AM Sustainability

How additive fits into a more sustainable future for manufacturing
About

VoxelMatters (formerly 3dpbm) is a leading media company providing insights, market analysis and B2B marketing services to the AM industry. VoxelMatters publishes VoxelMatters News, a global editorial website that is a trusted and influential resource for professional additive manufacturing.

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When we talk about sustainability in additive manufacturing, we're interested in a few perspectives. For one, it's important to talk about and understand the ways in which additive technologies are sustainable, especially compared to more conventional production methods. At the same time, we also want to understand how AM is creating opportunities for greater sustainability in certain applications, such as lighter aircraft parts. Finally, it's also important to address how additive manufacturing, as a technology and as an industry, can strive to be more sustainable.

In this eBook, we're looking at all these angles, first with an overview of the industries and applications where AM is enabling a more sustainable future, from wind turbines, to custom eyewear, to lab-grown meat. Next is an interview with Materialise’s Head of Sustainability Leen Kuijken and AMGTA Executive Director Sherri Monroe, who talk about how businesses in the AM sphere can kickstart their sustainability efforts and create a roadmap with a real impact.

In an interview with AM entrepreneur Andy Jeffery, we hear how sustainability has been a driving force in his prolific career, culminating in his recent venture Marvel Labs, which has developed a 3D printing technology that uses bio-based byproducts, like seaweed, sawdust, and coffee grounds as printing materials. Finally, we look at what some of the AM companies with the most ambitious sustainability missions are doing to improve their ecological impacts.
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Built upon first-hand data directly from our industry partners, our database has over 53K data points for 2022. Analysing 1,364 AM companies across 98 countries, our reports help industry leaders make better decisions, faster.
Analysis

Delivering AM’s promise of a more sustainable world

The potential is there but what will it take for additive manufacturing technologies to truly enable less wasteful, more efficient and cleaner ways of producing just about everything?
In this analysis, we examine recent applications in which additive manufacturing has been used with the goal of improving sustainability, including aerospace production, EV battery manufacturing, on-demand consumer products, energy generation and more.

Sustainability continues to be a major trending topic in the AM industry, and it has become increasingly relevant in recent months. AM companies understand that its inherent potential for more sustainable production is a key selling point to drive investments, both private and public, into the development and adoption of AM technologies.

VoxelMatters has been covering the potential sustainability of AM for the past three years through a focused eBook. We firmly believe that AM is the only truly sustainable manufacturing process and the only way to eventually make all production more energy-efficient. This is one of the main reasons why we prioritize coverage of this segment in industrial manufacturing.

However, this promise is still far from being fully realized. AM today primarily functions as a stand-alone process complementing other methods. It is also energy-intensive in some cases, contributing to emissions. The use of materials, including non-recyclable petroleum-based plastics and rare earth metals, is a primary cause of Earth’s pollution problems. Nevertheless, AM consumes fewer materials than any other process, and in many cases, it offers solutions to either replace these materials with cleaner alternatives or reduce wasteful consumption.

While claiming that AM guarantees sustainability may not be entirely accurate, it remains the only way for industrial production to eventually become sustainable. To assess the truthfulness of this statement,
we will examine recent uses of AM for sustainability in primary application segments to understand how sustainable they truly are.

**AEROSPACE**

**3D printing lighter planes**

Total addressable market for AM in aerospace parts: $900 billion in 2020

Aviation traffic decreased dramatically during the COVID-19 crisis, and though it has not yet returned to pre-pandemic levels, it is growing rapidly. Aircraft engines burn through tons of fossil fuel and are responsible for a significant chunk of global emissions. AM could play a role in curbing these emissions by reducing the weight of future aircraft.

Airbus was among the first major aircraft manufacturers to explore the potential benefits of AM. Aviation history was made on 20 June, 2014 when the first 3D printed metal part, a titanium bracket, took to the skies on board a commercial Airbus jetliner.

Weight reduction is the holy grail of aerospace engineering: every kilogram saved prevents 25 tonnes of CO2 emissions during the lifespan of an aircraft. Parts produced by AM weigh up to 55% less, while

In aerospace, every kilo of weight saved reduces fuel emissions by 25 tonnes over the span of an aircraft’s life.
reducing the raw material used by up to 90%. Decarbonization is the reason why the aerospace industry and Airbus led the charge in 3D printing.

The application of these new production paradigms doesn’t have to wait for years until the next generation of aircraft is developed, a process that spans decades. Rather, the technology can be used to replace a part on an existing aircraft model with a lighter 3D printed version.

In September 2017, following thorough testing and EASA approval, the first titanium 3D printed part was installed on a serial production aircraft. This was the first step towards installing more complex 3D printed parts on Airbus production aircraft, which have to meet the highest safety and quality standards.

Since this milestone, dozens of additive manufacturing service providers and aerospace industry part suppliers have been manufacturing more and more weight-optimized aircraft parts for engines and cabins using both plastics and metals.

In 2019, GE made AM history with the first flight of the Boeing 777X aircraft: each of the two GE9X engines powering the aircraft integrated more than 300 3D printed parts, including almost 250 low-pressure turbine blades (3D printed in titanium alumide on GE Arcam EBM systems), a fuel nozzle tip that precisely sprays a mixture of fuel and air into the combustion chamber, and a heat exchanger. Another component, the inducer, helps pull out dust, sand, and other debris the engine has ingested, extending its life. This type of component was so difficult to manufacture that it had never been used inside a commercial GE jet engine before.

**AUTOMOTIVE**

**Powering EV-mobility**

Total addressable market for AM in EV powertrain parts: $20 billion in 2020 and growing

Lightweighting is also the main driver for the use of AM in making automotive transportation more sustainable. This has become increasingly important with the introduction of EVs (including all types of e-mobility systems), as lighter cars benefit significantly in terms of mileage.

AM could (and probably will) play an increasingly relevant role in the production of EV powertrain elements. In the short term, AM is playing a key role in the rapid development of entirely new EV ranges by all the leading automakers.
In EV powertrains, AM is particularly effective for part consolidation, leading to weight reduction and performance improvements, enabling higher mileage. However, the actual penetration of AM in EVs—beyond applications shared with combustion engine powertrains, such as chassis, brakes, and fluid flow applications—is highly dependent on the ability to implement AM in serial battery manufacturing. Some efforts in this area are already underway but are still a long way from becoming a consolidated business opportunity.

In electric motors, a particularly interesting area for AM is copper. German firm Additive Drives has presented promising application cases. One involves 3D printed single coils used on a racing engine. In another project, copper 3D printed hairpin windings reduced the time required for the development and production of an electric traction motor prototype to one month. Additionally, direct production of individual lots was achieved for Dresden-based pedelec manufacturer Binova: using 3D printed individual coils, Binova produced several different types of electric bikes with an unconventional electric motor design and no tool adjustments.

