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Hydroelectricity: The Valuable and Cost Effective Energy

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Abstract— This research paper addresses the uses of energy source, Hydroelectricity.

INTRODUCTION

Hydroelectricity, or water power, is not a new technology, but is something that can be harnessed to be much more used and exploited rather than our typical use of fossil fuels. For example, if engines could be altered to use water rather than fossil fuels, the need for gasoline would be greatly reduced and the environment could be better off. It would also become less costly for a consumer, especially with the conservation of rain water. However, these could be lofty goals in the future.

Today, hydroelectric is still used quite regularly for producing reliable power. In fact, it "provides about a sixth of the world's annual electrical output and over 90% of electricity from renewables" (Boyle, 148). This means that there is already a major use for the energy and the ability to harness the energy for consumption is both documented and currently in practice all over the world. However, there are still many areas that hydroelectricity can improve and help decrease the reliance on fossil fuels.

Hydroelectricity is also valuable because of it does not need to rely on other fuel in order to create its own energy. Unlike nuclear, fossil fuels, and gas-driven turbines, hydroelectricity does not require any costs towards fuel, which makes it extremely cost effective (US Dept. of Interior, 17). In fact, its cost in total for fuel, maintenance, and operation is less than 1 cent per kilowatt-hour. (US Dept. of Interior, 17):

In order for hydroelectricity to continue its usage and become a dominant factor in replacing fossil fuels, the science of its energy must be explored. This involves looking to its past and present uses. After reviewing its current usage, combined with looking toward any negative or positive environmental impacts, can we determine the appropriate future for this type of alternate energy source.

HISTORY OF THE ENERGY

Using water to save energy is not a new science. Though there is no known date when the energy was first used, irrigation systems have existed for at least 5,000 years, through the use of a noria (Boyle, 157). A noria is a water wheel, which has paddles that dip into a flowing stream and lifts a series of jars used for irrigation (Boyle, 157).

Another major tool that harnessed hydropower was the water mills. Used by the Norse and Greek, watermills were first used in the first or second century BC (Boyle, 157). These mills were originally used as a means to raise water and grind corn, but would in later years be used for mining, iron working, paper-making, as well as use in the wool and cotton industries (Boyle, 157).

However, major technology changes occurred when hydroelectric plants were created to use turbines in order to create energy from moving water. In 1832, Fourneyron's turbine was created (Boyle, 160). This runner consists of a circular plate with curved blades around its rim and a central shaft. It spins under the force exerted by water flowing outwards between the fixed guide vanes and across its blades (Boyle, 160).

A major breakthrough in the evolvement of hydroelectricity came in 1935 in the United Kingdom. In 1935, The Galloway Hydroelectric Scheme on the River Dee was commissioned to provide extra power in the UK using six power stations controlled as one integrated system (Boyle, 148). Once the National Grid was established in the 1920s, it became feasible to create a system of lochs, and power stations that feed into it through the natural flow of the river itself. By positioning the power stations and dams according to the locations of certain tributaries, there is a consistent flow rate which is producing power through the use of a turbo-generator (Boyle, 150). A turbo-generator is a rotating turbine driven by the water and connected by a common shaft to the rotor of a generator (Boyle, 150).

This is one of the earlier examples of energy that is produced using power stations that are powered by the use of hydroelectricity. The power that is produced by these turbines at the power stations is instrumental not just to produce its own energy, but also to the contribution of power as a supplement to other sources. The Galloway Hydroelectric Scheme is still an example of how these systems can be used to access power from a naturally occurring situations (water running down stream). In fact, the Galloway Hydroelectric Scheme continues to be refined and is now one of the vital sources of energy throughout the United Kingdom (Department of Energy & Climate Change, 2014).

Currently, hydroelectric has been growing with other forms of energy for decades, however, it has had many increases in larger proportions than most other forms of electricity. (IEA, 11).

Science of the Energy

The energy that is formed comes from the energy of another. In nature, energy cannot be created or destroyed, but its form can change (US Dept. of Interior, 3). When water flows through a turbine, the water turns the blades which helps to create a mechanical energy which can then be turned into electrify (US Dept. of Interior, 3). In its simplest form water, through gravity, moves down into the turbine and the force helps to move the turnbines creating the energy. This water moves through the turbine and out the other end with virtually no direct harm to the travelling water. (US Dept. of Interior, 5).

This electricity must then be delivered, and networks of transmission lines are set up so that the power that is derived from these plants can reach businesses and homes that are sometimes very far away from the original source of energy creation (US Dept. of Interior, 5). Transformers at the locations of usage for this energy are installed in order to help control the energy flow and prevent too much energy from being pushed in and damaging all the products that are using the electricity (US Dept. of Interior, 5).

Environmental Impacts

Though possibly not considered to have many environmental impacts, the use of hydropower can have detrimental impacts to the environment and must not be overlooked. To very worrisome quotes:

"The environmental impacts of a hydroelectric project must be thoroughly analyzed since, after it is completed, they are essentially irreversible." Dorf, 1978.

"The ecological damager per unit of energy produced is probably greater for hydroelectric than for any other energy source." CONAES, 1979.

