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3D YAZICILARIN ENERJİ SEKTÖRÜNDE KULLANIM ALANLARINA ÖRNEKLER

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ÖZET: Günümüzde, 3D yazıcılar, sadece endüstriyel üretimde değil, enerji sektöründe de büyük bir etki yaratıyor. Bu teknolojik gelişme, enerji üretimi, depolama ve verimliliği gibi anahtar alanlarda önemli faydalar sağlıyor. 3D yazıcılar, enerji sektöründe çeşitli kritik kullanım alanlarına sahip. Enerji üretimi ekipmanlarının hızlı, özelleştirilmiş ve daha verimli bir şekilde üretilmesi, rüzgar türbini kanatlarının daha aerodinamik hale getirilmesi, prototip geliştirmenin hızlandırılması, yedek parça üretiminin aciliyetle karşılanması, pil teknolojileri, ısı değiştiricileri ve akışkan dinamiklerinde kullanım, 3D yazıcıların enerji sektöründeki kritik rollerinden sadece bazıları. Bu teknolojik ilerleme, enerji sektöründe daha etkin, sürdürülebilir ve yenilikçi çözümlerin geliştirilmesine olanak sağlıyor. 3D yazıcıların yaygın olarak benimsenmesiyle birlikte, gelecekteki enerji üretimi ve kullanımında önemli bir değişim ve gelişim öngörülüyor. Bu teknoloji, enerji sektörünün dönüşümünde belirleyici bir faktör olmaya devam edecektir.

Anahtar Kelimeler: 3D baskı teknolojisi, Enerji, Endüstriyel uygulamalar, Yedek parça üretimi

EXAMPLES OF USAGE AREAS OF 3D PRINTERS IN THE ENERGY SECTOR

ABSTRACT: Today, 3D printers are making a huge impact not only in industrial production but also in the energy sector. This technological advancement provides significant benefits in key areas such as energy production, storage and efficiency. 3D printers have various critical usage areas in the energy sector. Fast, customized and more efficient production of energy production equipment, making wind turbine blades more aerodynamic, accelerating prototype development, urgent spare parts production, use in battery technologies, heat exchangers and fluid dynamics are just some of the critical roles of 3D printers in the energy sector. This technological advancement enables the development of more effective, sustainable and innovative solutions in the energy sector. With the widespread adoption of 3D printers, a significant change and development in future energy production and use is predicted. This technology will continue to be a determining factor in the transformation of the energy sector.

Keywords: 3D printing technology, Energy, Industrial applications, Spare parts production

1. INTRODUCTION

3D printing technology, which has been developing rapidly in the energy sector in recent years, opens the doors to an innovative and groundbreaking transformation. This technology was subject to certain limitations when it was first proposed in the 1980s, but thanks to recent major advances, highly sophisticated 3D printers have been developed that can work with a variety of materials, including metals. These printers have the potential to revolutionize key areas of the energy industry, such as energy generation, storage, and distribution. This article aims to explain how three-dimensional printers used in the energy sector contribute to different application areas and a wide range of the industry. We will also examine how 3D printing benefits from prototyping to production and how this technology creates new opportunities in the energy sector. The energy sector is on the verge of a major transformation in recent years, and 3D printing plays an important role in this change. Additive manufacturing offers a significant advantage in the design and production processes of energy devices, from prototyping to production. The ability to produce customized parts at lower costs is one of the attractive factors of this technology. Additionally, the use of 3D printing in the energy sector also enables the development of innovative devices and the emergence of innovations such as solar panels [1-4].

