Journal of Soft Computing and Artificial Intelligence
Research Article | 2(1): pp:27-40 (2021)
Received: April 13, 2021 | Accepted: May 31, 2021
JSCAI
ISSN: 2717-8226

Investigation of Innovations in Solar Generator Systems

[1]Bekir Çırak , [2]Arife Pınar

[1] Department of Mechanical Engineering, Karamanoglu Mehmetbey University, TURKEY
[2] Mechanical Engineering Department Graduate Student, Karamanoğlu Mehmetbey University, TURKEY

Corresponding author: Bekir Çırak (bcirak@kmu.com)

ABSTRACT The sun, which has the most energy on earth, is also the world's main energy source. All fossil fuels are indirect solar energy. Many renewable energy sources, such as winds and ocean waves, are indirectly related to sunlight. Therefore, collecting energy directly from the sun is a practical way. Photovoltaic (PV) based solar panels currently on the market have also been used commercially for some time. PV modules started with the production of hard silicon solar cells in history. For this reason, flat solar panels have technological advantages. In this study, information about the details of the solar cells produced and in the design phase are compiled from the literature. In addition, scientific, theoretical and applied information about the elements of solar generators was collected. It was presented for the use of researchers. Future formations and innovations are mentioned about solar collectors and its elements.

KEYWORDS: Solar Energy, Generator, Photosensitive, Renewable Energy, Innovation.

1. INTRODUCTION

News about climate change is getting more annoying day by day, and knowing that climate change should not happen is the sad part of this situation. Energy sources that did not harm the world, did not change its atmosphere, and could provide energy for people, started to live with the creation of the universe. The energy sector will undergo significant changes in the future. The percentage of renewable energies will increase, especially in wind, solar and hydroelectric use. All of these variable resources will present challenges to national networks [1]. Fossil fuels were fairly simple to extract and use, and the Earth hadn't gotten much into solar work from them to charging technique, so they remained cheap without being expensive. Therefore, it continued to be forgotten for many years without coming together with advanced technology. Oil-free power generation is an engineering feat for mankind, between 2000 and 2010 was a period of powerful innovation for solar technology. Research projects or commercial initiatives have emerged that aim to make solar energy a power generation source. While some studies are financially supported by state institutions, entrepreneurs and industrialists do not provide this support in places where there is no state support. It is predicted that the efforts, reputation and financial instruments of scientists, engineers, entrepreneurs and philanthropists will have an important position in the future. It is among these predictions and claims that businesses and machines will operate with renewable energy, most of which is solar energy. In addition to the work these innovators do to move us in this direction, the efforts of politicians, educators and other visionaries who strive to prevent the worst climate consequences are also noteworthy. There are three major categories of solar technology;

1. Photovoltaic systems convert sunlight directly into electricity. In silicon conductors, they generate electricity using light-absorbing materials. Electrons in these materials are released by solar energy and pass through an electrical circuit to power electrical devices.

2. They are used for solar heating and cooling systems.

3. Concentrated solar technology concentrates the energy from the sun using mirrors to drive conventional electricity-generating steam turbines or engines [2].

In this article, research examples on photovoltaic cells, batteries, wireless solar transmission and Concentrated solar energy are presented.

2. PHOTOVOLTAIC CELLS (PV)

Photovoltaic cells convert photons in sunlight into electricity. The PV effect was observed by Alexandre Edmund Becquerel in 1839, and in 1954 Bell Labs invented the first usable solar PV device. The solar cell's conductive layer is made of a refined silicon crystal, similar to the material in computer chips. These cells have an efficiency rate of about 20 percent for converting sunlight into electrical energy. The rigid solar panel consists of a group of solar cells all integrated in a single plane [3]. PV cell research aims to reduce the cost of solar cells and increase their efficiency. It is important to use widely available materials in common innovations.

Another research parameter is to improve reliability: toxic or flammable materials should be avoided. Silicon-based solar PV manufacturing involves using the same materials as the microelectronics industry. Commonly used perovskite solar cells contain well-known toxin lead, methyl ammonium lead iodide is the preferred material for such solar cells. A very small amount and very low probability of leakage in a solar cell. However, researchers are investigating the health risks and dangers of lead-based perovskite materials [4].