More recently, Porsche and SLM Solutions revealed a project centered on manufacturing a complete housing for an electric drive using 3D printing. The 3D printed E-Drive housing on the engine-gearbox unit was produced using the laser metal PBF process and passed all the quality and stress tests. In the future, this may become a viable production method. Porsche also partnered with GKN on a case-hardened part that was greatly improved via metal laser PBF using a newly developed case-hardening metal powder, 20MnCr5. In total, Porsche already identified 52,000 parts that would be successful candidates for AM production.

Using the AM process in combination with GKN’s newly developed powder leads to significant optimization in weight, inertia and stiffness of the differential housing and ring gear while maintaining fidelity and handling all load requirements. This was possible by integrating functionalities and combining primarily conflicting components.

Printing EV batteries

Total addressable market for AM in EV batteries: $16 billion in 2020 and growing rapidly

In EVs, the battery’s size and weight have large implications for vehicle performance. A larger and heavier battery takes away from cabin/storage space and decreases energy efficiency and fuel economy. The best way to optimize performance is to maximize the battery’s energy density—that is, having a small, lightweight battery that stores as much electric energy as possible.

Batteries are both tricky and interesting for AM, and this interest will only continue to grow. Several efforts have been made to produce batteries using different 3D printing technologies, with both polymer and ceramic materials. Because batteries can take many different shapes and sizes for improved efficiency, AM could prove instrumental for testing—and eventually manufacturing—several new design iterations. The batteries used in EVs today are basically rows of hundreds of small-sized batteries fastened together to increase capacity. With 3D printing, the individual cells don't
have to be manufactured and assembled: the module can be designed and printed in the desired shape. AM can also make a difference in the structure of the electrodes of a battery: porous electrodes increase energy density, and AM is ideally suited to build electrode materials into lattice shapes that have more exposed surface area for the chemical reactions to take place, resulting in a more efficient battery.

Swiss firm Blackstone Resources has achieved a series of important milestones for its proprietary 3D printing technology to print lithium-ion solid-state batteries. Blackstone’s 3D printing process claims to offer substantial advantages over conventional battery cell designs that use liquid electrolytes. These include significantly lower costs, a higher level of production flexibility (when it comes to the format of the cell) and a 20% increase in energy density.

Last year, Blackstone Technology said that battery production started as planned and the first orders were already being executed. Battery research for the further development of its 3D high-speed screen printing...
technology was also successfully launched in the first half of 2022 and is reportedly running at full speed. The second generation of battery production facilities with a total capacity of 1.25 GWh is under implementation. The company also said it had successful initial discussions with Volkswagen AG.

Sakuu Corporation also presented its new industrial-grade battery 3D printer, developed specifically for e-mobility batteries. The breakthrough technology is intended to unlock the mainstream adoption of electric and e-mobility vehicles by solving the previous issues of cost, performance, sustainability and range. Offering an industrial-scale ‘local’ battery production capability, Sakuu’s technology is likely to expedite the use of EVs by providing increased manufacturer and consumer confidence.

Backed by Musashi Seimitsu, a leading Japanese automotive parts supplier to major OEMs, Sakuu is set to enable fast and high-volume production of 3D printed solid-state batteries (SSBs), which have the same capacity as lithium-ion batteries yet are half the size and almost a third lighter. The company’s KeraCel branded SSBs will also use around 30 to 50 percent fewer materials—which can be sourced locally—to achieve the same energy levels as lithium-ion options, significantly reducing production costs. Moreover, Sakuu’s SSBs will offer improved safety and sustainability benefits.

A fundamental manufacturing breakthrough with Sakuu’s new solution is its multiple-AM technology. This blends powder bed and jetted material deposition and uses completely different multi-materials in a single-layer capability. The process combines ceramic and metal, as well as Sakuu’s proprietary support material, PoraLyte, which removes part overhang limitations and enables the easier and faster creation of devices with internal channels and cavities.

Furthermore, with only half the material requirement and a ‘powder to powder process’ that ensures easier recyclability of the ceramics and metals by conventional methods, KeraCel SSBs score much higher when it comes to sustainability. There is no requirement to extract graphite, and the absence of polymer means no incineration or burial in a landfill.

Sakuu has been successfully 3D printing fully functional performance batteries in custom shapes and sizes since December 2022. These batteries are printed as patterned cells containing patterned openings for thermal management, in a fully dry process, at Sakuu’s Silicon Valley battery pilot line facility.

**CONSUMER PRODUCTS**

Total addressable market for AM in consumer products: over $2 trillion in 2020

The main advantages that AM can offer to make consumer products more sustainable relate to reducing consumption. This can be achieved through mass customization, on-demand production and by using less material (possibly recycled or upcycled) through shape and process optimization. While the range of consumer products for AM is varied and large, we are highlighting some of the key areas where AM has been implemented with a view for sustainability: footwear, eyewear and upcycled products.
Footwear optimized

Footwear is one segment that has already adopted AM for sustainability in the production of millions of parts—mainly midsoles—featuring optimized shapes and a more streamlined fully digital manufacturing process. The most evident is Adidas’ use of Carbon’s DLS technology for the mass production of its FUTURECRAFT series midsoles. In the future, AM could also play a part in streamlining footwear uppers production.

With one Adidas Model, the ADIDAS and Parley For The Oceans, the footwear company combined 3D printed midsoles with uppers made from plastic that was recycled from ocean waste. According to a study published by University of Georgia researchers in 2010, an estimated 8 million tonnes of plastic end up in the oceans.

In 2023, the Zellerfeld project for on-demand fully 3D printed sneakers took off globally, working with several designers and top brands around the world. By producing custom sneakers on-demand, Zellerfeld is offering a solution that does away with the factory and any waste, implementing automated printing to replace overseas shipments and labor. In addition, old pairs can be returned and fully recycled into new ones.

Mass customized, on-demand eyewear

Another example of how 3D printing can indirectly make consumer products more sustainable is found in the eyewear industry, where current mass manufacturing processes and practices implemented by the larger market players are extremely wasteful. The ability to produce and customize on-demand eyewear could eliminate a lot of this waste.

This year, Arkema and Materialise, two companies leading the 3D printed eyewear revolution, took the MIDO 2023 very seriously, presenting Arkema’s portfolio of innovative polymers tailored for both the injection molding and additive manufacturing of lightweight frames. The fact that Arkema’s materials are suitable for traditional eyewear manufacturing was certainly a factor in the company’s large presence.

