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Hydroelectric Power and Dam Removal

Executive Summary

Hydroelectric power is Washington's main source of energy. It is widely considered a green energy as it does not produce carbon dioxide or other greenhouse gases. The dams that are created to house the turbines however, do have negative ecological consequences. These negative impacts are especially felt by the pacific salmon, whose numbers have been decreasingly rapidly since the settlement of the northwest. These salmon are a keystone species, meaning that they play a vital role in the ecology of the area, and without them the food chain would be drastically different. Are the damages that these hydropower dams cause worth the renewable energy that they produce? In determining whether a dam's negative effects outweigh their positive energy contributions one must do a case by case study. While some dams may be too ecologically damaging to be worth their produced energy, others are efficient enough, and produce electricity for a large enough population, to be worth the damage they cause.

Introduction

Washington State is the largest producer of hydroelectric power in the U.S. It is estimated that the state consumed over 700 trillion btu's of energy produced by hydropower in the year 2013 ("Washington Energy", 2015). Washington has been praised time and again by many for its self sufficiency in energy production in comparison to much of the United States. Washington is also famous for cheap energy prices ("Washington

Energy", 2015). The consumers, both industrial and domestic, save vast amounts of money on their energy bills in comparison to a bill of equal consumption from a state with heavier reliance on fossil fuels ("Washington Energy", 2015). Hydropower is most highly praised however, for its title as a "green" energy. That is to say that it is both renewable, and does not output carbon dioxide or other greenhouse gases in its production of electricity. Undeniably however, it is not a perfect means of energy production. The negative ecological consequences that these dams cause are becoming more obvious over time, with an increased amount of studying. The state is then left with a difficult situation, is hydroelectric power, being a "green" and cheap form of energy production, worth the ecological damage that it causes? This paper will be addressing hydroelectricity as a whole, and the costs and benefits that come with it, while touching on the history of dam construction, and the spread of hydropower in Washington. We will discuss the success story that is the removal of the Elwha hydroelectric dam, and will further examine what characteristics of that dam and river made it a good candidate for removal. We will then broaden our scope and consider the political and social implications that may accompany similar projects.

It is clear that ecological concord, and energy production through hydroelectricity, are for the most part mutually exclusive. The debate is in which is more important. The answer, like most that involve either ecology or environmentalism, is not cut and dry. Whether a dam is worth removing depends on the river it obstructs, and the usefulness and efficiency of the dam itself. When one compares this information with the ecological damages that that particular dam causes, one can truly analyse the situation and come to a logical conclusion as to whether the dam ought to be left standing, or removed.

History and Benefits of Hydropower

The basics of hydropower have been used for thousands of years. The original design was used not to generate electricity, but instead to turn mills. Before electricity was involved hydropower rarely involved damming rivers. These damless hydropower turbines were called “run-of-river” water wheels, and used only the natural flow to turn the turbine (Bakis 2007). While less efficient, and non electricity producing, these turbines had virtually no effect on the ecology of the river. One of the first serious innovators to rethink hydropower was Lester Pelton, known to some as the “father of of hydroelectric power” (James, Jaquet, Kemper 2014). His patent, which went into effect in 1880, took the hydro turbine from being a saw tooth shaped wheel, to a design much like that we see today. Instead of having teeth that catch the water, his design featured what can only be described as buckets, attached closely to the wheel itself. He also included a funnel with a wide mouth and a narrow outlet, this channeled the water to be more powerful, much like the dams we use today. While his design has been much improved throughout the years, it was this transition from the water wheel known as the “hurdy-gurdy”, to the more modern turbine of the Pelton Wheel that made hydropower efficient enough to be used to generate electricity (James, Jaquet, Kemper 2014). While hydropower had been used throughout the United States as early as the start of the 17th century, it wasn’t until 1882 that the first hydroelectric plant was opened in America in the state of Wisconsin.

As Washington state began building serious infrastructure, it was obvious from the get go that Hydropower could be a very valuable resource. With huge rivers like the Columbia, mountains that have snow melt in the spring, and a climate on the west of the state that produces heavy precipitation, the energy of the moving water was asking to be utilized. The Grand Coulee Dam is an iconic hydroelectric dam seated on the columbia river. It was built between 1933 and 1942, and is the largest hydroelectric dam in the United

States (Bottenberg, 2008). It, and the Hoover dam are the nation's well known hydropower sites.

When looking at hydroelectricity as a means of energy production there are some very obvious benefits. The biggest one being that Hydropower dams create carbon neutral energy. This means that hydroelectricity does not produce net carbon dioxide emissions, it does not contribute to global warming and as such, is touted as clean and environmentally friendly energy. Usually, to produce energy a substance (generally fossil fuels) is burned, and water is heated creating steam. This steam then spins a turbine that will generate electricity. In the case of hydroelectricity, a dam is created and a reservoir of water is allowed to build upstream of the dam. The pressure built up by the mass of water is then allowed to funnel through a small tunnel in the dam that houses a turbine, it is the turning of this turbine that generates electricity. Hydropower is used throughout the world, and some areas rely heavily on it for their power. Hydropower makes up 20% of the world's energy production, and 40% of the energy used by developing countries (Bakis 2007). Hydropower is the leading source of renewable energy, making up 97% of all electricity generated by renewables (Bakis 2007). When this fact is considered, it becomes obvious the huge role that hydroelectricity plays in the fight against climate change, and the transition to renewable energies.