PV modules contain recyclable and reusable materials such as glass, aluminum and semiconductor materials. In today's technology, recycling of thin film and silicon modules takes place. The parts of the PV module are shown in Figure 1 [5] .

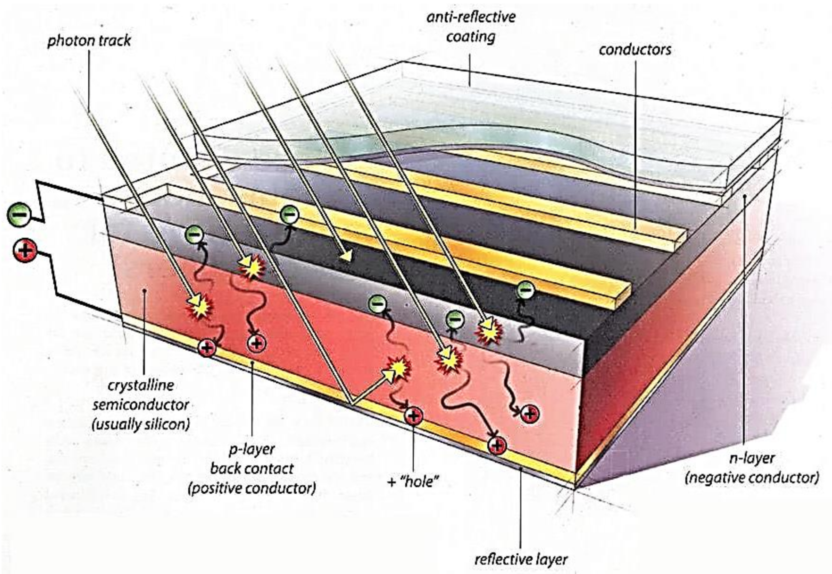

Figure 1. Elements of PV modules [5]

3. SPHERICAL SUN POWER GENERATOR

A Protatip solar generator will produce twice as much efficiency than a traditional solar panel despite having a much smaller surface area. With the hybrid collector, it is used to convert daily electricity and thermal energy at the same time [3].

The modular collector system, developed by German architect Andre Broessel for his company Rawlemon, it recharges and stores energy during the daytime and can even collect energy from moonlight and ambient light at night. Rawlemon website states, "Using a high efficiency multi-junction cell, the cell surface was reduced to 1% in optimum conditions compared to the same power output as a silicon cell. The system produces twice the efficiency of a normal panel Also, a smaller cell area has a lower carbon footprint as its production requires less valuable semiconductor or other building materials. "Multi-junction cells made of multiple materials react to multiple wavelengths of light and some of the energy to be lost can be captured and transformed. Multi-junction cells can only work with concentrator systems [6] Spherical lens systems are shown in Figure 2.

Figure 2. Spherical Lens Systems [6]

4. POLYMER SOLAR CELLS

Polymers are a technology inherent in products such as polystyrene plastic. When heated, the thermoplastic polymer softens and can be converted into semi-finished products such as films and sheets. Polymer solar cells have desirable lighter weight and flexibility properties. However, they require a technical extra process steps and coating technologies. The researchers added a textured substrate model that provides a thin, uniform light-absorbing layer to flexible, lightweight polymers. This textured substrate pattern remains thin in flat-topped protrusions that are less than a millionth of a meter. With this layer, productivity increased by 20 percent [7].

5. ULTRA SHORT PULSE LASER SCRİBİNG

Polymers are a technology inherent in products such as polystyrene plastic. When heated, the thermoplastic polymer softens and can be converted into semi-finished products such as films and sheets. Polymer solar cells have desirable lighter weight and flexibility properties. However, they require a technical extra process steps and coating technologies. The researchers added a textured substrate model that provides a thin, uniform light-absorbing layer to flexible, lightweight polymers. This textured substrate pattern remains thin in flat-topped protrusions that are less than a millionth of a meter. With this layer, productivity increased by 20 percent [8].