Several new bio-based and recycled materials were highlighted at the booth, along with transparent polyamide 11 grades designed to unleash unlimited options in terms of creative and fashionable eyewear design. Highlights include low-density Rilsan Polyamide 11 grades, enabling eyewear to float in the water, unique Pebax Rnew elastomer grades with up to 97% bio-based content for flexibility in the production of unbreakable frames for kids, carbon-filled grades for cycling sport frames with 30% recycled content, 100% bio-based Rilsan polyamide 11 grades with natural or mineral fillers, and Rilsan Clear Rnew grades for transparency.

Arkema’s polyamide 11 materials are derived 100% from renewable castor seeds. These advanced polymers offer a substantial reduction in product carbon footprint—made even lower now due to Arkema’s recently announced investment in renewable energy in its global polyamide 11 production network. Materialise showcased how polyamide 11 is used to create beautiful advanced eyewear solutions in a range of fashionable styles.
Upcycled 3D printed products

There are many examples of 3D printed products made from recycled and upcycled plastics, cement and scrap metals. One particularly fascinating project, Forust, uses waste wood.

Forust is a new process that uses production binder jetting technology from Desktop Metal to sustainably produce functional end-use wood parts. The Forust process upcycles wood manufacturing byproducts (cellulose dust) and byproducts from the paper industry (lignin) and re-materializes functional wood parts through high-speed 3D printing, including digital grain throughout the part. The process combines two waste streams from traditional wood production, sawdust and lignin, to sustainably produce isotropic, high-strength wood parts. Depending on the size of the parts, Forust can manufacture wood products using either the Shop System or a custom version of the new RAM 336 3D printer, which supports prints up to two cubic meters in volume at speeds in excess of 100 liters of parts per hour.

During the printing process, layers of specially treated sawdust are spread and selectively joined by a non-toxic and biodegradable binder. Digital grain is printed on every layer, and parts can then be sanded, stained, polished, dyed, coated and refinished in the same manner as traditionally manufactured wood components.
Additive manufacturing has found applications in various sectors of the power industry, both in building prototypes and in mainstream production, leading to process simplification and significantly improved operational efficiency. AM can produce components with complex geometries, while consuming fewer raw materials, generating less waste, and effectively reducing energy consumption and time-to-market.

Manufacturers are increasingly turning to AM for innovative solutions with reduced costs and significantly shorter production cycles. When analyzing the power generation segment and the vast potential impact of additive manufacturing, several insightful generalizations can be made about energy equipment.

### Nuclear energy

One of the hottest segments for AM adoption is the civil nuclear industry. Siemens made a significant breakthrough by successfully installing a 3D printed metallic impeller with a 108-millimeter diameter for a fire protection pump at the Krško nuclear power plant in Slovenia. This success has spurred the development of new AM applications for nuclear
power plants. AM, with suitable materials like ceramics and refractory metals, can be utilized for producing obsolete parts that are no longer available, thus enabling the continued operation of older power plants. Furthermore, radiation shielding materials such as boron carbide are now available as powders for binder jetting on ExOne systems. Recently, Swedish 3D printing companies Additive Composite and Add North 3D released a new boron carbide composite filament suitable for radiation shielding applications in the nuclear industry.

The exploration of 3D printed replacements and spare parts for nuclear reactors began officially in 2016 when the U.S. Department of Energy (DOE) selected GE Hitachi Nuclear Energy (GEH) to lead a $2 million additive manufacturing research project. This project is part of an $80 million investment in advanced nuclear technology.

GEH spearheaded the project by producing sample replacement parts for nuclear power plants. These samples were 3D printed in metal at the GE Power Advanced Manufacturing Works facility in Greenville, SC, and then sent to the Idaho National Laboratory (INL). After being irradiated in INL’s Advanced Test Reactor, the samples were tested and compared to an analysis of unirradiated material conducted by GEH. The results are now being used by GEH to support the deployment of 3D printed parts for fuels, services, and new plant applications.

Westinghouse Electric Company installed a 3D printed component into a commercial nuclear reactor at Exelon’s Byron Unit 1 nuclear plant during its spring refueling outage. Additionally, Westinghouse is actively involved in research and development to explore further applications of 3D printing in the nuclear industry.

One noteworthy endeavor, supported by the DOE’s Office of Nuclear Energy, is the Transformational Challenge Reactor (TCR) Demonstration Program. It is an unprecedented approach to develop a 3D printed reactor core by 2023. As part of deploying a 3D printed nuclear reactor, the program aims to create a digital platform to facilitate the technology’s rapid adoption in the industry. The TCR program, led by ORNL, seeks to address a concerning trend: despite nuclear power plants providing nearly 20% of U.S. electricity, more than half of U.S. reactors are expected to be retired within 20 years based on current license expiration dates.

The nuclear industry is currently experiencing rapid advancements, particularly in the realm of SMRs (small modular reactors). These reactors are scaled-down versions of nuclear reactors that encompass both current and
fourth-generation (fast neutron) technology. As of May 15th, the U.S. Department of Energy awarded grants to GE Research and the Massachusetts Institute of Technology (MIT) for research projects focused on developing digital twin technology for advanced nuclear reactors using artificial intelligence and advanced modeling controls. These research projects will employ a digital twin of the company’s BWRX-300 small modular reactor as a reference design.

Wind-powered energy

Total addressable market for AM in wind-power energy generation: $44 billion by 2030

Development and innovation in materials and manufacturing technologies are crucial for the wind industry to prosper and increase its annual energy production. In the future, AM could enable on-site manufacturing of turbine components tailored to the unique needs of a particular location’s resources. Additionally, AM can address the demand and supply for wind turbine spare parts of discontinued models, for which manufacturers may have limited quantities. 3D printing also proves valuable in mold and pattern production, which is a time-consuming and labor-intensive process in wind blade construction, allowing for significant resource savings.

Both market-ready and R&D AM technologies in the wind industry have the potential to impact the prototyping and manufacturing costs of wind energy tooling and components. A study published by ORNL suggests that economically feasible AM application areas for wind components include direct-print blade molds, functionalized nacelle covers, permanent magnets and lightweight, high-efficiency heat exchangers.

In the future, AM technologies could enable on-site manufacturing of turbine parts and production of site-optimized components tailored to a specific location’s wind and grid resources. As new technologies, such as Large-Format Additive Manufacturing (LFAM), high-capacity Wide and High Additive Manufacturing (WHAM), and Large-Scale Metal AM machines mature, we may witness a shift towards directly printing various wind turbine components.

One notable benefit of this shift would be the elimination of the need to transport large wind blades over long distances, especially in cases where highway transportation is impossible. Instead, the 3D printer could operate on-site and print the blades, thereby reducing transportation costs. Moreover, the manufacturing time of the mold could be cut down by 35%, and different materials could be combined in various areas of the blade.
Not only can large-format polymer and metal additive manufacturing technologies be implemented, but cement-based ones as well. Purdue University engineers are working on 3D printing wind turbine parts using concrete, a less expensive material that allows parts to float to a site from an onshore plant, eliminating the need for molds. This concrete additive manufacturing process, developed in collaboration with RCAM Technologies, could significantly reduce the capital cost of offshore substructures and towers compared to conventional methods, making them up to 80% cheaper. It also increases production speed up to 20 times, using low-cost regionally sourced concrete without expensive formwork.