The energy sector is one of the pillars of modern society and continues to grow and develop constantly. This sector includes many sub-branches from electricity generation to energy storage, and these areas need more innovation and technological development every day. In this context, 3D printers are a breakthrough in the energy sector [5,6]. The use of 3D printing technology in the energy sector offers a number of advantages, such as increasing efficiency, optimizing production and developing sustainable energy sources. In this article, we will focus on the usage areas of 3D printers in the energy sector and examine the contributions of this technology to the sector. Parts Production and Maintenance; Power generation facilities sometimes need important parts or components while operating continuously. Traditional production methods are time consuming and costly to meet this need. However, 3D printers can enable the production of these parts quickly and precisely. For example, part of a generator can be quickly printed and replaced, ensuring continuity of energy production. Prototype Development; Innovative energy technologies development processes require many trials and improvements at the prototype stage. 3D printers can speed up the design process by enabling rapid production of prototypes. This allows for faster development and launch of new energy sources or storage systems. Wind power; Wind energy stands out as one of the clean energy sources. Wind turbines involve large and complex structures. 3D printers can be used to produce turbine blades and other components. Wind turbine blades can be designed to be more aerodynamic and lightweight, which can increase energy efficiency [7]. Conventional horizontal axis wind turbines have been used in the wind energy industry for many years. These produce energy by rotating on the horizontal axis of the wind. On the other hand, vertical axis wind turbines obtain energy by rotating on the vertical axis of the wind. The studies include the comparison of traditional horizontal and vertical wind turbines with turbines produced with 3D printing technology in terms of efficiency. These comparisons consider factors such as energy efficiency, production costs and environmental impacts of turbines. The results obtained can help us understand which turbine design is more effective under certain conditions [8]. Solar energy; Solar panels are a key component of energy conversion. 3D printers can be used to produce mounting systems or components for solar panels. This contributes to making solar energy systems more cost-effective and efficient [9]. Energy Storage; Energy storage systems are critical to managing energy more efficiently. 3D

printers can be used to customize and optimize components of these systems. This may contribute to energy storage technologies becoming more effective [10].

In conclusion; 3D printers have many different areas of use in the energy sector, and these areas are constantly expanding. This technology supports making energy production more efficient, optimizing maintenance processes and developing renewable energy sources. In the future, we expect the role of 3D printers in the energy sector to grow further, which will contribute to making the sector more sustainable and competitive.

2. 3D PRINTER USAGE AREAS

2.1. Nuclear Energy

The American Atomic Energy Institute (NEI) has adopted cutting-edge technology to develop new reactor projects to meet future energy needs and increase the sustainability of nuclear energy. The latest manufacturing technology used in these projects includes 3D printers. This innovative approach has been used to accelerate the production and reduce the costs of microreactors, especially those with low power requirements. This newly produced microreactor was produced in just a few weeks, as opposed to a production process that could take several months with traditional manufacturing methods. This rapid production provides the opportunity to increase energy production capacity more quickly and can help meet urgent energy needs. Additionally, using 3D printing technology offers a great advantage in terms of cost. The production of microreactors can be achieved at 10% less cost than traditional methods. This enables nuclear energy to become more widely adopted and economically more attractive. NEI's 3D-printed microreactors represent a significant advance in the energy sector. This technology allows energy production to be produced more efficiently, quickly and economically in the future. It is also an important step to meet energy needs and promote environmentally friendly energy sources by opening the door to a wider use of nuclear energy [12].

Figure 1. Reactor produced by 3D printing [12]

2.2. Solar Cells

Currently, developments are ongoing for the production of panels on a 3D printer. Although 3D printers or 3D printing technology are not directly used for solar energy production, this

technology can be useful in the design, prototyping, and production of components of solar energy systems.