6. FDT LİGHT HARVESTİNG FİLM

One of the successful and preferred solar cells is light-harvesting films produced from perovskite materials with the same type of crystal structure as calcium titanium oxide ($CaTiO_3$). Perovskite-based solar cells use expensive hole-carrying materials to move the positive charges created when light hits the perovskite film. Scientists have now made a molecularly engineered hole-carrying material called FDT. By comparison, they claimed that FDT was easy to synthesize and its cost would be almost 1/5 of the available materials."FDT is able to keep the solar cell's efficiency above 20% [8]. The Light Harvesting Film of crystallization and its chemical structures are shown in Figure 3.

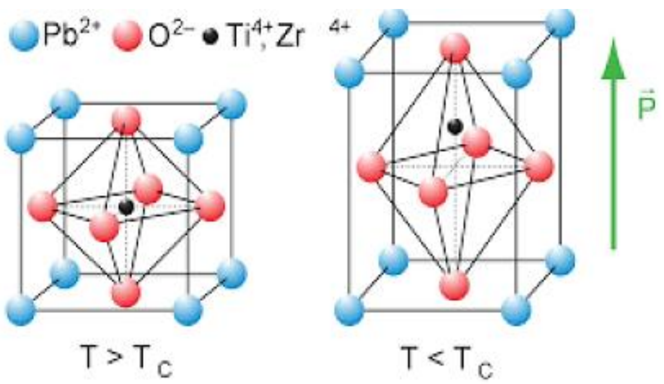

Figure 3. Light Harvesting Film of Crystalling and Chemical Structure [9]

7. TANDEM PEROVSKİTE SİLİCON CELLS

Researchers believe perovskites pave the way for high-efficiency, low-cost solar cells. Perovskites are easily synthesized and absorb light in the blue region of the spectrum, contain silicon that can absorb long wavelength red and near infrared light. Scientists found that a new tandem solar cell containing monolithic perovskite and silicon produced electricity with an efficiency of 18 percent.Although this is not the maximum solar cell efficiency rate, they believe it may be sufficient for industry studies. Many parts of the world have established production facilities for silicon cells. Perovskite layers can significantly increase the productivity level. To achieve this, production techniques need to be supported by only a few production steps FG [10]. The crystal and natural structure of Light Harvesting Film is shown in Figure 4.

Figure 4. Light Harvesting Film of Crystalling and Natural Structure [10]

8. 3D PRİNTED SOLAR ENERGY TREES

Researchers at the VTT Technical Research Center in Finland developed some decorative prototypes thanks to advanced solar and 3D printing technologies and called them "energy harvest trees". Thanks to the small leaves, it can provide power to small household appliances and mobile devices by storing solar energy. Small leaves thrive indoors and outdoors, and can collect kinetic energy from the surrounding wind and temperature differences. The leaves of the tree are flexible organic solar cells and each individually has a power converter. The crates are 3D printed and wood-based bio-composites are used as raw materials. They are mass producible [11]. The crystal and natural structure of Light Harvesting Film is shown in Figure 5.

Figure 5. 3D Produce of Energy Harvesting Trees [11]

9. CERİA FOR SOLAR FUEL PRODUCTİON

Ceria or cerium oxide, which is the most common on earth, tends to exhale and exhale alternately as it warms or cools oxygen. It is considered a tool for generating fuel. A new prototype formulated by the researchers uses a quartz window to pass sunlight through a small gap in a cylinder filled with cerita. When water or carbon dioxide is pumped into the tank, hydrogen and / or carbon monoxide is formed. Hydrogen is used alone in hydrogen cells, and a synthetic fuel (syngas) is produced by mixing hydrogen and carbon monoxide. The resulting fuels are portable and can be used at any time. Researchers believe that improved insulation and smaller openings increase efficiency by up to 19%, making this a viable option [12]. Crystallized and atomic structures are shown in Figure 6.

Figure 6. Crystalling and Atomic Structure for Seria [12]

10. BATTERİES and STORAGE

The biggest problem of generating electricity from renewable sources is that it is not continuous. Photovoltaic cells can generate energy from sunlight. However, in order for this energy to be available at night or in cloudy weather, they must be integrated with some kind of storage mechanism. The users of the energy they obtain with photo voltaic can use it if they need energy when the sun is not shining.

Until now, energy storage batteries have been based on lead-acid chemistry, which is polluting, short-lived and unreliable. Lithium is an alternative to lead as it is the lightest of all metals and has great electrochemical potential. Lithium ions are advanced technology produced in the market. Various battery chemistry studies are close to this technology. Battery storage systems are among the researches that are being conducted all over the world [13].