**Cleaner fossil fuels**

Despite the drive for sustainability, fossil fuels will continue to be part of the world's energy mix for many decades, necessitating efforts to work with them in the most efficient way possible. AM can play a role in making the oil and gas extraction process more sustainable.

Kueppers Solutions, a German company specializing in energy-efficient product redesign and optimizing thermal process plants, collaborates with GKN on AM activities, focusing on reducing NOx emissions from thermal power plants. In a recent project involving several institutions, Kueppers developed a new mixing unit for gas burners that significantly reduces nitrogen oxide emissions. This innovative geometry was manufactured using 3D printing to create a precisely dosed gas-air mixture that burns more efficiently.

Nitrogen oxides (NOx) are toxic and highly reactive gases that form when fuel is burned at high temperatures. Kueppers aims to become a supplier, similar to a manufacturer of injection systems in the automotive industry, by retrofitting thousands of industrial burners to significantly reduce nitrogen oxide emissions.

In the field of industrial burners, certain dimensions and sizes are standardized across manufacturers. This allows for the replacement of many burners on existing systems, similar to switching a light bulb to an energy-saving lamp, without the need to renew the entire system. This option is particularly crucial since thermal processing systems are used for 30 to 50 years.

Another research effort to curb emissions from fossil fuels involves GE, UC Berkeley, and the University of South Alabama collaborating on the DOE-backed project, AIR2CO2. They are developing a system that captures CO2 from the air using heat exchanger technology and sorbent materials. Additive

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**Image: Kueppers Solutions**
manufacturing is used to design and develop the unique heat exchanger structure required, while the sorbent materials are essential for removing CO2 from the air.

CONSTRUCTION

Total addressable market for AM in construction: $10.5 trillion

The construction industry is notorious for being one of the most emissions-intensive sectors in the world. Additive manufacturing, while still a niche segment within construction, offers potential solutions. Various 3D printing technologies designed for on-site printing could reduce the need to transport large building supplies to the construction site, which would significantly cut back on transport emissions.

In terms of materials, using locally sourced raw building materials to create a base for the construction slurry could shorten the supply chain and minimize the requirement for long-haul transportation. Moreover, new materials with lower carbon footprints can be employed. For example, construction tech company Mighty Buildings and materials specialist Fortera have developed a printable cement that reduces CO2 emissions by over 60% compared to traditional cement. This achievement is the result of reintegrating the CO2 released during the production process back into the building material.

Another notable sustainability benefit of construction 3D printing is waste reduction. Traditional construction projects generate an enormous amount of waste, which 3D printing can significantly diminish. Unlike traditional construction methods requiring formwork, 3D printed structures are built directly, eliminating the need for excess materials and reducing scrap. Construction 3D printers are engineered to consume only the necessary amount of material for constructing the housing structure, further minimizing waste.

One of the most significant use cases for 3D printing in construction involves the production of bases for large wind turbines. Danish company COBOD, known for its large 3D printers for robotic construction printing, collaborated with GE and LafargeHolcim in 2019 to develop 3D printed concrete wind turbine towers. The partners successfully 3D printed the first 10-meter tower base in 2019, followed by another in 2020. This achievement led GE to showcase its work at the Leaders Summit on Climate organized by the White House, highlighting how this technology could eventually create extra-tall towers and reduce CO2 emissions.

FOOD

Total addressable market for AM in plant-based food: $7 billion in 2020, growing rapidly

The production of meat, dairy, and eggs places a substantial strain on the environment, surpassing that of any other food production. As the world population increases and agricultural land decreases, finding sustainable solutions to meet our dietary needs becomes imperative.

The Food and Agriculture Organization of the United Nations (FAO) predicts a 2/3 rise in meat demand in the next 40 years, but current production methods are unsustainable. This increasing demand for meat production
may lead to costly luxury items for both meat and staple foods unless sustainable alternatives are found.

Livestock contributes to global warming by releasing methane, a potent greenhouse gas. As demand rises, methane, carbon dioxide, and nitrous oxide levels will increase, causing biodiversity loss. To address these challenges, the Future Food foundation advocates for artificial or bioficial food products, which are cheaper and potentially healthier than traditional animal-based options.

One of these startups, Aleph Farms, based in Tel Aviv, focuses on producing edible meat without the need to raise and slaughter animals. The company gained attention by successfully growing synthetic meat in the Russian segment of the International Space Station (ISS), through a collaboration with American companies Meal Source Technologies and Finless Foods and Russia-based 3D Bioprinting Solutions. In the experiment, bovine cells were collected on Earth and then used by the 3D printer to produce meat in unprecedented conditions.

Aleph Farms aims to make its technology viable for feeding the growing global population. Their process involves taking stem cells from a living animal, combining them with growth factors that mimic a cow’s natural muscle regeneration process, and then using a bioink and special 3D printer to rebuild the meat layer by layer.

Another player in the food 3D printing space, GOOD Meat (a subsidiary of Eat Just Inc.) plans to establish the largest known...
bioreactors for avian and mammalian cell culture in collaboration with ABEC. The goal is to produce up to 30 million pounds of meat, mainly chicken and beef, at their U.S. facility, all without slaughtering any animals. GOOD Meat’s cultivated chicken products are already approved for sale in Singapore.

Israeli company Redefine Meat specializes in plant-based meat alternatives. They produce meat-like products, including beef and lamb cuts, premium burgers, sausages, lamb kebabs, and ground beef. Their food 3D printing process is crucial in replicating the textures of real meat products.

The 3D printed seafood market is also emerging, with startups like Plantish from Israel, which focuses on premium whole-cut fish made from plant proteins. Their patent-pending AM process replicates the texture of fish species like salmon by reproducing various components of the fish, including connective tissue and muscle tissue. Additionally, MeaTech 3D Ltd. and Umami Meats are collaborating to develop 3D printed cultured seafood, while MeaTech establishes a pilot plant for 3D printing cultured chicken fat.
Reconfigure manufacturing!

Demand for increasingly complex and customized parts is rising, product cycles are becoming shorter, established supply chains are being called into question and sustainability is playing an ever greater role.

In short: Industrial production is becoming more demanding. Additive Manufacturing offers solutions to meet these challenges and inspire your customers.

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Where ideas take shape
Feature

Building a roadmap for sustainability in AM

Leen Kuijken from Materialise and Sherri Monroe from AMGTA share their knowledge on building a sustainability roadmap that really makes an impact.