While solar energy has gained an important place as a clean and sustainable energy source, portable solar panels also contribute to the spread of this technology. South Dakota-based Peppermint Energy has combined the power of innovation and 3D printing technology to create FORTY2, a portable solar panel. Peppermint Energy designed the FORTY2 as a compact solar panel with enough power to power a range of portable electronic devices, such as a laptop or lighting. However, there were some difficulties encountered while prototyping this innovative product. In the production of FORTY2's prototype case, 3D printing technology was used on a Stratasys industrial printer. This provided a great advantage in improving the design and eliminating defects. The first version was difficult to use and had a cumbersome structure. But thanks to 3D printing, the design was quickly simplified and the portability of the product increased. Simplifying the original design and quickly producing prototypes provided Peppermint Energy with major cost savings. The use of the 3D printer reduced production costs by approximately $250,000. This helped bring FORTY2 to market at a more competitive price. Peppermint Energy's FORTY2 project is an example that highlights the importance of 3D printing in the development of portable solar panels. 3D printing contributes to the successful development of such innovative energy solutions in areas such as rapid development of the design, production of prototypes and cost savings. Such technologies will help meet future energy needs by increasing access to clean energy [13].

Figure 3. Portable solar panel [13]

Australia-based Commonwealth Scientific and Industrial Research Organization (CSIRO) has taken a groundbreaking step to transform solar energy technologies. The organization produces solar cells in roll form using 3D printers. This enables the production of the largest photovoltaic cells ever seen. These innovative solar panels are made of elastic and lightweight plastic material. These features make it possible for the panels to be applied to different surfaces, especially windows and buildings. Their more flexible structure compared to traditional solar panels offers great design freedom for architects and engineers. A notable advantage of CSIRO's 3D-printed solar panels is their high efficiency. These panels can capture and store solar energy more effectively, increasing energy production. Additionally, 3D printing technologies enable panels to be produced precisely and reliably, so the company can offer accurate and reliable solutions for solar energy systems. Compared to traditional

solar panels, solar panels produced with 3D printers provide a 20% higher efficiency. This contributes to making the use of solar energy more economical and environmentally friendly. This technological advancement from CSIRO represents an exciting step towards making energy production more efficient, while moving the solar industry towards a more sustainable future. These innovations can help spread solar energy to a wider range of uses and meet our energy needs in a more environmentally friendly way [14].

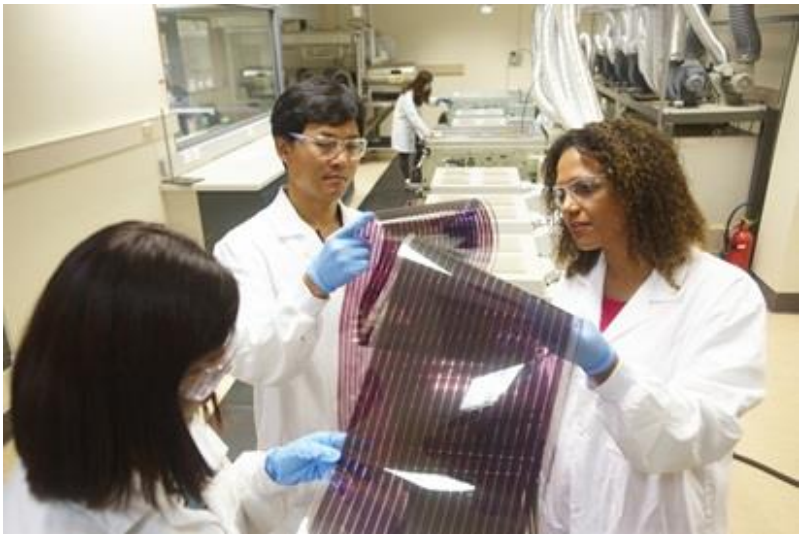

Figure 4. 3D printed solar cell [14]

A Dubai-based company has developed "Smart Palm", an innovative project where people can charge their phones and connect to Wi-Fi on the city's streets and beaches. The main purpose of this project is to combine an aesthetic design that will meet the needs of modern life with environmentally friendly energy production. "Smart palm trees" have an aesthetic design that brings a modern touch to the cityscape. These trees are used to collect solar energy and meet energy needs. Firstly, these stations were planned to be made of steel. However, the use of reinforced plastic materials has been switched to reduce the weight of the structure and adopt a more sustainable approach. The Smart Palm project offers a practical and innovative service to people traveling around the city. While it offers powerful charging points for those who want to meet their charging needs, it provides constant connection thanks to Wi-Fi access. Additionally, the environmental impact of this project cannot be ignored; The use of solar energy reduces dependence on fossil fuels and promotes the city's green energy transition. Dubai's Smart Palm project stands out as an example that combines technology and environmental awareness. Such projects may have greater importance in the future to increase the sustainability of cities and offer better living conditions to citizens [15].