The aim of all these developments is to produce cheaper, safer storage capacity for renewable resources with longer life and operational capacity [14].

The first period in lithium battery history. The success of lithium iodine battery, lithium potential and somehow clearing the way the development of a capable range of new batteries it was to meet the demands of various, diverse applications. [15]

10.1 Tesla: Lithium İon

Tesla began manufacturing the lithium-ion Powerwall battery at a large factory near a lithium mine in Nevada. Powerwall is a household battery that partners with solar panels to provide the stored power for use at night or during outages. With the battery, a house can achieve net and zero energy ratio, meaning it can generate as much energy as it consumes while connected to the electricity grid during periods of high demand. Each Powerwall has an energy storage capacity of 7 kWh and multiple batteries can be installed together to meet larger energy needs. This capacity can be increased up to 10 kWh [16].

Tesla presented its first demo home system batteries in 2015 and 2016. It also offers a 100 kWh battery for utility scale use. Tesla aims to generate 10,000 Powerpacks and 1Gw of electricity. Tesla CEO stated that with 160 million Powerpacks it will enable the entire USA to transition to renewable energy and with 900 million Powerpacks the whole world will make the transition.The lithium ion powerwall battery is shown in Figure 7 [17].

Figure 7. Lithium-İon Powerwall Battery [16]

10.2 Sonnenbatterie: Lithium İon

Sonnenbatterie, a German company, also entered the US market in 2015. German scientists discovered the lithium-ion Sonnenbatterie in 2015. For their storage systems, Sony Fortelion uses lithium-ion batteries and they claim that they can be used for up to 10,000 charge cycles [18], [19].

10.3 Aquion Energy: Aqueous Sodium İon

Cradle to Cradle Material Health certified The world's first battery works with salt water and other commonly available materials and stores enough solar or wind energy to run a home for eight hours. A dishwasher or small refrigerator size, the Aqueous Hybrid Ion (AHI) battery can be easily placed in grid and micro grid positions. Aquion Energy has full scale production in many countries of the world [16]. The Aqueous Hybrid Ion (AHI) battery is shown in Figure 8 [20].

Figure 8. Aqueous Hybrid Ion (AHI) Battery [20]

10.4 Ambri: Liquid Metal

The Ambri battery has different weights and melting points and allows the two metals to work together by separating them with a layer of salt. Electric currents heat metals to 700^0 Celsius ($1{,}292^0$Fahrenheit), pushing electrons into molten salt. It has been observed that Ambri, which has negative test results, attaches importance to the production of gaskets that keep the liquid electrodes closed and steel boxes that must be sealed airtight with long-life materials. In other words, in the production facility of Ambri, he is still looking for a solution to the sealing problem [21],[22].

10.5 Seeo: Dry Lithium

Seeo, the founder of Silicon Valley, is developing a battery for the electrolyte that uses a solid dry polymer that is less flammable than a liquid one. It uses lithium for the anode and a new material that can store more energy for the cathode in the manufacture of the battery. Seeo has been producing these batteries for testing purposes for some time now. Recently, it was seen that German auto parts manufacturer Bosch bought dry lithium production [18]. The dry lithium battery is shown in Figure 9 [23].

Figure 9. Dry Lithium Battery [23]

10.6 In Research: Lithium-Air

The potential of lithium air is due to the fact that it uses lithium and oxygen, two very mild elements that react to form the lithium peroxide product. In October 2015, the University of Cambridge announced several changes in Science that would start mass production of lithium air cells, but some major transactions are still in progress. The team plans to create a highly porous electrode using sheets of graphene as thick as a single atom. Another modification was to replace lithium peroxide with lithium hydroxide (LiOH) [24].

11. IN RESEARCH: POLYMER BASED REDOX FLOW

The battery developed by German scientists consists of organic polymers and a harmless salt solution. The electrodes of this redox flow battery are made of dissolved form materials. It is not made of solid materials such as metals or metal salts. Electrolyte solutions are stored in two tanks that form the negative and positive terminal of the battery. Polymer solutions are transferred with the help of pumps to an electrochemical cell where the polymers are electrochemically reduced or oxidized, through which the battery is charged or discharged [25].