In collaboration with Materialise
There’s no question that every additive manufacturing business (and more broadly, every manufacturing business) should be not only thinking about sustainability but updating policies and practices with sustainability as a top priority. But figuring out how to improve sustainability in a meaningful way can be challenging. Fortunately, there are organizations leading the way in creating a more sustainable future—both for AM as a technology and as a business—that are showcasing how others can follow suit.

In recent years, Belgian 3D printing company Materialise has made some significant strides in improving its ecological footprint. In 2020, for instance, the company set itself the ambitious goal to cut its CO2 footprint by 50% by 2025. As of our interview last year with Head of Sustainability Leen Kuijken, the company was well on track to meet these targets. This progress is owed in large part to the multi-pronged strategy Materialise has taken, in which it has defined material areas to focus their sustainability efforts and bold targets for transforming them.

In this article, Leen Kuijken illuminates how Materialise has really taken sustainability to heart and how other companies can use its roadmap as a foundation to boost their environmental missions. Sherri Monroe, Executive Director of the Additive Manufacturer Green Trade Association (AMGTA), also offers insights into how the additive industry on the whole can take
steps in the right direction and looks at why targeting sustainability is not only beneficial for the companies in the long-term but is essential.

**Short-term strategies are fine, but long-term is what counts**

Establishing a long-term sustainability strategy is paramount to making a true impact, but it can be a daunting process. For many, it can seem more feasible to start with small steps, or “quick wins”. This is a fine place to begin, but it shouldn’t be the end goal.

As Sherri Monroe explains: “Just get started if you’re discouraged and don’t know where to start. Begin with the easiest thing, get people onboard with the idea, and go from there. It might come off as greenwashing to some people, but quick wins are more baby steps. What determines whether something is greenwashing or convenient marketing is based on the company’s next actions. Is the company continuing to do the easy things, or is it progressing to more complex objectives? Customers, employees and investors quickly see through a lack of commitment.”

In 2020, Materialise made the goal to cut its CO2 footprint by 50% by 2025. To date, it is on track to meet this target.
Leen Kuijken suggests that a good way to lay the foundation for a successful sustainability mission is to first understand what ecological impacts your business actually has. “This all starts with calculating your emissions and deciding where to make significant reductions,” she says.

In other words, take stock of things like how much energy your business consumes, where that energy comes from, and what your transportation usage looks like. “Understanding your energy usage and the different types of energy you consume, and converting to renewable, sustainable energy sources as much as possible will help immensely,” Kuijken adds. “Once you’re aware of certain metrics, you can set specific targets, like electrifying your fleet of company cars and reducing your business flights. “Setting a carbon budget—the maximum amount of CO2 you want to spend e.g., on business travel—and assembling projects that tackle lowering emissions would certainly be constructive. Along with reviewing our energy and transportation usages, we’ve identified that emissions related to

Understanding where your company’s emissions are generated is the first big step to making meaningful changes.
the production of the powder we print with is a big component of our emissions. We’ve invested a lot into ways to print more efficiently and have reused waste powder more effectively over the years. But it goes without saying that to reach serious reductions – the powder suppliers need to be part of the exercise and need to be convinced to invest in lowering their CO2 emissions for producing the printing powders as well.”

As Monroe further emphasizes, one of the most important things is that the goal of improving sustainability should reach every corner of an organization. “Sustainability actions should permeate every aspect of the company,” she says. “While characteristics like location and cultural business practices may influence the conversation, creating the mindset within the company is the start. And that comes from leadership.”

**Setting ambitious, long-term targets**

With both the intention to pursue sustainability and an understanding of current climate impacts, the next step is to lay out a roadmap with long-term goals and measurable objectives. For Materialise, the current roadmap aims to drastically cut CO2 emissions by 50% by 2025, but for another company, the goals and steps to get there might look completely different.

“It’s important to realize that what is important may differ from organization to organization,” Kuijken states. “However, it’s important to stress that we’re dealing with huge, long-term challenges that need a long-lasting approach. Consequently, I believe there’s no better way to embrace these challenges than by creating a roadmap.

“Before defining a roadmap, however, the company should involve a broad group of internal stakeholders to outline the organization’s sustainability strategy and direction. At Materialise, we’ve defined a materiality matrix to figure out the key areas we will focus on and where we, as a company, can add to the sustainability discussion. We’ve selected six areas in our materiality matrix and have goals on these, like specific reduction targets within a specific time, being transparent about our carbon footprint, etc.”

The six focus areas defined by Materialise are:

- Carbon footprint
- Material use efficiency and waste reduction
- Ecodesign and innovation for sustainability
- Sustainable procurement
- Diversity and inclusion
- Employee engagement and well being
Because sustainability can sometimes feel like an abstract topic, finding specific objectives that all advance towards a long-term target is a good way to get people on every level—especially decision makers—on board with the mission. It’s also important to recognize that there will be challenges and setbacks along the way, but to focus on the progress being made.

Kuijken reinforces this idea: “It helps if you have a sustainability team at the heart of your long term strategy, but companies should make sure this is not only a bottom-up grass movement: support must come from senior people at the top too. Finally, the company must communicate its progress internally and externally, even in the implementation phase. Progress might be bumpy, and that’s the risk we’re taking. It’s important to show that this journey is far from easy. Nevertheless, even if we fail to reach our targets, we’ll still have made important steps, and our actions will benefit the industry in the long run.”

Ultimately, creating a sustainability team that exists separately from your business operations or laying out vague goals probably won’t deliver meaningful advances. Businesses really have to take sustainability targets to heart and think about them in every decision that is made.

“Companies shouldn’t consider sustainability as something separate from your strategic business objectives,” Monroe sums up. “Sustainability sits alongside these objectives across all levels of business, such as being more efficient, less waste and less energy consumption. These goals will naturally lead to shorter lead times and more efficient supply chains: targets that drive every business. So, remember that sustainability is part of every aspect of your business.”

The importance of sustainability in AM

While the AM industry has often marketed itself as a more green alternative to traditional manufacturing, the reality is slightly more complicated. Yes, AM enables on-site production and more efficient designs, which both contribute to fewer emissions, but ecological impacts are multi-faceted and complex, encompassing far more than just CO2 output. Both the AMGTA and Materialise are hoping to remind the industry of this.

“Next to CO2, sustainability has environmental aspects like examining the toxicity of products and materials,” comments Kuijken. “There’s also social sustainability. How do we deal with people in the supply chain? Where and how are the materials produced? And do our suppliers have policies to protect people (i.e. anti-slavery and conflict mining)? These are just some topics that touch on totally different parts of sustainability, and it’s important to stress this.”

Image: AMGTA
It’s also important to dispel certain ideas about AM’s inherent sustainability. For instance, there is a misconception that 3D printing uses less energy. This, as Monroe points out, is not always true. “If you look at the powder production process, it’s very energy intensive, especially to produce a viable powder—certain aspects like that need to be factored in.”