Figure 5. "Smart palm trees" with solar panels[15]

2.3. Batteries

Researchers from Manchester Metropolitan University, the University of Chester and Central South University in China have made an exciting breakthrough that shapes the energy storage devices of the future. These new energy storage devices contain disc electrodes produced by 3D printing using graphene. This technological breakthrough provides great freedom in the design of electrical devices and also offers new opportunities in the field of energy storage. Additionally, it offers the opportunity to use various printing materials that can be adapted to the project. This discovery opens the doors to a much easier and feasible method that will enable more effective storage of renewable energy resources. Graphene-printed disc electrodes, which form the basis of these devices, are a revolution in the fields of electrical engineering and electronics. Depending on the goals of the project, the ability to use different materials with 3D printing increases the flexibility in energy storage technologies. This offers a wide range of applications to optimize renewable energy production and storage in the future. It should not be forgotten that additive technologies play a critical role in the creation of energy production and storage systems based on renewable energy sources. 3D printing with graphene represents the beginning of a new era in this field and has great potential to shape the future of the energy sector. These innovations promise hope for the environment and the future of humanity by increasing energy efficiency and making sustainable energy sources more accessible [16].

IBM and ETH Zurich researchers have taken an innovative step by creating a unique liquid battery capable of producing energy and cooling. This unique battery is called a "redox flow" battery and was developed by taking advantage of 3D printing technology. Researchers used 3D printing to create a microchannel system to deliver electrolytes. This approach allows controlling the high temperature inside the system while minimizing the pumping power. The most notable feature of the redox flow battery is that it has the ability to both generate energy and cool. This battery breaks new ground in energy storage and heat management. The use of 3D printing technology provides great flexibility in the design of the battery and makes it possible to control the electrolyte flow more effectively. It also makes energy conversion more efficient. The microchannel system accelerates redox chemical reactions used in energy production while effectively cooling the battery. This improves the performance of the battery

while also controlling the internal temperature. This feature prevents batteries from overheating and increases safety levels. It can be said that this innovative redox flow battery, developed by IBM and ETH Zurich researchers, is a significant breakthrough in the fields of energy storage and thermal management. This technology can contribute to making energy storage systems safer and more efficient in the future, and can also open the door to a more sustainable energy future by providing solutions to heating problems [17].

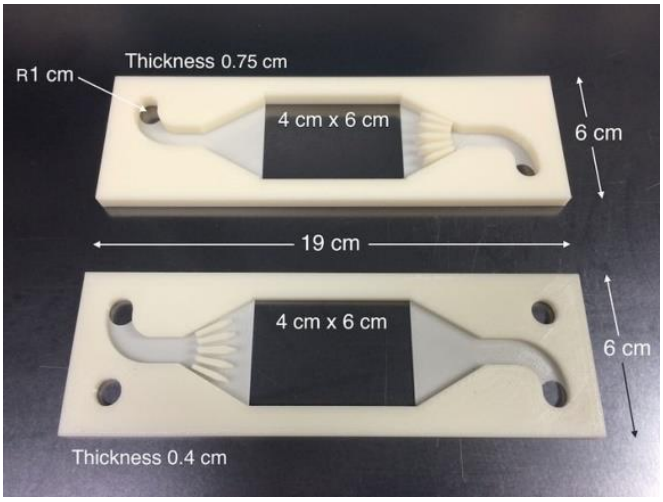

Figure 6. Parts of 3D printed Redox Flow battery housing [18]