The first major effect to consider is the hydrological effects of using hydroelectric. This would refer to water flows, groundwater, water supply, and irrigation. By creating dams and reservoirs, you are essentially re-routing the natural course of the water which can have many detrimental effects. Wildlife may be reliant on the resources in one area and will no longer have access because of re-routing or the building of plants and dams. Trees and plants that grow along the rivers may not be able to thrive without the close proximity or levels of water that it had relied on for sometimes millions of years. Lastly, people may be displaced and have to move for the repurposing of the water in new locations (Boyle, 177).

The building of dams and reservoirs can also create problems that many may not consider. By building dams and reservoirs, you run the risk of structural problems which may not only destroy the building, but neighboring communities.

During the twentieth century, some 200 dam failures outside China are thought to have resulted in the deaths of more than ten thousand people. And Within China, in one year alone, 1975, it is estimated that almost a quarter of a million people perished in a series of hydroelectric dam failures (Boyle, 179).

The quote above is just in China, many people have died or had their entire lives changed by the destruction a broken dam can provide. Even when not the fault of the construction of a plant, natural disasters that hurt the plants can also have a major detrimental effect on people and structures.

One other environmental that may be overlooked when talking about hydroelectric is the effect on wildlife. I think that it can be overlooked because it is more indirectly effecting individuals, rather than directly showing climate change, pollution, or other harmful effects that can be seen clearly. For example, with hydropower in the Galloway system, there was an issue about the effect of the dams on salmon fishing, as salmon typically make their way upstream (Boyle, 151). The resolution to this was to create fish ladders at the dams which could allow fish to leap from pool to pool, which has worked in many cases (Boyle, 151).

However, there are efforts to help prevent the problems that might occur with the use of hydropower plants. In the United States, there are Federal facilities and non-Federal facilities that require licensure by the Federal Energy Regulatory Commission in order to operate (US Dept. of Interior, 9).

The Current State of Hydroelectricity

Hydroelectricity is completely reliant on supply. What this means is that it cannot be readily defined as giving a certain amount of output. It depends upon rain and snow, which can contribute to the annual amount of energy that plants will be able to retain from the added rain and snow. Therefore, there can be years where there is more energy, as well as years where there can be much less.

In order for a total output to be measurable, it must be determined the amount of rain and snowfall that can be carried by flowing rivers from higher land. "Recent estimates have tended to suggest just over 40,000 TWh per year" is the total or available resource, which is about fifteen times the world's present hydroelectric output (Boyle, 153).

To be using 1/15 of all the available resource seems to be a good number, meaning that much of the current output that could be captured is being taken advantage of. However, this also means that there is a lot of potential to grow this energy in the majority of places that rivers would be available to create this renewable energy. The technical potential is lower, at about 14,000-15,000 TWh per year (Boyle, 153).

Though this is not surprisingly much lower, what it does say is that there is opportunities to increase annual output. Also, around 50 years ago, this number would have been around 6,000 TWh per year (Boyle, 150). That means that there has been a growth in the technology for capturing this technology, and in the future there may be an even larger increase in the technical potential of these rivers as a very large resource for energy.

All in all, the world capacity and output for hydroelectric has been steadily increasing over the last few decades. In fact, there has not been much of a decrease since 1965. The world annual hydroelectric output from 1965-2000 has had an increase year over year of around 50 TWh per year since 1965 to the year 2002 (Boyle, 154). These numbers are high, but are not growing at the same rate as all total electricity, showing a less growth comparative to other forms of electricity. For example, from the decade of 1991-2000, there was an increase in annual hydro output of 24% (Boyle, 154). This increase is compared against an overall increase in total electricity by 30% (Boyle, 154). This means that this growth is being outshined by the growth of other electricity, much of which is not renewable energy sources but is the growth of larger fossil fuels.

The Future of Hydroelectricity

The future of hydroelectricity looks very promising. This is due to the fat that many studies have concluded that there is a major advantage in researching and furthering the efforts made toward this energy over some other forms of renewable energy. The International Energy Agency has made many recommendations for the next ten years that may present a very bright future for hydropower.

They have found that, "hydroelectricity presents several advantages over most other sources of electrical power, including a high level of reliability, proven technology, high efficiency, very lower operating and maintenance costs, flexibility and large storage capacity (IEA, 7). In order to help get investment to achieve sustainable hydropower, the IEA believes that, "governments must take the lead in creating a favorable climate for industry investment. Actions necessary to achieve these targets relate to the policy and market framework, sustainability, and public acceptance, financial challenges and further technology development (IEA, 8).

This has already been achieved with success in many countries. There are many countries who have been able to generate more than half of their electricity from hydropower in 2010 (IEA, 12). Of those, though there are many smaller countries on this list, larger countries such as Norway, Brazil, Canada, Austria, and New Zealand have also had the ability to get most of their power from hydroelectricity (IEA, 12).

There is certainly already a growing use for hydroelectricity for all the advantages listed above. Most countries are already utilizing these benefits in order to power most of its electricity. It is a renewable energy source that will continue to provide electricity with environmental impacts that can be managed through Federal and International regulations throughout the world. It is extremely important for those implications to be taken seriously in order for this renewable energy source to be utilized and maximized in the future.

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