12. IN RESEARCH: THERMO CHEMİCAL TECHNOLOGY

In solar energy conversion, it uses photovoltaic cells to convert beam energy into electricity. Researchers at the Massachusetts Institute of Technology (MIT) used a method to capture and release solar energy via thermochemical fuel. Thermochemical technology captures solar energy and stores it in the form of heat in its chemical molecules, conserving heat energy to be converted and used later. In fact, the product can be called "rechargeable heat cell". In early experiments, a rare chemical element, ruthenium, was used at a controllable cost. Researchers are examining the exact working mechanism of the ruthenium to find another chemical element more readily found in nature or to synthesize the material in the laboratory [26].

13. WİRELESS SOLAR TRANSMİSSİON

Much greater efficiency in converting sunlight into electricity could be achieved if the energy conversion is done in space, not on earth. Although the field of climate researchers is to determine the parameter values of the energy flow to the earth, it is a fact that about 29% of the solar energy reaching the top of the atmosphere is reflected back into space by clouds and atmospheric particles. Bright ground like sea ice and snow is big in this projection [27].

Therefore, Japanese scientists conducted a successful ground demonstration test for wireless power transmission. They also revealed that long-range wireless power transmission technology is an applicable technology. It will play a role at the center of space-based solar energy (SBSP) systems, which are expected to be among the new technologies. A solar cell orbiting 36,000 kilometers above the earth could potentially generate power, which could then be sent to earth via a microwave without being connected to wires. Researchers think that this new technology could be an effective energy source in solving both environmental and energy problems in the world. Their goal is to transmit energy from solar panels in orbit by 2030 [28], [29]. Space Based Solar Energy Systems (SBSP) are shown in Figure 10.

Figure 10. Space Based Solar Power Systems (SBSP) [29]

The Space Solar Energy Exploration Research and Technology program (SERT) was created by NASA and then aimed to convert sunlight into electricity using an inflatable photovoltaic gossamer structure with condenser lenses or solar heat engines. Included China and India in the NASA Space Solar Program. This collaboration is space collaboration talking about space-based solar energy. China announced that scientists are planning the construction of a solar power plant 36,000 kilometers above the ground. If realized, it will be the largest space project ever [30].

14. CONCENTRATİNG SOLAR POWER (CSP)

Solar power plants use mirrors to collect sunlight and store the collected energy as heat. Many CSP systems, such as natural gas, coal, and nuclear power plants, also require access to water for cooling. All require little water to collect and wash mirror surfaces, but some plants can use wet, dry, and hybrid cooling techniques to maximize water savings. CSP facilities must have access to an electricity grid to distribute the harvested power nnn [26]. In 2016, the largest concentrated solar power (CSP) power plant in the world went into operation.

In Morocco, it is planned that, in addition to hydro and wind, about half of its electricity will be supplied from renewable sources by the end of 2020. It is the location of a complex of four interconnected solar mega-power plants. The project is an important step in the use targets for the country. It makes deserts free from energy. When construction is complete, the plant will have the capacity to generate 580 MW of electricity, enough to power one million homes.

In the first phase, 500,000 parabolic shaped solar mirrors are used in 800 rows with a generation capacity of 160 MW. Each parabolic mirror is 12 meters high and focuses on a steel pipeline that provides heat transfer, a synthetic thermal oil that is heated to 393^{o}C as it bends along the gutter before being wound on a heat engine. There it is mixed with water to create steam that spins energy-generating turbines. The heat tank contains melted sand that can store heat energy for three hours. Morocco imports 94% of its energy as fossil fuel from abroad. Concentrated Solar Power (CSP) facility is shown in Figure 11 [14].

Figure 11. Concentrated Solar Power (CSP) Plant [14]

15. HYDROGEN PRODUCTION and USE

The main technique used in this study is green hydrogen. It is used to denote low-carbon hydrogen produced from renewable energy sources. It is also used to denote blue hydrogen. Low carbon hydrogen produced from non-renewable sources, typically natural gas and coal, brown. He talks about the use of carbon capture and storage technology. In this study, clean hydrogen was used as an element.