The second main benefit to hydropower is the cost of the energy it produces. Washington, and many of the other states that rely heavily on hydroelectricity, pay some of the lowest prices for energy in the country ("Washington Energy", 2015). This is the case because once a hydroelectric dam has been constructed, there is very little maintenance required, and thus the power generated is very cheap. When fossil fuels are an area's main source of energy, the fuels must be repeatedly purchased in order to continue heating the steam and running the turbine. This will obviously cost more money, and the cost is passed to the consumer. This is even true if the state itself is producing the fossil fuels, though most don't, and those who do often fail to supply their state's needs fully.

Hydroelectricity's carbon neutrality, paired with the low cost of energy for the consumer make it a smart and eco friendly renewable resource to help people live comfortably, while combating climate change. Washington's history with hydropower, and the extensive infrastructure that the state has built around it makes it easy to continue on this path, without needing to front the costs of creating many more dams. The topography of the land makes the Pacific Northwest an ideal location for this kind of energy production.

Ecological Damages Caused by Dams

While Hydroelectric dams and the energy they produce have many large and obvious benefits, they also create lots of environmental and ecological damage for the surrounding areas. This aspect of hydropower is very often overlooked, as people tend to be concerned solely with creating "green" energy. They often choose to ignore the impacts on the ecosystem, instead only noting that they are not contributing to global climate change. These ecological issues however are both serious and symbolic, with the most notable damage being done to the Pacific Salmon.

When it comes to hydroelectric dams, for the most part, the bigger it is, the more power it can produce. This is because a larger reservoir of water builds up more pressure, and thus pushes through more turbines and at a quicker rate, spinning them faster and consequently generating more electricity. Dams that are hundreds of feet high however are entirely impassable for fish. This issue alone has had a devastating impact on pacific salmon populations in Washington, and the rest of the Northwest. When salmon reach sexual maturation, they return from the oceans to the rivers that they were born in. They reproduce upstream and the next generation of Salmon are born. When the fish are unable to get far enough up river, or the river's flow is no longer suitable for reproduction due to damming, the fish population declines. Not only are salmon a meaningful and symbolic creature of this area, they are what is considered a keystone species (Woodward, Schreiner et. al. 2008). A keystone species is one that plays a unique or crucial role in the way an ecosystem functions. Without them, the ecosystem would be drastically different, or would cease to exist completely. Preventing a keystone species from getting up river to their spawning grounds could have devastating ecological implications. That is not to say that scientists are not trying to mitigate these problems, with their own remedies. At smaller dams, many have implemented what is known as a salmon ladder. These "ladders" are composed of a series of pools rising in elevation, with water pouring from one to the next, highest to lowest. In essence, a bunch of miniature waterfalls of a size that the salmon have the ability to leap up. This ladder then goes from the bottom of a dam, to the top, allowing fish to reach the reservoir. While the idea is solid, in actuality it is far from foolproof. For one, As previously stated, this only works on smaller dams. A salmon ladder spanning the entire couple of hundred feet up the Grand Coulee Dam, would be near impossible for the fish to successfully navigate, not to mention costly for the little success it would have. Which brings up the next issue, even on the smaller dams, there will always be fish that are unable to use the salmon ladder, be that because of lack of energy, or lack of understanding. It is sometimes difficult to find the often narrow ladders, which are often located on the side of a dam. As such, the population who are able to reproduce will undoubtedly be much lower than it would have been had the river been unobstructed. While this is better than a completely impassable river, it is not a perfect or permanent solution. The other solution that is used widespread, but again is far from perfection, is fish hatcheries upstream of the dam. While this does a decent job of replenishing numbers, it requires intensive work, and large capital investments. And despite the effort that goes into it, the assisted reproduction of these salmon are not bringing their population numbers to what they once were before the widespread implementation of hydroelectric dams (Brenkman, S. J., Mumford, S. L., House, M. Patterson, C. 2008).

Beyond salmon habitat and spawning, damming rivers has negative effects on the ecology of the area both up and downstream. Building the giant reservoir that pressurizes the water into turning the turbine takes space. It creates a deep and large lake, where once there was only a river. This submerges much of what used to be riverside habitat, disrupting the natural ecosystem. Also, because the reservoir water sits relatively stagnant for a while, and often with lots of surface area, the water tends to heat up. This has negative consequences on the fish down the river as they prefer cooler water, in addition, warm water holds less oxygen, which is also detrimental to the health of the fish, increasing their chances of mortality. The amount of water let through the dam at any given time is made to be variable. This is because at some points in the year, water may accumulate faster in the reservoir than at other times. For this reason, downriver experiences changes in river flow volume. While it may not be immediate, this still has negative ecological consequences, on both the inhabitants of the river, and on the terrestrial species that live in the surrounding environment. Unstable conditions make for an unstable ecosystem, and with the declining numbers of the keystone species of these ecosystems the Pacific Northwest is seeing and will continue to witness potentially irreparable ecological damage.

