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Japan, Renewable Energy

Catalyzing Tomorrow's Future

Abstract

As newer technologies develop and populations grow, the demand for energy rises. However, our historical reliance on fossil fuels has left an uncertain future. As global petroleum reserves dwindle and gas prices rise, the world needs renewable energy sources. Nonetheless, some of the most popular renewable energy sources such as wind, solar, and hydroelectric are region-specific and not necessarily available everywhere or throughout the year. Biofuels are a renewable energy source whose only condition is farmland. Biofuels could change the pace of development for countries globally and liberate countries from their fossil fuel dependence.

Introduction

The growing demand for efficient and plentiful resources has left corporations and governments scrambling. In the wake of the astonishing rate of development and innovation, renewable energy has been at the forefront of environmental discussion. The issue has transcended into the education system and has even made its debut in politics. Developed countries such as Japan are attempting to spearhead the initiative for a cleaner future but appear to struggle in abandoning their historical reliance on fossil fuels.

Located off the coast of the Korean peninsula in the North Pacific Ocean lies the Japanese archipelago. Japan consists of 6,852 islands with a population of 124.69 million people. Japan is the 63rd largest country on earth by area and the 11th largest country by population (CIA World Factbook, 2021). Japan is well known for its cleanliness and a strong economy. The Japanese economy is the fourth largest national economy in the world (Amadeo, 2021).

The typical Japanese household follows the nuclear family model (Cultural Atlas). The average birth rate in Japan is 1.4, which is not unusual for its development status. The immediate family keeps close relations with the extended family. It is common in Japan for paternal grandparents to live with their children. However, as living spaces in Japan decrease in size, family size is getting smaller. The Japanese workforce was once entirely dominated by men. It was taboo for women to work. However, with a rise in gender equality, more women are involved in the Japanese workforce. Nonetheless, males make up the majority of the workforce.

In recent years, Japan has found itself reliant on other countries for its energy needs. Crude oil and petroleum gas are Japan's largest imports (Observatory of Economic Complexity, 2021). These imports are indicative of the Japanese dependency on fossil fuels for energy. In 2016, fossil energy accounted for 89% of Japanese energy consumption (Zhihai, 2019). This dependency on petroleum imports makes Japan increasingly vulnerable to energy crises and has correlated with a rise in energy costs for both corporations and households (Zhihai, 2019).

Japan had planned to reduce its reliance on coal by more than 50% in the coming decade, but instead, it has increased (Lonsdorf, 2020). Japan has also implemented new coal operations that threaten the world goal to eliminate new carbon emissions by 2050. Due to the limited supply of fossil fuels, the economic burden of importing fossil fuels will only get worse over time. The limited supply puts Japan in an incredibly vulnerable position. In many ways, it forecasts an unstable future concerning energy.

The reliance on fossil fuels does not end with its economic pitfalls. Farming systems globally, including Japan, are heavily reliant on fossil fuels (Church, 2005). Farms, especially in developed countries, rely on fossil fuels to operate machinery, and the process from seed to table undergoes many instances where crude oil is used. Once again, Japan finds itself in a vulnerable position. Petroleum and gas prices will rise, this will result in a rise in production costs of crops. Energy security translates to food security. The rise in production costs of crops threatens the food security of Japan. Japan already imports food from foreign countries. In time Japan will find itself unable to afford oil imports, imports of foods, and its people will be unable to afford the rising energy costs and oil prices.

Biofuel Method

To lessen the effects or possibly even neutralize the effects of an energy crisis in the future, Japan will need to begin implementing renewable energy. One promising alternative to fossil fuels is biofuels. A fuel cell works like a battery, except it does not require charging. As long as fuel is being supplied, a fuel cell can generate electricity or heat. A biofuel cell utilizes biomass as the source of fuel. Biofuel cells can be categorized into different types: enzymatic biofuel cells, microbial biofuel cells, microbial electrolysis cells, and biodiesel.

Enzymatic Biofuel Cell

An enzymatic biofuel cell is a fuel cell that uses enzymes to catalyze the fuel cell process instead of traditional metals. Enzymes can be produced relatively easily and at an affordable price. In an enzymatic biofuel cell, a fuel, in most cases glucose, oxidizes in the anode. The glucose oxidation process is catalyzed by enzymes. This reaction releases electrons that enter the cathode side through a circuit. In the cathode, oxygen is reduced, producing electricity.