It is derived from low carbon hydrogen, green, blue, and nuclear energy. The term hydrogen was not used in majority in this study, but nuclear derived hydrogen has been explicitly mentioned. CO_2-free hydrogen is often used in Japan denotes low carbon hydrogen but it is not included in this study.

The distinction between hydrogen and hydrogen based fuels is discussed in this article. Hydrogen, a form of synthetic fuel, for greater clarity, hydrogen and other synthetic fuels were used separately. The molecular formula of hydrogen is (H_2). Synthetic fuels; It has been used for synthetic fuels other than molecular hydrogen. Power-to-X (PtX) is used for this. In this study, to produce hydrogen and hydrogen-based synthetic fuels, the study has been continued by taking the entire usage process of electricity as a reference [31].

Low carbon investment options; Energy-related CO2 emissions have increased by 1% per year in the last decade. As health shock and oil slump could suppress emissions in 2020, a recovery it would revive the long-term trend.

The Transformation Energy Scenario offers a climate-safe path instead [31].

16. DRILLING THERMAL ENERGY STORAGE APPLICATIONS and ON-SITE THERMAL RESPONSE TEST - THE CASE of TURKEY and THE SITUATION IN TURKEY

Underground thermal energy storage system; (UTES) is reliable, sustainable and energy efficient. Building cooling, heating technology and is used in industrial processes all over the world. In this article, various UTES applications in the last 20 years are mentioned. UTES, a technology for energy storage; used in ground, aquifers or underground pools. Inside, heat waste from solar energy is stored in different ways and is. It is used for heating. A similar method is followed in the cooling process. This method has been applied in many applications. It has been developed within the framework of the International [32].

16.1 History of Thermal Intervention

Thermal conductivity; It is found by the proper dimensioning of the ground and an underground covering an energy well. This system is a thermal energy system. Effective in-situ heat to estimate the conductivity of the system; The thermal response of a well is found by measuring the ground. Field tests are done with a mobile thermal response test (TRT) apparatus (Figure 1) [32].

Figure 12. In-situ TRT apparatus [32]

17. CONCLUSİON

Future energy plans depend on many factors. State leaders, scientists, and energy investors may not always agree on the best route. Low carbon investment options Energy-related CO2 emissions have increased by 1% per year in the last decade. As health shock and oil slump could suppress emissions in 2020, a recovery it would revive the long-term trend. The Transformation Energy Scenario offers a climate-safe route instead [33]. Fossil fuel energy is currently required to implement solar applications, and if the remaining oil and gas resources are not applied to their development, subsequent generations will be fed directly or roughly by sunlight before the industrial revolution. The pioneers whose work is described here will encounter both alternatives of the fossil fuel age. They will be exposed to more primitive means. This article aims to plant a seed of foresight in mind to see beyond the oil age. Technologies currently under development point to a time when there will be cleaner, cheaper and safer ways to generate heat and cooling, provide water, and empower people with more power than humans for daily work. [2], [7].

REFERENCES

[1] International Energy Agency, "Implementing Agreement for a Programme of Research and Development on Energy Conservation through Energy Storage", Strategic Plan 2016 – 2021.

[2] Anonim, SEIA, "The Solar Energy Industries Association", [Çevrimiçi]. Available at: https://www.seia.org/initiatives/about-solar-energy .

[3] M. Mercure, "Photovoltaic (Pv) Cells", 2021. [Çevrimiçi]. Available at: https://solarindustrymag.com/.

[4] Anonim, "PV Cell Research". [Çevrimiçi]. Available at: http://materials.com/.

[5] Anonim, "Photovoltaic", 2017. [Çevrimiçi]. Available at: http://www.renewableenergyfocus.com/category/60/photovoltaics-pv/.

[6] Rawlemon, "Spherical Solar Power Generators", 2019. [Çevrimiçi]. Available at: https://rawlemon.com/spherical-solar-power-generators.

[7] Anonim, "Alternative Energy", [Çevrimiçi]. Available at: https://www.alternative-energy-news.info/best-use-of-polymer-solar-cells/.

[8] E. Venere, "'Ultra fast laser "engraving" Technique to Reduce Costs and Increase the Efficiency of Solar Cells'", 2011. [Çevrimiçi]. Available at: https://www.purdue.edu/.

