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REVIEW OF NEW ENERGY SOURCES AND THEIR APPLICATIONS

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Abstract- It is quite obvious that our fossil fuel resources are finite and will be all used in a few decades, and according to Wikipedia circa 87% of the World's total energy consumption in 2015 was proved to be produced by fossil fuels [8], which shows that we are very dependent on fossil fuels, and that is why we should start looking for independent alternative energy sources. Today there are many discussions about what energy sources are going to be used in around 100 years from now. Experts say that it should definitely be a renewable source, so we can continue using it afterwards. Besides being renewable, the source should also be cost-effective, efficient and clean regarding electricity generation. This paper explains some new energy sources, that may be used in the future. These energy sources are tremendously cost-effective, efficient and clean, if the right technology is used to take advantage of them. These new energy sources are solar fuels, hydrogen power, space technologies, algae fuel, piezoelectricity, antimatter annihilation, fusion power and thermoelectricity.

Keywords: Photosynthesis, Combustion, CHP, Electrolysis, Fuel Cell, Microalgae, Annihilation, Seebeck Effect.

I. INTRODUCTION

In This paper we are going to look at these tremendous energy sources, which was explained earlier. First of all, we are going to look at solar fuels in chapter II. In chapter II it is explained how we can capture carbon dioxide from the atmosphere by an artificial tree, combine it with water and using sunlight to convert the compounds into usable chemical fuels and oxygen via photosynthesis. In chapter III, it is explained that how we can produce hydrogen and use it in power plants, e.g. combined heat and power (CHP) stations, or how it can be used to power fuel cells, and how do they work. In chapter IV, the possibilities of space-based energy technologies are explained, majorly space-based photovoltaic solar panels. In chapter V the process of algae fuel production is explained, and what advantages does it have compared to fossil fuels or even other biofuel resources. In chapter VI, the concept of piezoelectricity is explained following some incredible ideas and projects that are not yet commercialized. In chapter VII, the principle of matter-antimatter annihilation is explained, and we are also going to be talking about how to use this method to produce electricity. In chapter VIII, nuclear fusion is explained. In chapter IX, the focus will be on thermoelectricity. We are going to have a special focus on the Seebeck effect. And finally, chapter X concludes on the energy sources, and where we should locate them, so they are more effective and cost-efficient regarding electricity generation.

II. SOLAR FUELS

Solar fuels are fuels produced in the process of converting carbon dioxide, water and sunlight into reusable chemical energy such as glucose, gasoline, methane etc. [1] This process is called photosynthesis, which takes place in plants. The idea is to capture the carbon dioxide from the atmosphere by an artificial plant, and afterwards you can by the help of different chemical reactions and the right system get different combinations

$$6CO_2 + 6H_2O + ATP \rightarrow C_6H_{12}O_6 + 6O_2 \quad (1)$$

$$16CO_2 + 18H_2O + ATP \rightarrow 2C_8H_{18} + 25O_2 \quad (2)$$

$$CO_2 + 2H_2O + ATP \rightarrow CH_4 + 2O_2 \quad (3)$$

Reaction scheme (1) shows the reaction for photosynthesis, where carbon dioxide, water and sunlight (ATP) are converted into glucose (sugar) and oxygen.

Reaction scheme (2) is the reverse reaction for octane combustion, where the same combinations and compounds from the 1st reaction scheme are used, but this time instead of glucose, octane is produced. [3] Gasoline consists mostly of octane.

Reaction scheme (3) is the reverse reaction for methane combustion, where methane gas is produced as the result [9]. The final and resulting combinations can later be used (mainly for electricity generation).

If scientists and researchers could invent a system where the following chemical reactions could function using solar energy (ATP) as a converter, they would be able to convert the sun's energy into a storable chemical fuel, without being dangerous for the environment [1].

There are many different possibilities in this field regarding electricity generation, e.g. thousands of artificial trees could be put together, like a Photovoltaic power station, and could power the power plants nearby including CHP stations by producing the fuel that they rely on.

Technically we are not increasing the amount of emitted carbon dioxide to the atmosphere. Even though the produced fuel itself later is emitted back to the atmosphere

in form of carbon dioxide, but it gets captured again by the help of the explained system. That is why this energy source is both carbon neutral and renewable. This notion has for a long time been a tantalizing target for researchers and scientists, whom have been studying photosynthesis, respiration, combustion, artificial trees etc. [1].

This theory is not quite practical yet, but researchers and scientists at Harvard's Nocera Lab, MIT's Grossman Group and the University of North Carolina's Energy Frontier Research Center have made some researches, experiments and attempts over the past decade in this field [1].