2.4. Wind Turbines

RCAM Technologies, an innovative startup, has decided to take a step that will revolutionize the production of wind power plants. The goal of this initiative is to produce large-scale turbines instead of microturbines. These large turbines operate more efficiently the higher their settings are. The basic idea is this: 3D print some wind farm components on site. This unique approach from RCAM Technologies represents a significant transformation in the wind energy sector. It aims to optimize energy production by enabling the production of larger and more efficient turbines by using 3D printing technology instead of traditional production methods. This technology offers the ability to produce parts of wind power plants on site, reducing transportation and assembly costs and enabling projects to be completed more quickly. Additionally, it contributes to making wind power plants more competitive by increasing the efficiency in energy production. This innovative approach from RCAM Technologies is poised to transform the energy sector and offers great potential to make energy production more sustainable and efficient. Therefore, it has been included in the list of top startups using layered technologies in the energy sector in 2019 by StartUs Insights analysts. This success provides an exciting example of how the future can be shaped in the energy sector [19].

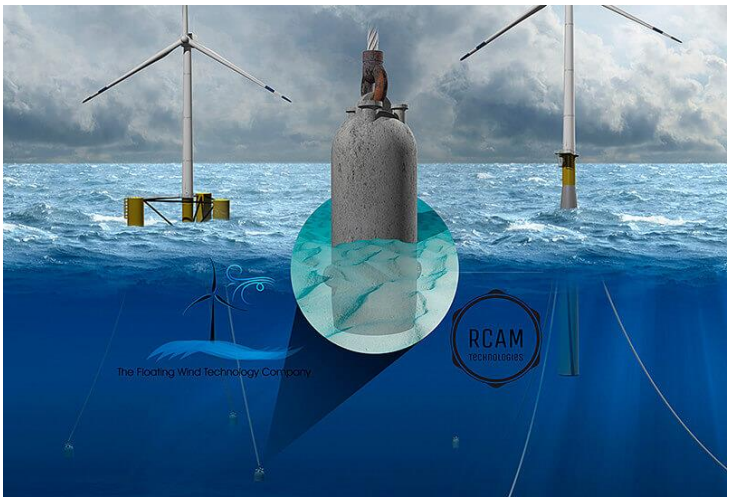

Figure 8. Illustration of a 3D-printed concrete suction pile anchor for connecting floating wind turbines to the seabed via mooring lines. [19]

2.5. Gas Turbine Blades

Engineers at the Siemens facility in England decided to take an important step that could be a turning point in the energy sector. This step is related to the production of blades, which are one of the basic components of gas turbines, with 3D printing. These blades must withstand extreme pressure and temperature conditions, and Siemens engineers have used 3D printing technology to develop specially designed blades that can withstand these harsh conditions. The performance of gas turbines is highly dependent on the durability of the turbine blades. The wings produced by Siemens with 3D printing can move at incredibly high speeds, over 1,600 km/h. In addition, they have the ability to withstand even a 1°C temperature increase with rapid cooling technology and can withstand temperatures as high as 250,400°C by resisting the effects of environmental temperatures. This technological advancement is revolutionary for energy production and industrial applications. Siemens' 3D printed gas turbine blades offer great potential for the construction of more efficient and durable facilities in the energy sector. Additionally, this development highlights the power of 3D printing in industrial design and manufacturing and could lead to more widespread adoption of this technology in the future. This innovative approach of Siemens engineers should be considered an important step to push the limits in energy production and reach more sustainable energy sources [20].