[9] Anonim, "Solar Cell", [Çevrimiçi]. Available at: https://actu.epfl.ch/news/cheaper-solar-cells-with-202-efficiency/ .

[10] Anonim, "Silikon Solar Cell", [Çevrimiçi]. Available at: https://cleantechnica.com/2015/11/12/tandem-perovskite-silicon-solar-cell-efficiency-record-broken/.

[11] Anonim, "3D Printed Solar Energy Trees", [Çevrimiçi]. Available at: http://www.alternative-energy-news.info/3d-printed-solar-energy-trees/.

[12] Anonim, "Alternative Energy", [Çevrimiçi]. Available at: https://www.alternative-energy-news.info/ceria-mimics-plant-life/.

[13] A. Sherden, "Explained: The tesla powerwall and what it means for Australia's energy market", 2016. [Çevrimiçi]. Available at: https://batteryuniversity.com/.

[14] Anonim, "US agency reaches 'holy grail' of battery storage sought by Elon Musk and Gates", 2016. [Çevrimiçi]. Available at: https://www.theguardian.com/international.

[15] B. Scrosati, "History of Lithium Batteries", Journal of Solid-State Electrochemistry, 15(7-8), 1623-1630, 2011.

[16] Anonim, "Tesla: Lithium İon". [Çevrimiçi]. Available at: https:// www.teslamotors.com

[17] Anonim, "No Title", 2015. [Çevrimiçi]. Available at: https://www.emirates247.com/search7.117?sd&qlithium+ion&author&dr&dfdt .

[18] W. Steel, "Tesla's schröder moving back to sonnenbatterie". [Çevrimiçi]. Available at: https://cleantechnica.com/.

[19] R. Ossenbrink, "Sonnenbatterie begins product development in the USA". [Çevrimiçi]. Available at: https://sunwindenergy.com/.

[20] Anonim, [Çevrimiçi]. Available at: http://www.aquionenergy.com/energy-storage-technology .

[21] Anonim, [Çevrimiçi]. Available at: https://www.bloomberg.com/searchquery=Ambri: liquid-metal

[22] M. LaMonica, “Ambri is better grid battery”, 2013. [Çevrimiçi]. Available at: https://www.technologyreview.com/ .

[23] K. Fehrenbacher, “Why bosch is buying silicon valley battery startup seeo”, 2015. [Çevrimiçi]. Available at: https://fortune.com/.

[24] Anonim, “New breakthrough in lithium-oxygen battery technology”. [Çevrimiçi]. Available at: https://iflscience.com/.

[25] F.-S.-U. Jena, “Synthetic batteries for the energy revolution”, 2015. [Çevrimiçi]. Available at: https://www.sciencedaily.com/.

[26] D. L. Chandler, “Catching The Sun’s Heat”, 2010. [Çevrimiçi]. Available at: http://www.alternative-energy-news.info/ .

[27] Anonim, [Çevrimiçi]. Available at: https://earthobservatory.nasa.gov/features/EnergyBalance/page4.php .

[28] Anonim, “Expanding the potential for new industrial applications”, 2015. [Çevrimiçi]. Available at: https://www.mhi.com/news/1503121879.html .

[29] E. Ackerman, “Japan demoes wireless power transmission for space-based solar farms”, 2015. [Çevrimiçi]. Available at: https://spectrum.ieee.org/energywise/green-tech/solar/japan-demoes-wireless-power-transmission-for-spacebased-solar-farms.

[30] Anonim, “Space solar energy exploration research and technology program (SERT)”. [Çevrimiçi]. Available at: http://www.xinhuanet.com/english/home.htm.

[31] Frontier Economics, Internatıonal Aspects of a Power-to-X Roadmap: A Report Prepared for the World Energy Council, Germany (https://www.frontier-economics.com/media/2642/frontier-int-ptx-roadmap-stc-12-10-18-final-report.pdf), 2018

[32] U. Stritih, D. Rajver, B.Turgut and H. Paksoy, & quot; Borehole thermal energy storage applications and in-situ thermal response test-Example from Turkey and situation in Slovenia", Journal of Mechanical Engineering, 50:6, 328-340, 2004.

[33] IRENA, International Renewable Energy Agency. Global Renewables Outlook: Energy Transformation, Abu Dhabi, 2020-2050.