photopolymer. Meanwhile others jet out a single layer of liquid and then use an ultraviolet light to set it solid before the next layer is printed. A few of the 3D printers that are based on the latter technology are able to mix and solidify many different photopolymers at the same time, so allowing them to print out multi-material objects made of parts with different material properties. For example, the latest Convex printers from a company called Strategy's can build objects in up to 14 different materials at the same time. These range from hard plastics in a range of transparencies and colors, to softer, rubber-like compounds. A final category of 3D printing hardware creates objects by selectively sticking together successive layers of a very fine powder. Such 'granular materials binding' can be achieved either by jetting a liquid glue or 'binder' onto each powder layer, or by fusing powder granules together using a laser or other heat source. Already granular materials binding can be used to 3D print objects in a very wide range of materials. These include nylon, ceramics, wax, bronze, stainless steel, cobalt chrome and titanium.

4.0 IMPROVING PRODUCT DESIGN

Already 3D printing is starting to be used to improve product design. It does this by facilitating the rapid creation of 'concept models', so allowing physical manifestations of in-progress designs to be viewed and handled early in the design process. While computer graphic renderings of new products are now highly sophisticated, still nothing compares to holding a 3D model of a potential new product in your hand. Often potential design flaws that are not obvious when a design is viewed on a computer screen or tablet become very evident when a physical concept model can be seen and touched. By allowing concept models to be rapidly created – sometimes in full color – 3D printers are therefore already improving the communication flow between designers and their clients. In turn this often helps to speed up the design process, as well as allowing better products to be created. Beyond the concept design stage, 3D printers are also already being used to create 'verification models' or 'functional prototypes'. For this reason, in some industrial circles 3D printing has subsequently become known as 'rapid prototyping' or 'RP'. This is also a little sad, as in my experience the use of the 'rapid prototyping' label is blinding some people to the wider application of 3D printing technology.

5.0 TRANSFORMING TRADITIONAL PRODUCTION

Beyond concept model and prototype fabrication, 3D printers are also starting to be used in industrial preproduction. Most traditional production processes require the creation of bespoke jigs, tools, patterns and molds that are then used during manufacturing to shape metals and plastics into appropriate forms. Like product prototypes, such items have traditionally been crafted by hand in a manner that has proven both time consuming and expensive. The use of 3D printers to help tool-up factories for traditional production may therefore save a great deal of time and money. A particularly promising application of 3D printing is in the direct production of molds, or else of master 'patterns' from which final molds can be taken. For example, as we shall see in the next chapter, '3D sand casting' is increasingly being used to print molds into which molten metal's are then directly poured to create final components. As explained by Ex One a pioneer in the manufacture of 3D printers for this purpose by 3D printing sand casting molds, total production time can be reduced by 70 per cent, with a greater accuracy achieved and more intricate molds created. In fact, using 3D sand casting, single part molds can be formed that would be impossible to make by packing sand around a pattern object that would then need to be removed before the mold was filled with molten metal. Some 3D printer models are created exclusively for the production of molds or patterns. For example, the range of Solidscape printers sold by a company called Strategy's print in wax-like plastics that are used to produce small molds or patterns in dental labs or for jewelry making. Like sand casts, these molds or patterns are 'sacrificial', as the process of producing a final object using them results in their destruction. The use of 3D printers to create molds, patterns and other production tooling may rarely if ever be seen let alone appreciated by the consumers of most final products. For example, few people today are ever likely to realize that the soles of their trainers were probably produced in a mold that was derived from a 3D printed pattern master. Nevertheless, even though it will remain a behind-the-scenes development, the use of 3D printers in industrial pre-production is likely to prove a key facet of the 3D Printing Revolution.

6.0 DIRECT DIGITAL MANUFACTURING

While 3D printing is already an established part of some design and pre-production processes, the ultimate application of the technology will be in the development of 'direct digital manufacturing' (DDM). This does what it says on the tin, with DDM using 3D printers to create final products, or more usually parts thereof. As we shall see in chapter 4, DDM is already gaining traction in industries as diverse as aerospace, jewelry making, dentistry, toy production, and the manufacture of fashion items like designer home wares and customized sunglasses.

One of the amazing things about 3D printing is that it can be used to create objects which cannot be directly produced using traditional manufacturing techniques.

For example, a 3D printer can print a necklace made up of links that do not have a break in them, not to mention a whistle with the pea already inside, or a ship in a bottle. Some 3D printers can also directly print working, multi-part mechanisms like gearboxes. Traditionally, the manufacture of multi-component products has always involved a final assembly stage. But when things are made using 3D printers this no longer has to remain the case. In the future it is possible that almost anything could be manufactured using 3D printing technology, including entire aero planes. While this may sound crazy, a small team at Airbus is already designing a revolutionary airliner that would be 65 per cent lighter than a conventional aircraft because it would be 3D printed from a plastic resin. While such an aircraft – and the 3D printer required to make it – may not be ready until 2050, in 2011 Airbus parent company EADS opened a £2.6 million Centre for Additive Manufacturing at the University of Exeter. The goal of this research facility is to develop 3D printed parts for aircraft, including the current Airbus A380.

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7.0 CONCLUSIONS

In this paper, we have presented and analyzed the impact of 3D printing technology on the society and economy. After presenting in the introduction a brief history of 3D printing, in the second section we have depicted the additive technology and the materials used in rapid prototyping. In the third section, we have highlighted the main advantages and limitations of the 3D printing technology, while in the fourth section we have made a survey of the most significant existing 3D printing solutions. We have compared these 3D printing solutions, taking into account their technical specifications and prices. One can conclude that the 3-D printing technology's importance and social impact increase gradually day after day and significantly influence the human's life, the economy and modern society.