III. HYDROGEN POWER

Hydrogen power is a concept for hydrogen combustion, which is a zero-emission energy source, meaning that it does not emit any waste products which can pollute the environment or cause climate change. The reaction scheme for hydrogen combustion is shown below [4].

$$2H_2 + O_2 \rightarrow 2H_2O + \text{energy} \quad (4)$$

But where can we find hydrogen? Apparently 74% of the universes mass is accounted by hydrogen [2], but on planet earth hydrogen accounts for only 0.75% of earth's crust's mass, and it is only found in combination with carbon, nitrogen and oxygen, e.g. the most important one is H_2O (water), or CH_4 (methane) [5].

By combining these to compounds at high temperature (700-1100 degrees Celsius), a process called "reforming" occurs. The reaction scheme is shown below.

$$CH_4 + H_2O + \text{energy} \rightarrow CO + 3H_2 \quad (5)$$

$$CO + H_2O + \text{energy} \rightarrow CO_2 + H_2 \quad (6)$$

The resulting compounds of reaction scheme (5) are carbon monoxide and the hydrogen gas. The carbon monoxide can then be used to produce more hydrogen gas in lower temperatures (350 degrees Celsius), as shown in reaction scheme (6) [4, 5].

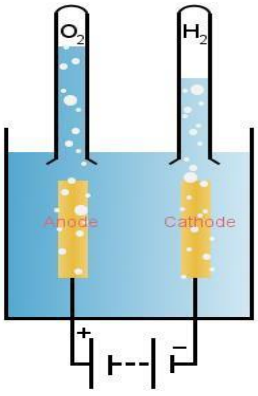

Figure 1. The schematic of the electrolysis process [7]

Besides the steam-methane reformation process, we can use a process called "electrolysis", to separate the hydrogen and oxygen of water from each other, using direct current. The oxygens are absorbed by the positive electrode, and the hydrogens are absorbed by the negative electrode, dividing water into oxygen and hydrogen, which later can be used (Figure 1). Now that we know how to produce hydrogen, let us see how we can take advantage of this great and unique fuel.

As you can observe in Figure 3, a fuel cell consists of an anode, a cathode and an electrolyte, just like a battery, but their functions are totally different [6].

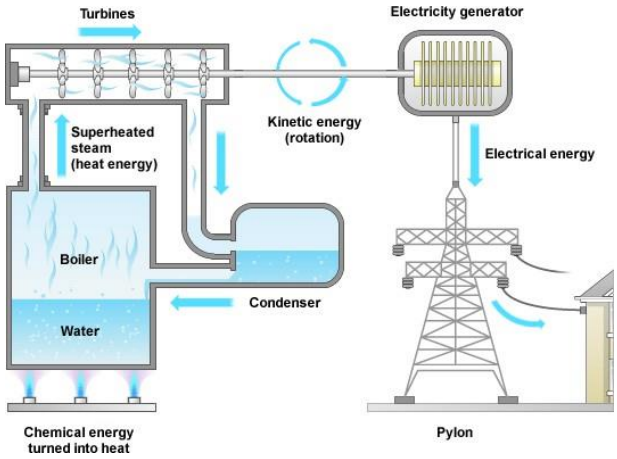

Figure 2. The schematic of a power plant [10]

As it was explained earlier, we can use hydrogen by combining it with oxygen, which produces water and energy. This energy (heat) can be used in e.g. combined heat and power stations, to vaporize the water in the other tank to turn the turbine that is connected to a generators rotor, which in conclusion produces electricity, as shown in Figure 2.

Another way of generating electricity with hydrogen is by using a fuel cell. A fuel cell uses a fuel and an oxidizing agent to produce electricity through some reactions [6].

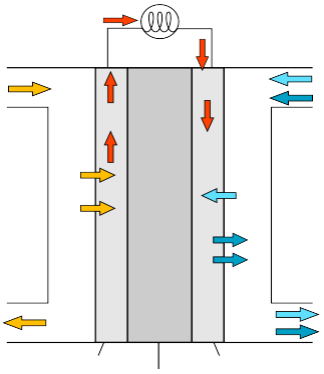

Figure 3. The schematic of a fuel cell [6]

At the anode side of a fuel cell there is a catalyst, which splits the hydrogen molecule (H_2) into two positive hydrogen ions ($2H^+$) and two electrons. This process is called oxidation. The reaction scheme for oxidation is shown below [6].

$$H_2 \rightarrow 2H^+ + 2e^- \quad (7)$$

The electrolyte is specially designed so it is only ions that can pass through it, but the electrons cannot. By creating a way for the electrons to meet the positive charged ions (hydrogens) at the electrode side, e.g. wire, we can take advantage of the electron move, which produces electricity. Once electrons reach the electrode, they reunite with hydrogen ions and oxygen, creating water as shown in reaction scheme 8 [6].

$$4H^+ + 4e^- + O_2 \rightarrow 2H_2O \quad (8)$$

Hydrogen fuel can also be used to power internal combustion engines directly [6]. These technologies are apparently being used by some of the world's biggest automobile companies, such as Tesla, Toyota, Honda and Hyundai [2].