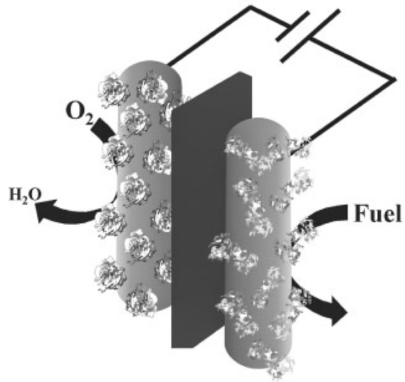


Figure 2. Schematic representation of an enzymatic biofuel cell.

Currently, EFCs, enzymatic fuel cells, can only be applied to medical devices and smaller items. These include pacemakers, watches, and even phones. The issue with enzymatic biofuels is that their electricity production is lower than other alternatives.

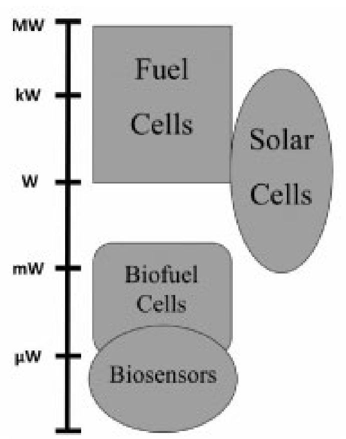


Figure 3. Schematic representation of the power range that some of the alternative energy production methods provide (adapted from reference 8)

However, its use in pacemakers and other medical devices could cause a societal acceptance towards biofuels. Its implementation into smaller devices could promote its research and development as well. While its electricity output is low currently, EFCs still are cheap, plentiful, and can be produced to meet demand (De Valle). Even if it is on a smaller scale, the use of EFCs still has a positive impact. If Japan invests in research and development of EFCs through government funded initiatives, we could overcome its present issue and make it approachable for large-scale electricity production.

Microbial Biofuel Cell

Microbial biofuel cells are a subcategory of biofuel cells. MFCs, microbial fuel cells, are arguably the biofuel cell that requires the most development currently. However, that does not change its possible potency and use in the future. An appealing aspect of MFCs is their application in water treatment centers. MFCs work by having microorganisms utilize the wastewater and oxidize it. This process generates electricity while simultaneously treating wastewater.

The electricity that MFCs generate can offset the energy costs of operating the plant (Alternative Energy). The Israeli company, Emefcy, claims to cut sludge down by 80% in their wastewater treatment processes by utilizing MFCs (Alternative Energy). While in need of more development, the microbial fuel cell has shown promise in its real-world application.

The government of Japan and globally could pursue more research and development into MFCs. Japan has already been attempting to make the switch to renewable energy. Japan has implemented government plans and goals to mitigate carbon emissions and adopt cleaner energy. By putting more money and resources into MFCs, their application and potency could skyrocket and ultimately help Japan achieve its energy goals.

The development of MFCs will not merely assist in energy production. The waste management company Cambrian Innovations uses MFCs in tandem with a separate set of electrodes to generate methane gas from wastewater. The methane gas can be stored and used later to create heat or energy. Microbial fuel cells can also function as biosensors. The biosensors can measure the biochemical oxygen demand value of water bodies. The Naval Research Laboratory has utilized MFCs in powering low-load devices. The uses of MFCs extend beyond generating electricity and adds another reason why its research can be beneficial.

Microbial Electrolysis Cell

Hydrogen is a promising energy source for the future. Hydrogen has three times more caloricity[1] than petrol while having no corrosive effect on the metals (Chorbadzhiyska et al., 2011). With the use of electrolysis[2], hydrogen production could prove beneficial in the fight against climate change. Dries Acke, head of the energy program at the European Climate Foundation, states, "Hydrogen is essential to get to net zero in certain sectors like industry, but we are talking about the last 20% of emission reductions." The current issue with producing hydrogen is its dependence on a large amount of electricity. However, microbial electrolysis cells could be a solution to this problem.

As stated previously, the microbial electrolysis cell is beneficial for reducing carbon emissions and can allow for the same hydrogen production with a smaller toll on electricity consumption. A MEC, a microbial electrolysis cell, uses electrochemically active microbes, which grow on the anode, to break down organic matter into carbon dioxide. The breakdown continues until we can split the CO_2 into electrons and protons. The electrons and protons pass through the external electric circuit and combine at the cathode to create hydrogen.

