Sustainable Clean Energy and Hawai'i's Movement Away from Fossil Fuel Reliance

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Abstract

This paper examines the various sources of sustainable, renewable, and clean energy as well as the methods of capturing that energy. It explores the importance of sustainable energy, its limitations, and its concerns.

Keywords: sustainable, renewable, clean energy, solar power, wind power, hydropower, tidal stream, barrage, tidal lagoons, wave energy, geothermal energy

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Due to the dwindling resource known as fossil fuels and its growing processing costs, there is a developing movement towards clean and sustainable energy sourcing. Hawai'i is the first state in the US to declare a 100 percent renewable energy standard by no later than 2045. It is currently being called the most aggressive clean energy goal in the nation (Mellino, 2015). Due to initiatives like the Hawai'i commitment to clean power, it is increasingly evident that our community is moving towards a more reliable, brighter tomorrow. Hawai'i holds eleven of the thirteen climate zones and is, therefore, the perfect example for utilization of naturally occurring sources of energy.

The question must first be asked, what is sustainable energy? Sustainable energy comes from a non-exhaustible source and meets present needs, while also not taking away from future generation's power sources. Fossil fuels are limited and continued use of this resource at the current rate will be more environmentally destructive than before as supplies are depleted and methods like fracking and oil fields are explored to meet the demand. A renewable energy is a naturally occurring system that exerts energy, which then is replenished on a human timescale. Environmentally, fossil fuels are poisonous to wildlife and vegetation and their byproducts are equally an irreversible footprint on our waste stream. This brings along the alternative idea: clean energy, which ideally is a gathering of energy that does not negatively impact lifeforms on Earth. The current options for clean, renewable, and sustainable energy list the following systematic energy systems: solar, wind, hydropower, geothermal heat, and organic vegetation.

Solar Power

Primarily, the sustainable energy source that is taking to the roofs of houses all over the Hawaiian Islands, are photovoltaic systems. Additionally, there are many different ways to harness the power of the sun besides using solar panels for electricity. Solar systems, using black colored piping containing water, have become a popular way to naturally heat the water needed in a typical household. Of course, if the sun fails to penetrate the clouds, solar systems are not provided the necessary energy to function. Most Hawai'i households install rooftop solar panels as a cheaper alternative to shareholder-owned utility costs. Furthermore, Hawai'i has a weather pattern that highly supports solar energy harvesting. However, solar is just one of several sustainable energy sources.

Wind Power

Wind is claimed to be the most viable alternative source of energy, and on some Hawaiian Islands, it is available 40 percent of the time, which is among the best in the nation (Mellino, 2015). The most common translation from wind to electricity comes in the form of a large wind turbine, which is much like a windmill. Wind turbines are surprisingly quiet and have little impact on birds and other aviary wildlife when compared with conventional fuels that pollute the air and water. This electricity generation is non-polluting and also does not consume water, unlike some other forms of this same generation. Currently, wind turbines are typically used for pumping water and powering communication grids; however, a higher utilization of wind energy could considerably lower fossil-fuel-generated energy consumption. Farmland can be limited, and only so much land can be devoted to wind turbine energy generation; therefore, even further expansion of other sources is necessary to meet the energy consumption demands of current cities.

Hydropower

The ocean is considered a renewable resource because of the endless cycle that water undergoes on the planet. The ocean is a source of both thermal and kinetic energy. Although it is difficult to develop technology that can convert the ocean's energy into electricity, the energy contained in the ocean can still be utilized. Cool deep-sea water has been experimented with in order to replace the traditional energy usage for air conditioning. Makai Ocean Engineering, Inc. has been contracted by the Office of Naval Research (ONR) to develop and research seawater air conditioning. This method uses deep sea water pumped to a cooling station, and then to the building needing to be cooled. Using this method, the desired cooling of air can be achieved using only one-tenth of the energy used in traditional air conditioning (Makai Ocean Engineering, 2015). This method of renewable energy is best for ensuring an energy efficiency much greater than current methods.