IV. SPACE TECHNOLOGIES

Space-based energy technologies, such as mining hydrogen from our moon for powering the fuel cells here on Earth, or orbiting solar arrays that can absorb direct sunlight from the sun, and beaming the energy back to our stations on the earth via low frequency electromagnetic waves, are still only imaginary and not practical yet [1].

The idea is to capture the sun's energy via photovoltaic panels, converting it to microwaves or radio waves and sending (beaming) it to the stations on the ground, where later it can be converted to electric energy again.

This notion has been tested by the Japan Aerospace Exploration Agency (JAXA) in 2015, where they had successfully converted 1.8 kilowatts of electricity into microwaves and beamed it to a distance of 50 meters, which in conclusion proves the viability of the earlier explained concept [2].

Besides JAXA, other organizations such as NASA, the U.S. Naval Research Lab and Solaren have afterwards invested a lot of money in the technology. The technology is not quite ready yet, but could be commercialized in about 20 years from now [1].

V. ALGAE FUEL

Algae fuel is a relatively new energy source, that uses the oil from mono-cellular microalgae, which can be very easier to produce and stronger than other biofuel sources such as corn and sugarcane [11].

But how is Algae fuel produced? The process is started by multiplying the algae by feeding them carbon dioxide, nitrogen, sunlight, water etc. Then the Algae are pulled out, and later dried out. The dried algae are easier to control, and by stressing and feeding them in certain ways, they produce oil and other beneficial products. The algae themselves can later be used for many purposes, such as food consumption [12].

The oil can be used to produce different biofuels such as Biodiesel, bio-butanol, jet fuel, methane, bio-gasoline, ethanol, green diesel etc. [11]. Algae fuel has many advantages regarding electricity generation, e.g. it can be produced and grown very fast and quickly using nitrogen from the wastewater. furthermore, algae combustion releases only carbon dioxide, whereas fossil fuels produce also other compounds including Sulfate (SO_4) during their combustion process, which can lead to acid rain.

Since algae is a plant, it captures carbon dioxide from the atmosphere and converts it into oxygen in the process of photosynthesis, thus it does not increase the rate of the emitted carbon dioxide to the atmosphere after combustion, and therefore algae fuel is also a zero-emission fuel source [11].

The Algae fuel has made progress and developments in recent decades, but companies such as Global Algae Innovations, can still not make enough Algae fuel to compete with giant oil and gas industry companies [12].

VI. PIEZOELECTRICITY

Piezoelectricity is a concept for the electric charge created when a special solid matter is physically stressed. This means that when a piezoelectric material is physically put under pressure or stretched, a voltage is created. The piezoelectric material can be crystals, special ceramics, bones, DNA and some proteins [13].

There are many potentials in this field when it comes to electricity generation, e.g. there could be a piezoelectric material instead of your shoe sole, and for charging your phone, you could go outdoors and exercise. That way you both generate electricity and live a happy and healthy life.

Another way to generate electricity via piezoelectricity could be to implant piezoelectric material on the highways, so the cars and trucks drive on it, and in conclusion produce electricity.

VII. ANTIMATTER ANNIHILATION

Antimatter is the opposite of matter. This means that instead of quarks, antimatter has antiquarks, and instead of electrons, it has positrons. When matter and antimatter collide, a big amount of energy is released, aka. matter-antimatter Annihilation. This energy could someday be harnessed and used for electricity generation with help of e.g. CHP stations etc.

Besides electricity generation, this principle can also be used for medical treatment purposes etc. Although the process of making antimatter costs 1 billion times more to produce than harness [14].

According to Paul Dirac after the big bang the same amount of matter and antimatter were created, which annihilated with each other right away. But the question is that why we have more matter today and almost no antimatter. There are many theories regarding this subject. One of the well-known theories is that there might be a parallel universe of anti-matter. If this theory was true, if we somehow could in the future discover something like this, it would be a revolutionary energy source that would power the world till eternity.

This energy source is quite theoretical and may not be put into practice in more than a millennium.

CERN (European Organization for Nuclear Research) has been doing several successful researches regarding this subject, but nothing regarding electricity generation using the principle [14].

VIII. FUSION POWER

Fusion power refers to the power generated (released) when two lighter nuclei fuse together to form a heavier nucleus, plus some other non-important products, such as an extra neutron.