To better understand AM’s actual ecological impact and to figure out where opportunities for improvement are, organizations like Materialise and the AMGTA have been spearheading Life Cycle Analyses. These studies look at every single step in a production process, from raw material extraction to the final part’s end of life, to determine the real impact it has. The data derived from LCAs provides valuable insights into where the biggest opportunities and challenges for sustainability lie.

“It’s incredibly important that the industry should take this opportunity to continue investing in research and data,” says Kuijken. “As we lack so much data, there are many examples where we don’t know how sustainable a particular product or process is—and that’s crucial because sustainability is important in all walks of life and across sectors."
“We need to continuously invest in life cycle analyses (LCAs), create and maintain partnerships to gain further insights, and figure out how to support each other to tackle key challenges. For example, how can we reduce energy, use more sustainable materials like recycled powder, and what alternative materials can we invest in or investigate in the future?”

A promising outlook

The good news is that despite the challenges that additive manufacturing companies may face when opting for more sustainable solutions and in building long-term strategies, there is enthusiasm across the industry to increase the focus on sustainability. It’s clear to all that it’s a necessary path to take.

“Everyone is trying to figure out how sustainability fits into their business model and where the opportunities present themselves,” says Monroe. “Personally, that’s encouraging. However, I don’t think companies will have a choice. Customers, employees and society are increasingly demanding this right now. The pandemic and other global events in the last couple of years have pushed this to the front of people’s minds when it might not have been three or four years ago.”

Kuijken also offers good advice for those passionate about making AM more sustainable: “My advice for everybody that wants to make additive manufacturing increasingly more sustainable is to lead by example and make your company lead by example. Show that the topic is close to your heart and take the initiative. Search out like-minded colleagues, put sustainability on the table for debate and make your voice heard. And to leaders, sustainability is rapidly becoming extremely important for all young (and mature) people, whatever position they enter in your organization, so take notice.”

Once there is interest in pursuing ambitious sustainability projects, the next step, as Kuijken adds, is to get organized in a sustainable way. “For us, that meant switching to renewable energy sources wherever possible.” From there, she summarizes how to make sustainability a success: “create more transparency by understanding your emissions and where you could make noticeable reductions. Finally, you need to innovate and invest: figure out the gaps and problems you’ll inevitably encounter and think of creating partnerships and original ways to solve them. That’s what I’d advise AM and non-AM companies to do.”
In this eBook we take to the skies, exploring the market value of AM services in aerospace, how AM is revolutionizing satellites, how 3D printing materials are increasingly meeting the needs of aerospace production, and more.
Mapping

Sustainability-driven companies in the AM industry

Taking a closer look at the policies of AM companies that are leading the way in making their manufacturing processes and workflows better for the world we live in.
Here is a selection of additive manufacturing companies that are leading the way in sustainability and the policies and practices they have implemented to help make the AM industry more sustainable.

By definition, AM is a more effective and efficient manufacturing process that helps reduce environmental footprints. Unlike traditional manufacturing techniques that create waste accumulating in landfills, AM’s additive process creates parts layer by layer, on-demand, without molds or carved away waste, giving it an environmental edge.

Moreover, it allows for lighter, stronger and individually tailored products for each application, delivering environmental and economic savings. This reduces oversupply, makes inventories obsolete and eliminates the need for unnecessary physical product iterations.

3D printing is becoming a driving force in manufacturing transformation, with several leading companies across the AM industry committed to supporting sustainable efforts throughout the industrial value chain for the benefit of people and the planet.

Digital global manufacturing utilizing 3D printing brings additional inherent benefits. It enables a digital supply chain, moving at nearly the speed of light, with minimal transportation logistics and carbon footprint.
Sustainability takes center stage as they employ 3D printing in various production processes, including reducing, recycling, reusing, repairing and redesigning, contributing to the creation of a more circular economy.

Let’s explore some of the prominent efforts made by leading AM companies in implementing policies for a more sustainable growth strategy.

**Stratasys**

As the overall AM industry leader, Stratasys takes its environmental strategy very seriously. All sustainability activities are part of the company’s overarching “Mindful Manufacturing” strategy, which focuses on bringing value to customers while helping them reduce their environmental impact. This includes improved circularity that delivers economic value, with reduced footprints through Design for Additive Manufacturing (DfAM) and Design for Environment. The company details these activities in its ESG and Sustainability Report 2022.

Stratasys’ first Carbon Footprint Assessment Scope 1 reflects direct emissions from company-owned and controlled resources, primarily gasoline used for company vehicles and emitted natural gases. Scope 2 reflects...
indirect emissions generated from acquired and consumed electricity, steam, heat or cooling. These emissions, calculated from consumed electricity at manufacturing sites, offices and warehouses, occur at sources owned or controlled by other organizations but are a direct consequence of Stratasys’ activities. The company plans to expand data collection and disclosure of these scopes and scope 3 emissions, which encompass all other indirect emissions throughout the value chain.

Ensuring sustainable consumption and production patterns includes environmentally sound management of chemical waste, waste disposal and efficient use of production materials. Stratasys is committed to innovation in reduced waste, reused materials and recycled packaging, and believes that additive manufacturing with greater utilization of recycled and renewable materials can be a more efficient production method. The company not only aims to reduce its own carbon footprint but also to make it easier for its customers to do the same. Climate change targets can be achieved by reducing the movement of product parts worldwide and by utilizing more efficient, digital manufacturing methods.

Materialise was among the first AM companies to integrate sustainable practices into its business.
Stratasys’ growth strategy involves increased production over time, which the company believes can be achieved without extending its carbon footprint. Each incremental shift in Stratasys’ offering can significantly impact various industries, from aerospace and healthcare to automotive and consumer products.

The company’s mission is to translate its leadership in 3D printing into mindful business applications, where less waste is produced, and more value is derived from the digital processes at the core of its additive manufacturing solutions.

Stratasys customers are also invited to participate in the Recycling + Returns program, where the company accepts used cartridges, canisters, spools, print engines and containers for reuse or recycling. With easy-to-follow return instructions and printable labels, the comprehensive program makes it simple for customers to identify recyclable products, reducing waste, logistical activity, and saving space.

**Materialise**

Materialise, the Belgian 3D printing service provider operating worldwide, was among the first AM companies to integrate sustainable practices into its core development strategy. As a signatory of the UN Global Compact, Materialise has been publishing its sustainability report since 2017, showcasing its initiatives and progress. The recently released 2022 edition of the Materialise Sustainability Report highlights how the company’s environmental management system (EMS) enables a comprehensive understanding of as well as minimization of its ecological footprint. With this policy implemented at its headquarters in Belgium, ACTech operations in Germany and Polish facilities, along with ISO 14001:2015 certificates, Materialise is committed to protecting the environment and complying with European environmental legislation, regulations and customer-specific requirements across all its operations, processes, and services.