Using the Tides for Energy

Kinetically, scientists have attempted to develop technologies that are essentially wind turbines that use

water currents instead of wind currents. There are three common ways of harnessing the energy of ocean tides: tidal streams, barrages, and tidal lagoons.

Tidal Stream. A tidal stream is a fast-flowing path of water, and the method of energy production places turbines that resemble windmills underwater and rely on the movement of water to turn the blades. This method is difficult because the turbines often disrupt the very flow of water to be harnessed. However, the turbine blades move very slowly, allowing marine life to avoid getting caught in the system. The first tidal stream system in the world was constructed in Northern Ireland at Strangford Lough, where the tides move at speeds of four meters per second (National Geographic, 2011).

Barrage. The barrage is a large dam that generates tidal energy using the same methods as a dam. The method utilizes flowing water with a barrage then allows small openings in the obstruction through which water can flow, while simultaneously turning installed turbines. The environmental impact of this method can be huge. The water being kept from flowing will no longer support the organisms that exist in the lagoon area and will most likely be disrupted to the point of population loss. The fish are trapped and can be caught in the quickly moving turbines. Additionally, birds may choose to migrate because of dwindling food sources. Despite zero fuel costs, a barrage is much more expensive compared to a single turbine and requires heavy machinery for construction as well as consistent supervision to monitor power output levels (National Geographic, 2011).

Tidal Lagoon. A tidal lagoon is a body of water that is enclosed by natural coastline barriers or by man-made barriers. The method of capturing this energy is much like a barrage in the way turbines are turned using the filling and emptying flows of the lagoon. Unlike a barrage, however, the barrier can be built along or using the naturally exiting coastline. The environmental impact of a tidal lagoon system is surprisingly low. Marine animals could swim around the structure, which could be built with materials like rock. Sharks would be unable to penetrate into the lagoon, so fish would likely thrive, causing birds to migrate to the area. Consequently, the power generation would likely be low because the tides rise and fall only twice a day. Currently, there are no functioning examples of a tidal lagoon system; however, China is constructing a tidal power plant located at the Yalu River near the border of North Korea (National Geographic, 2011).

Capturing Wave Energy. In the basic construction of the system, a lifted bowl-like structure is built. Then, a connected ramp is faced toward the waves of the ocean. The shape of the ramp is like a wide-open mouth, which narrows in an uphill fashion. The narrowing of the ramp propels the momentum of the water up the ramp and into the bowl-like structure. From there, the water can be led by gravity back into the ocean through a turbine generator (Lawson, 2005).

Historical Tidal Power. River water has been utilized in history with large wheels being spun by flowing water, producing kinetic energy that can be connected to machines for various uses. Greek engineers used this method more than 2,000 years ago in order to grind wheat into flour. Additionally, in 1880, water turbines were used to run a dynamo for the purpose of producing arc lighting. Arc lighting is a light source created by a consistently running spark between two conductors. This method provided street lighting at Niagara Falls, New York, with direct current electricity (Office of Energy Efficiency & Renewable Energy, 2016).

Water energy is sometimes difficult to harness when compared with our current fossil fuel model due to the availability of technology. If the technology used to harness water energy was cheap enough to produce and advanced enough to be efficient across different parts of the world, then perhaps water energy would be a more attractive alternative to fossil fuels.

Geothermal

Geothermal energy is an almost household term in Hawai'i when referring to renewable or clean energy available due to the volcanic nature of the Hawaiian Islands. Steam that naturally occurs from the molten lava under the earth can be used to run generators that create electric power. The heat from the depths of the land can be diverted to households in order to provide warmth.

Geothermal Power Plants

One method of geothermal energy extraction is called the hot dry rock method. Deep in the earth's crust, at least two holes must be bored. Then, water is fed down at high pressures to the super-heated rock and is received through the other bored channel in the form of steam, which can then be used to run a generator. Another geothermal energy retrieval method is done by tapping into a naturally occurring steam vent and using the pressures to operate a generator (Lawson, 2005).