Salmon more than any other species are facing serious population declines due to the over damming of the Northwest rivers. They are unable to get to their spawning grounds, and mitigation efforts by humans have not been effective enough to be called successful. Habitats upstream of dams are being entirely submerged, eliminating homes for many species. Downstream habitats are being severely disrupted, and are threatened by changes in water flow, and temperature.

Elwha Dam Removal Success Story

The Elwha river is located primarily in the Olympic National Forest, an area that is renowned for its pristine nature, and nearly untouched landscape. While this is true, the land is not unblemished, far downstream on the Elwha river there used to sit two hydroelectric dams. These dams had for 80 years been blocking what used to be one of the more populated and important pacific Salmon runs in Washington (Brenkman, S. J., Mumford, S. L., House, M. Patterson, C. 2008). In 1992, the Elwha River Ecosystem and Fisheries Restoration act was passed (Wunderlich, Winter, Meyer, 2011). This called for an analysis of alternatives to the current dam situation, that entirely cut off the salmon population from their up river habitat. They were debating between implementing passageways for the salmon over the dam (ie. salmon ladder) or removing the dam entirely (Wunderlich, Winter, Meyer, 2011). The goal was to figure out which solution would require minimum cost and effort, while still fully achieving full restoration of salmon populations and habitat. It was eventually decided that full recovery could only be achieved if both dams were entirely removed.

Before the ruling of the EREFR act however, there were certain conditions at this particular dam that allowed for it’s removal to even be considered. The dam was notorious for being both unneeded, and on what used to be a particularly populated salmon run. The two hydro dams were initially built to provide power to an industry that had long since been removed from the area (Woodward, Schreiner et. al. 2008). As such the energy they output needed to be sent far in order to be used. This was not only unnecessary but a hassle for engineers to redirect the power. To make matters worse the two dams were found to be horribly inefficient. As it turns out, these dams, that had been blocking historic salmon habitat for 80 years, were producing such little electricity that they could be replaced by implementing only four wind turbines (Woodward, Schreiner et. al. 2008). When examined closely it quickly became clear that these dams were of little importance in energy production.

When the Elwha dams were proposed to be torn down there was an initial public outcry. The state had been promoting hydroelectricity for many years and people could not understand why they would want to tear down existing infrastructure that was providing energy. On top of that the cost of the project would be very large. People were very hesitant to be paying vast quantities of money on the largest scale dam removal that had ever occurred. After enough information had been spread however, eventually the project got the go ahead and thus began the revitalization of the Elwha river system.

Unfortunately the act of tearing down a dam is not as easy as it sounds. Besides the engineering feat of the actual tear down, which in and of itself is quite difficult, came a slew of environmental concerns. The biggest of these was the expected sediment deposition downstream which would cloud the waters, and choke out life (Wunderlich, Winter, Meyer, 2011). In addition what used to be the water reservoir upstream of the dam would now be back to pre-dam water levels. Meaning there would be land habitat that would be exposed for the first time in 80 years. While this doesn't seem a huge issue, scientists feared that invasive species, who may be able to outcompete natives, would rush to this newly exposed and nutrient rich soil, creating a habitat of unwanted specimens that would in no way benefit the ecosystem (Woodward, Schreiner et. al. 2008). In order to help solve this problem, when the land was exposed many native plants were planted on these soils. The scientists picked plants they thought would take well to this environment, and they successfully blocked out many of the invasives. The unwanted species that did grow, despite the scientists efforts, were quickly pulled in the early days of the restoration. As the project went on, the ecosystem was able to balance itself and fill in with native foliage that both held the soil in place, and provided both the shade and the habitat that the creatures of that ecosystem needed, fish included.

Before the removal of the dam, estimates had been made as to how many years it would take before noticeable or meaningful changes in pacific salmon populations began to reappear. As the extensive post removal study went on scientists were wildly surprised by how quickly the salmon population seemed to recover (Woodward, Schreiner et. al. 2008). Although not at one hundred percent, they had made a quick and large reboom in the area. This further justified the action of the dam removal and set a precedent for further cases, that it could be done successfully, and the results would show a meaningful boost in pacific salmon populations.

In the end however, the issue of hydropower versus ecology is still not an easy choice. I believe firmly that in instances of mass energy production and efficient hydroelectric dams, the damage done to the ecosystem may be worth the lack of greenhouse gas emissions, and the cheap energy that this region experiences. It is obvious to all that no fish can survive on an inhospitable warmed planet. However in certain cases like the Elwha river, the choice for ecology and habitat restoration is easy. The dam was invaluable, and inefficient, its reason for being built gone, and the river it was blocking important to the salmon runs. In deciding whether or not to eliminate, or let alone a hydroelectric dam, a very serious cost benefit analysis must be done to determine what the best course of action is for that particular river and in regards to that specific dam. The resource of hydropower is too readily available in this part of the country, and too clean to ignore. The state does though need to be smart about when and where it decides to use this potentially disruptive resource.

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