Figure 8. Siemens UK starts additive manufacturing of turbine blades [21]

2.6. Hydroelectric

Turbulent, a Belgium-based startup, is focused on developing an innovative vortex turbine for a compact hydrogen generator designed to power private homes. This aims to make electricity supply to their homes more accessible by using the energy of streams or small rivers, offering great potential especially for people living in remote areas. The vortex turbine developed by Turbulent makes energy production smaller-scale and customizable, allowing electricity production in previously inaccessible areas. Using 3D printing in the production process of this technology makes the turbine more cost-effective while increasing flexibility in production. There are 1.3 billion people around the world who do not have access to the electricity grid or experience constant power outages. Additionally, there are many people who remain dependent on energy sources that are not environmentally friendly (for example, gasoline or diesel generators). Turbulent's vortex turbine offers an innovative solution to these problems and makes it easier for more people to access sustainable energy. This initiative aims to make a significant difference in both energy production and energy access. Turbulent's work contributes to sustainability and accessibility goals in the energy sector, serving the purpose of protecting the environment while meeting energy needs. Therefore, Turbulent's vortex turbine should be considered an important innovation in the energy sector [22].

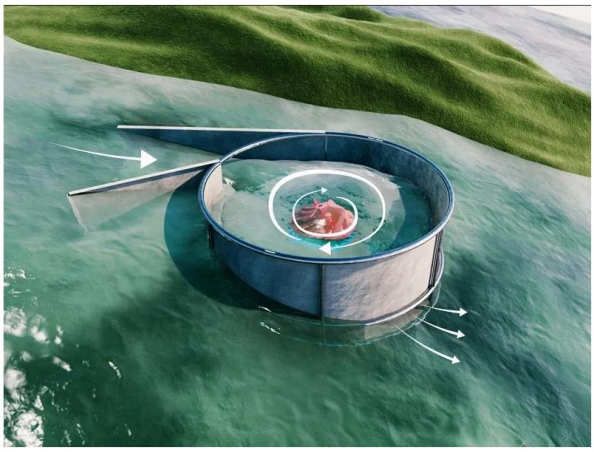

Figure 9. Turbulent prototype hydrogen generator [22]

Ted Christopher made a significant innovation by developing a prototype river turbine that can produce electricity without adversely affecting the environment. The result of this development is the "Volturn" system, named after the river god in Greek mythology. Volturn has a horizontal structure that generates energy and detects obstacles such as rocks, plants or logs in the riverbed. The Volturn system was implemented with a prototype produced using 3D printing technology to be tested in local rivers. This prototype is designed for practical application in rivers. The main feature of the system is the combination of 5 different turbines in a single system. These turbines can meet the electricity needs of approximately 40 homes by converting the kinetic energy of the river flow into electricity. The Volturn system should be considered a groundbreaking step in sustainable energy production. This innovative approach by Ted Christopher contributes to environmentally friendly energy production by using natural energy resources in rivers more efficiently. It also offers a zero-carbon footprint solution to meet the energy needs of local communities. Therefore, the Volturn system can

contribute to a more sustainable and environmentally friendly energy production in the future [23].

Figure 10. 3D printed Volturn system [23]

3. CONCLUSION

In this article, we examined the various usage areas of 3D printers in the energy sector and the contributions of this technology to the sector. We have seen that 3D printing offers significant advantages in terms of energy production, storage, efficiency and sustainability as an alternative to traditional production methods.

3D printers stand out as an important tool in making the energy sector more sustainable and efficient. This technology provides innovation and cost savings at many stages, from energy production to maintenance, from design to production. It is certain that in the future, the energy sector will be further transformed with 3D printers and more sustainable energy solutions will be developed.

The energy sector plays an important role in using energy resources more intelligently and reducing environmental impacts. 3D printers also contribute to this sector reaching these goals. Therefore, closely following the advances and innovations of 3D printing technology in the energy sector is seen as one of the keys to meeting the energy needs of the future in a more sustainable and effective way.

As a result, 3D printers stand out as a powerful tool to make the energy sector more efficient, economical and sustainable. This technology will help the energy sector better respond to future energy needs by accelerating its growth and transformation.

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