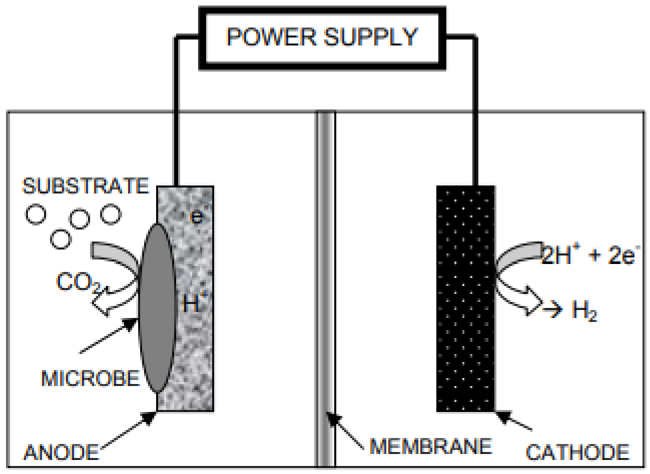


Fig.1: The working principle of a microbial electrolysis cell

Recent development and research into better microbial cultures and microbial biofilm have made this process more efficient.

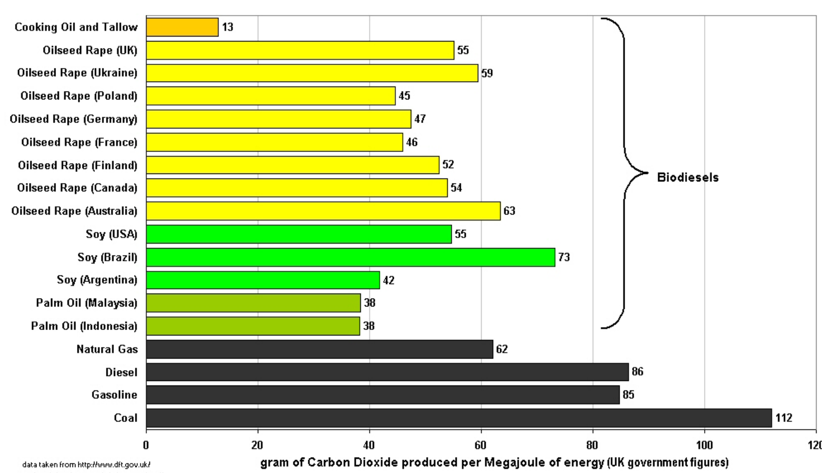
Another benefit of MECs is their ability to provide energy globally. Professor of future energy systems at the Delft University of Technology in the Netherlands, Ad van Wijk states, “A solar panel in the Sahara generates 2–3 times as much power as one in the Netherlands. If you convert that power to hydrogen, transport it here and turn it back into power via a fuel cell, you are left with more energy than if you install that solar panel on a Dutch roof. In a sustainable energy system, you calculate in terms of system costs, not efficiency," (Renssen, 2020).

In 2017, Japan implemented the “Basic Hydrogen Strategy” with the sole purpose of lowering carbon emissions and using hydrogen to achieve this goal (Chaube et al, 2020). The "Basic Hydrogen Strategy" is a step in implementing hydrogen energy and MEC usage. Currently, the hydrogen market in Japan is not economically viable (Makino, 2020). Makino explains that almost all hydrogen and fuel cell technologies are dependent on public funding (2020). To combat this, Japan needs to make hydrogen production a global effort and a more attractive alternative. Japan will need to cooperate with countries involved in hydrogen projects like Brunei, Norway, Saudi Arabia, and Australia, to name a few. Through international cooperation, these countries could create a hydrogen market globally which would increase its appeal to other countries and Japanese people alike. Motor companies such as Toyota have begun the production of fuel cell vehicles that utilize hydrogen. The Fuji Keizai study showed that by 2030, the use of fuel cell vehicles will increase to 636,900 in Japan (Makino, 2020). These include cars, buses, and forklifts. The study is an example of how increased public exposure of hydrogen production to consumers and companies can increase viability.

To fulfill its 2017 goal, Japan will need to appeal to other countries to increase the production of hydrogen to create a hydrogen market. Global demand for hydrogen at the corporate level will allow Japan to meet its goal and in the long term, provide energy and economic security to Japan.

Biodiesel

Biodiesel is an alternative to crude oil diesel. Biodiesel is a renewable, biodegradable fuel manufactured domestically from vegetable oils, animal fats, or recycled restaurant grease (U.S. Department of Energy). Biodiesel is appealing because it is independent of the limited petroleum reserves while having a smaller environmental impact. B100, 100 percent biodiesel, eliminates all sulfur emissions associated with traditional diesel, cuts emissions of carbon monoxide and smog-producing particulate matter almost in half, and reduces hydrocarbon emissions by 75 to 90 percent (Green America). Even biodiesel with some levels of petroleum sees a reduction of carbon emissions. B20, which is 20 percent biomass-based and 80 percent petroleum-based, reduces carbon emission by 15 percent (Green America). Theoretically, biodiesel production is almost net-zero carbon emissions. The carbon dioxide absorbed by the plants used to develop biodiesel is almost equivalent to the amount released from biodiesel usage.