The company is fully committed to investing in research to better understand the positive impact of 3D printing solutions and has established policies to ensure sustainability is firmly integrated into its global business strategy. The corporate sustainability team, primarily based in the headquarters in Leuven, Belgium, manages and executes the sustainability program. In 2022, the team was led by Leen Kuijken, Head of Sustainability and Corporate PMO, and comprised 20 part-time members, including a full-time coordinator, along with local sustainability champions (“Ambassadors”) at HQ and in all international entities.
Powering a more sustainable 3D printing industry involves staying at the forefront of innovation and technology. Materialise achieves this through life cycle assessments (LCAs) to understand the environmental impact at all stages of a product’s life, identifying best practices, and seeking opportunities for innovation.

For instance, in collaboration with Nyenrode Business University and consultancy PerfoVision, Materialise completed an LCA comparing the production of eyewear using selective laser sintering versus CNC milling. The study found additive manufacturing to be an ideal method for mass-customized eyewear due to lower inventory costs, shorter lead-times, reduced energy consumption of the production line, and less manual labor.

In partnership with BASF, Materialise also conducted an LCA for the production of one million pairs of shoe midsoles. While 3D printing is often considered environmentally friendly, the report revealed that for large series of identical products, this technology is currently not the most sustainable choice. However, the research indicated that 3D printing can offer advantages for producing smaller or customized series.

**Oerlikon**

Oerlikon AM, a leading metal AM service provider catering to the aerospace and energy industries, is part of a group rated among the top 10% of companies in the industrial sector in terms of sustainability, following rating upgrades in 2022. The company showed remarkable improvement in all operational environmental targets, including +5 sites using solely renewable electricity, a -16.9% reduction in GHG emission intensity, and a 28% decrease in waste disposal. Additionally, Oerlikon defined a sustainable procurement roadmap for 2022 to 2030.

Presently, Oerlikon has EnMS in place at 55 of its sites, representing a third of all sites and covering 71% of the company’s global energy consumption. These systems allow the Group to better manage energy usage, identify opportunities for improving energy efficiency, and conserve energy. Such systems also support decision-making for the purchase and use of renewable sources of electricity. With the addition of five more sites, Oerlikon now has a total of 18 sites using electricity solely from renewable sources. Moreover, the company successfully reduced its GHG emission intensity from 60.9 to 50.6, representing a significant 16.9% reduction, and lowered its share of waste disposal from 42% to 28%. As a technology innovator, Oerlikon increased its R&D expenditure from 72% to 73%, focusing on developing sustainable products that help customers save energy, reduce waste and avoid emissions.

The company also publishes a [Sustainability Report](#). The 2022 edition highlights how the component and materials business encompasses precision components, friction systems components, the materials business, and additive manufacturing. As this is the broadest scope of the company’s business, criteria are based on the product application. The provided solutions need to improve the overall system compared to industry standards in one or more of the following areas: energy consumption, social impact, waste, emissions, or service time. Solutions are not
classified as sustainable if there is no comparable industry standard.

**Siemens**

Siemens, through Siemens Energy and Siemens Digital Industries, is a major metal AM service and AM technology provider. Sustainability is a core element of its portfolio, which is designed to drive the digital and sustainable transformation of industry, infrastructure, transportation and healthcare. With technology-driven purpose, Siemens empowers its customers and partners to maximize their contributions to the health of our planet.

Sustainability is deeply ingrained in all business activities, investment decision-making, and governance, reflected in the DEGREE framework, offering a 360-degree view of Siemens’ ESG priorities.

Siemens also publishes a yearly Sustainability Report. The 2022 edition highlights how AM, as a Company Core Technology (CCT), enables flexible production of components with entirely new topologies, acting as a crucial driver of innovation. Siemens has developed a digital tool chain supporting the design and printing of components, ensuring they are “error-free and from one cast.” The company also
focuses on innovative materials to enhance the efficiency of generators, switchgear, and other equipment, while promoting lightweight design for railway vehicles.

Furthermore, Siemens prioritizes technologies driving the digital transformation of industry, smart infrastructure, and sustainable mobility, significantly contributing to achieving the UN’s Sustainable Development Goals (SDGs). By bridging the gap between the real and digital worlds, Siemens maximizes customer benefits.

Digitalization, automation and sustainability serve as growth engines for the company’s business. In terms of sustainability, Siemens’ portfolio particularly contributes to decarbonization, resource efficiency and the circular economy.

**OECHSLER**

At OECHSLER, a leading manufacturer of polymer parts and provider of polymer additive manufacturing services, sustainability is a global consideration based on all three ESG pillars (Environment, Social, and Governance). OECHSLER aims to achieve CO2 neutrality concerning Scope 1 and 2 emissions by 2030 latest.
As a family-owned business, the company instills these values across all its global sites, which are consistently validated through rigorous certifications and customer audits.

OECHSLER is dedicated to making a meaningful contribution to climate protection. The company goes beyond assessing climate protection within its own sphere of influence (Scope 1 and Scope 2 emissions) and also considers upstream and downstream processes (Scope 3 emissions).

Recognizing technology as a key driver for performance improvement and reducing environmental impact, OECHSLER invests in its production sites to implement measures with energy-saving potential. Self-generated energy is considered the cleanest form of energy access. Consequently, OECHSLER has launched a global multi-million Euro investment program to significantly increase the share of self-generated energy. By mid-2023, solar systems with a capacity of about 8,000MWh will have been installed at five of OECHSLER’s seven production sites, with about 50% of the target already achieved.

As the largest source of energy consumption, purchasing green electricity is the fastest way to achieve CO2 neutrality. OECHSLER is actively expanding the use of electricity from renewable sources, backed by corresponding guarantees of origin. The company follows the principle of implementation to achieve results as quickly as possible. This approach will be progressively expanded in the future. Additionally, carbon credits have not been introduced yet. However, OECHSLER aims to achieve CO2 neutrality concerning scope 1 and 2 emissions through offsets by 2030 at the latest. Emission credits will only be utilized for unavoidable emissions resulting from production processes or to offset emissions from countries where meeting targets is challenging.

EOS

Polymer and metal AM hardware OEM EOS has been prioritizing environmental management since 2016, and its activities in this area have been steadily growing. The company publishes a yearly sustainability report. The 2022 edition explains how EOS’ corporate purpose is “Responsible Manufacturing,” serving as the foundation of their business model and corporate strategy. EOS senior management views responsible production and corporate governance not only as a moral imperative but also as a business case for sustainability.