Dry steam power plant. A dry steam power plant uses steam as its primary fluid and generally transports naturally occurring steam to a turbine, which runs an electricity-producing generator. The steam power eliminates the need for fossil fuels as the means of turning the turbine and effectively removes the need for fuel storage/transportation. The Geysers in Northern California is the largest single source dry steam power plant still in operation (Office of Energy Efficiency & Renewable Energy, 2016).

Flash steam power plant. The flash steam power plant is the most common type of geothermal power generation plant in operation to this day. This method involves pumping water down to a level where the surroundings are naturally heated by the earth. Then, using high-pressure rates, the water is pumped back up into a low-pressure tank. The rapid change in pressure causes a sudden vaporization of most of the water, hence the term "flash." The vapor is then used to drive a turbine which runs an electrical generator. If any liquid

remains in the tank, it can be "flashed" again to extract the maximum amount of energy (Office of Energy Efficiency & Renewable Energy, 2016).

Binary cycle power plant. A binary cycle method is much like the other two general methods of power generation, but different in the following way: the water/steam never comes in direct contact with the turbine generator. The moderately geothermally heated water (below 400°F) is pumped into a heat exchanger, where the heat is transferred to a liquid with a much lower boiling point than water. That liquid "flashes" at a lower temperature and becomes vaporized by the heat from the water, running the turbine, which drives the electrical generator. The "binary" term refers to the two different liquids used in this geothermal system. This method is a closed loop system, where virtually nothing other than water vapor is emitted into the atmosphere. Because most geothermal resource locations are typically below 300°F, this method is very viable and will most likely be the system utilized in future geothermal power generation plants (Office of Energy Efficiency & Renewable Energy, 2016).

Concerns and Limitations

The limitations and problems associated with some of these sources of renewable energy are seemingly inevitable but must be taken into consideration when contemplating this type of energy.

Biomass. With biomass, the crops that are grown for energy and fuels take the growing space that could be used for food crops. When the biomass is used to generate electricity by being burned, like any combustion, carbon dioxide, and other pollutants are released upon ignition. Despite the ability to harness energy from plant combustion, further study is needed on the balance of water usage, air pollutants, and ecosystem damage before biomass can be considered a sustainable energy source (Union of Concerned Scientists, 2015).

Hydropower. When looking at hydroelectric renewable energy plans, flooding and drought are important factors contributing to the success or failure of energy generation. Additionally, natural landscapes can essentially be hurt or even ruined upon the expensive initiation of a hydroelectric power plant on a stream or waterfall (Lawson, 2005). Therefore, the benefits of certain renewables must be balanced against the drawbacks in order to be truly sustainable into the future.

Hawai'i's Energy Antithesis

The realization of Hawai'i's progress toward 100 percent clean energy is most evident on the island of Kauai. The Kauai Island Utility Cooperative (KIUC) has recently completed a 12 megawatt, $54 million, 60-acre solar array consisting of more than 59,000 solar panels. KIUC claims they will replace 1.7 million gallons of imported oil a year with the facility and will generate 20 percent of Kauai's daytime needs. By the end of 2015, 37 percent of the electricity generated on Kauai will come from sustainable energy sources (D'Angelo, 2015).

Conclusion and Realization

The quest for clean, renewable, and sustainable energy seems conceptually simple. The challenge comes from the inability to have power when none of the sources are currently generating power. In other words, the real difficulty is perfecting the systems of power storage. There are two types of efficient energy storage: kinetic and chemical. To realize non-polluting, renewable, alternative energy sources, the best alternative energy storage is based on kinetics. One of the most common examples of kinetic storage combines hydropower and solar. During peak generation hours, excess energy is used to pump water uphill into a reservoir, then during peak consumption hours, the water is gravity fed down the slope through a turbine. This type of system is necessary if hopes are high to create a consistent system that meets demands. Additionally, many sources of energy generation could be combined in order to make a dependable system from inconsistently predictable sources.

Once we can reach the point of non-reliance on fossil fuels or carbon-emitting fuels like coal, we can be closer to solving the impending crisis of global climate change due to the extreme excess of carbon in our atmosphere. Without converting current energy demands from non-sustainable fuels to clean renewable sources, humanity, and life as we know it is surely doomed.

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