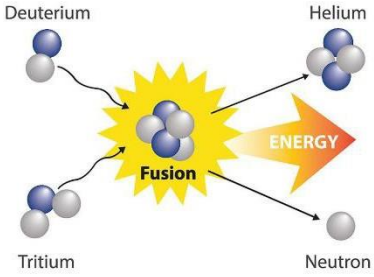

Figure 4. The process of fusion reaction [15]

The best-known fusion reaction is occurred by two of hydrogen's heaviest isotopes (Figure 4). To be precise, Deuterium and Tritium. This process takes place in the sun. A very high temperature and a very high pressure is needed for this process to take place.

Deuterium is abundantly found in seawater, while Tritium is harder to find. An alternative for Tritium might be Helium-3. Helium-3 can be found on the moon's surface, and probably we could mine it in the near future to power fusion reactors here on earth [16].

Some few private energy companies, such as Oxfordshire-based Tokamak Energy are working on some spherical tokamaks. They use high temperature superconductors aka. HTS, to contain plasma in a tremendously strong magnetic field inside the tokamak. This company has until today built three tokamaks. the third one has been able to reach plasma temperatures of over 15 million degrees Celsius, which is even hotter than the core of the sun [15].

Besides the mentioned company, MIT (Massachusetts Institute of Technology) has also begun experimenting with tokamaks. They use pretty much the same principles, but instead of spherical tokamaks, MIT uses doughnut-shaped tokamaks [15]. These new technologies can still not yet be used for industrialized electricity generation purposes but may be in the future.

IX. THERMOELECTRICITY

The concept of thermoelectricity refers to the Seebeck, Peltier and Thomson effects. We will only be talking about the Seebeck effect.

In 1822 Thomas Johann Seebeck discovered that a circuit made of two junctions at different temperatures connected by two dissimilar metals e.g. iron and copper would deflect a compass magnet, thus proving that there is an electric current flowing through out the circuit [17].

The relation between the produced emf (electromotive force), the temperature difference and the junction's material can be described as in Equation (9) [17].

$$V = a\Delta T \tag{9}$$

where, V refers to the produced emf across the terminals of the circuit, a is a proportionality constant called the Seebeck coefficient, which indicates how much voltage a junction can deliver relative to its temperature, which depends on the material the junction is made of. The Seebeck coefficient is measured in volts per kelvin (V/K) according to the International System of Units (SI). And finally, ΔT refers to the temperature difference between the two Junctions ($T_{High} - T_{Low}$) [16, 17].

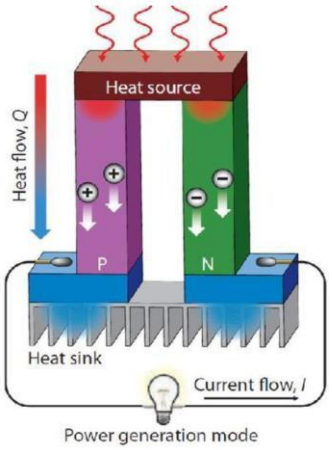

Figure 5. Harnessing energy from the Seebeck effect [19]

Figure 5 demonstrates a possible way to harness the emf produced by the junctions. In real life there would be unlimited possibilities around this field. A possibility could be to use equator and south pole as junctions and somehow connect them using iron and copper, which are not that expensive metals compared to Silver etc. As said, there are many possibilities, but unfortunately, we have not yet started using this principle to produce electricity at a big scale.

X. CONCLUSION

Some of these new energy sources have not been commercialized yet but may be in a couple of decades. These energy sources are alternatives to some of today's finite energy sources, such as fossil fuels. Each of the sources is better used in its own geographical location, e.g. solar fuels are more effective in palaces with a lot of sunlight, a place located on the equator, somewhere like the continent Africa. Hydrogen power is better used somewhere where it can get supplied both with water and methane. Since 50-60% of all incoming solar light does not make it through the atmosphere layer [2], solar panels are more effective when located outside the atmosphere layer. Algae are grown somewhere with water, nitrogen, carbon dioxide and sunlight supplement. Piezoelectric material is better used when heavy objects press on it, a place like a highway. To cause matter-antimatter annihilation, we first need to produce antimatter in e.g. CERN in Switzerland. To run a fusion reaction, we need Deuterium and Tritium. As explained in chapter VIII, Deuterium is abundant in seawater, while Helium-3, which is an alternative for Tritium, can be found on the moon's surface. Thermoelectricity needs a high temperature junction and a low temperature junction. For this purpose, equator and south pole could be used as source junctions. So, these sources can cover the world and power our energy consumption and help with climate issues that we apparently have here on our planet earth.

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BIOGRAPHY

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