A drawback of biodiesel is that it requires the cultivation of crops to create energy. The land requirement could put some farmers in a position to decide whether to cultivate for consumption or energy production. However, as Laura Golsteijn explains, “To increase biofuel production while preventing food shortages and deforestation for food production, agricultural practices need to be intensified in a sustainable way. There are many areas where the yield per hectare can be enhanced, sometimes even doubled. The benefits are not only a reduction in land occupation but also a reduction in greenhouse gases per produced amount of food" (Golsteijn, 2016). Another possible solution to the land requirement needed to cultivate biomass is growing the biomass in water. Farming algae for energy production could reduce the pressure on the farmland.

Traditional diesel already provided 20 to 40 percent better fuel economy than gasoline (Sayaloune, 2020). Biodiesel can provide the same fuel economy while reducing carbon emissions. Biodiesel is also accessible to any country with the technology. With biodiesel being accessible to a large number of countries, it removes the dependency on a few countries for energy.

Developing countries will benefit the most from biodiesel production. Many developing countries are limited in the development of their farming methods. The limitation is due to the high costs of petroleum for farm equipment and the unequal opportunity for petroleum extraction. By increasing biodiesel usage, their farming techniques and efficiency would develop. The development of the farmers in developing countries will assist in mitigating the burden on the land required for biomass production. These farmers would be producing more biodiesel, which the farmers can utilize themselves, or sell, and produce crops for consumption simultaneously. The access to more developed practices will also discourage slash and burn farming, which is known for releasing a large number of carbon emissions.

Japan has already started to mass-produce biodiesel for jet fuel. Euglena, a Japanese biotechnology company, can produce 125 kiloliters of bio-jet fuel and biodiesel per year, and it plans to raise the production capacity to 250,000 kiloliters by 2025 (Okutsu, 2018). Biodiesel prices are expected to drop from the current 10,000 yen per liter to 100 yen by 2025. The price decrease will put the price of biodiesel closer to the current price of petroleum-based jet fuel at about 70 yen (Okutsu, 2018). The reduction in the price of biodiesel allows for easier integration at the consumer level.

Japan can promote the use of biodiesel by creating a government program dedicated to its adoption. This program would provide financial incentives to corporations that use or develop biodiesel or any other biofuel forementioned. The program will not be challenging to initialize as Japan has made strides to pursue renewable energy sources. By increasing the supply of biodiesel, its application will spread in a variety of fields. If real-world application grows, its price will decrease to that of petroleum as petroleum prices rise and biodiesel production grows. In doing so Japan will develop from biodiesel exportation. By creating the market and raising the demand, Japan could integrate biodiesel into everyday life.

Conclusion

Holistically, the energy revolution of the future does not need to start with Japan. Japan historically has found itself dependent on fossil fuels, but their recent initiatives to rescind that practice make Japan more likely to adopt new practices. Japan has access to ports and holds strong economic prowess in East Asia and the globe. The reasoning behind Japan being the country in question is its viability to diffuse biofuel technology and biofuels themselves.

The energy debate is not limited to a few countries, it challenges humanity as a whole. Biofuels and biofuel cells are the future. With the assistance of developed countries, such as Japan, its benefits can develop and diffuse to areas throughout the earth. The enzymatic and microbial biofuel cells show great promise and are currently viable in wastewater treatment plants and medical devices. Microbial electrolysis cells could be the bridge connecting us to a hydrogen-powered society. Biodiesel possesses the ability to be produced anywhere in the world where crop cultivation can occur, making it an appealing prospect for developing countries.

The world needs a global effort led by economically powerful and influential nations to relieve our dependency on fossil fuels and open up economic opportunities to the underdeveloped. Biofuels provide more than just energy. Biofuels have the potential to catalyze the process of development and introduce new technologies to these nations.

Biofuels could be the breakthrough in the fight against climate and secure energy security. The development of biofuels, especially biodiesel, could generate food security for millions of people. Energy security is food security, and by establishing a secure system of energy production, transportation, and supply, we can develop our farming methods to ensure food for ourselves now and food for future generations. Biofuels are not only catalyzing energy production but can catalyze human development.

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Caloricity[1]: Physiological ability to develop and maintain heat
Electrolysis[2]: chemical decomposition produced by passing an electric current through a liquid or solution containing ions.

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