EOS is actively exploring new opportunities to ensure greener production through a partner network and employee support in finding solutions that increase energy efficiency, reduce waste, and conserve resources throughout the entire life cycle.

The sustainability department reports directly to the CEO and is responsible for coordinating the sustainability strategy, including all sustainability projects in the company. The ISO 14001:2015 certified environmental management system for the Krailling and Maisach sites forms the basis of the environmental activities in the company. EOS’ CEO, in coordination with the head of the sustainability department, establishes the environmental strategy and its measures.
Regarding the environment, the materiality analysis highlights key topics such as material origin, resource efficiency, climate protection and the circular economy. EOS firmly believes that innovation and technology can contribute to creating a better world for all. As most current manufacturing techniques are restrictive, wasteful, and inefficient, the company is convinced that additive manufacturing can overcome these limitations. Thus, EOS management is dedicated to accelerating the transition to responsible manufacturing to meet customer needs and act responsibly towards the planet.

Alongside resource-saving processes in additive manufacturing within the company, EOS strives to create added value for customers through efficient and environmentally friendly product usage. The ultimate goal is to reduce energy consumption, material input, waste materials, and wastewater. Environmental impacts and sustainability play critical roles in the development and optimization of EOS additive manufacturing processes.

"Responsible manufacturing" is the foundation of EOS’ current business model and corporate strategy.
AM Service Bureaus

In many ways the backbone of the AM industry, services not only make the technology more accessible and help to drive adoption, they also play a big role in technological innovation and application development. Tune into our next eBook for new perspectives on this segment.
Biomaterials, sustainability, and 3D printing with Marvel Labs

How years as a trailblazing AM entrepreneur led Andy Jeffery to found Marvel Labs and how the company is leading the charge towards an eco-friendly manufacturing industry.
In this interview, we look at how industry pioneer Andy Jeffery has been inspired by sustainability over the years and how his vision has led to the founding of Marvel Labs, which specializes in 3D printing bio-materials, like sawdust and seaweed.

The ever-evolving world of 3D printing stands at the crossroads of innovation and sustainability, with industry pioneers like Andy Jeffery leading the charge. As we came to understand during a recent interview, Jeffery’s journey into the realm of 3D printing began in the textile weaving industry, where he initially found his calling in the manufacturing sector. His story is a testament to the transformative power of innovation, entrepreneurial spirit and a commitment to creating a sustainable future.

Jeffery’s background provided him with a unique perspective on production processes, inspiring him to draw parallels between the mechanisms of weaving and the emerging technology of 3D printing. This conceptual leap was a foundational moment in his journey towards transforming 3D printing into a tool for sustainable development.

This idea of sustainable manufacturing came to Jeffery through MIT, a hub of innovation and a cradle for budding entrepreneurs. It was here, amid a series of lectures and venture forums, that Jeffery was exposed to the words of ethernet inventor, Bob Metcalfe. Metcalfe’s talk on leaving one’s job to start a new company resonated with Jeffery. As he scribbled down
the conditions that needed to be present to embark on such a venture, he found his own list aligning perfectly with Metcalfe’s.

This realization catalyzed his leap into the world of 3D printing and resulted in the co-founding of his first company, Specific Surface. As one of the first licensees of the Binder Jet 3D printing process developed at MIT, the team focused on manufacturing ceramic filters for industrial gas cleaning.

“We bought our first machine in 1996, and that was the start of my 3D printing career,” said Jeffery. This initial foray into 3D printing set the stage for his future endeavors.

Following the success of Specific Surface, Jeffery co-founded Viridis3D, which started as a materials company but evolved into a machine company. This shift was driven by Jeffery’s fascination with making parts using 3D printing rather than solely focusing on inventing or improving the hardware.

His experience at Viridis3D led Jeffery to start his next venture, Figulo, which emerged as a result of a serendipitous encounter with an artist expressing frustration in finding 3D printing services for her artistic creations.

Marvel Labs has the ability to 3D print materials made from sustainable byproducts, like coffee grounds.
Inspired by her words “Don’t think that artists don’t have money. We do. And we wanna spend it”, Jeffery made the bold decision to pivot from technical ceramics to consumer ceramics, a move that proved highly successful.

Figulo grew rapidly, becoming a prominent supplier of ceramics to major online 3D printing companies like Shapeways. However, Jeffery’s journey didn’t stop there. In 2013, Figulo was acquired by 3D Systems, where Jeffery continued to work for a few years before, once again, exploring new opportunities.

His next venture was Boston Ceramics, which initially focused on technical ceramics, and whose technology was eventually moved to Europe. During this period, Jeffery’s interest in sustainability and circular economies deepened.

Jeffery’s vision (one of many) is intriguing: to establish a factory teeming with a thousand 3D printers, churning out products autonomously, without the need for lights or people. This concept, while seemingly drawn from the realm of science fiction, is rooted in the reality of today’s weaving industry. It is the image of thousands of highly computerized
machines, weaving denim, that inspires Jeffery’s dream for the future of 3D printing.

His interest in sustainability led him to co-found his current company, Marvel Labs, with the goal of developing sustainable materials and exploring the potential of bio materials and byproducts, such as sawdust, coffee grounds, and seaweed, in 3D printing. Marvel Labs aims to create products that embody concepts of circularity, with a focus on reusability, biodegradability, and recycling.

“Our focus is not just on creating beautiful and functional parts but also on incorporating sustainability and circularity in our products. We want to redefine the end-of-life scenario for these parts, ensuring they can be reused or biodegrade without harming the environment,” said Jeffery.

The team at Marvel Labs’ goal is to develop products that exhibit strength similar to wood and can be used in a similar manner. Achieving this level of performance is essential for the printed objects to meet necessary standards, such as the ability of a chair to withstand substantial weight.

In order to achieve this strength, the team is developing a bio-based binder and exploring various post-processing methods, including the use of bio-resins that can be reclaimed after use. One interesting method they are considering involves using a type of ‘super glue’ produced by bacteria to bind the bio-materials together or to infiltrate the printed structures for added strength.

“We have complete freedom in the Z-direction to do some very interesting things,” said Jeffery. “Longer term, we see interiors as really a sweet spot and we’re thinking about automotive and boat interiors as well.”

Jeffery acknowledges the challenges that lie ahead, particularly for objects that require a degree of structural integrity. However, he remains optimistic and driven by the vision of a sustainable manufacturing future.

By the end of the year, Jeffery anticipates a number of Marvel Labs’ 3D printers will be operating in the biomass space, marking a significant milestone in the quest for sustainability.

Andy Jeffery’s journey underscores the profound impact one can have when conventional industry knowledge is combined with cutting-edge technology and a commitment to sustainability. As we look to the future, it’s clear that his work in 3D printing will continue to drive innovation, pushing the boundaries of what’s possible while paving the way for a more sustainable world.
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