Hydroelectricity: Implications of the Itaipu Dam

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Abstract

Hydroelectricity is seen as not only a useful alternative to energy production, but *necessary* for densely populated countries whose demand for power cannot be satiated. While clean and renewable energy is required for a sustainable future, construction of hydroelectric dams come with a fair share of consequences and repercussions. Millions of tons of rock must be excavated and disposed of, thousands of acres of forest end up underwater, people and wildlife must be displaced or rescued, and entire ecosystems must find new ways to live in and around the blocked off river and new reservoir. However, the success of the dam post-operation and thousands of available water sources to choose from in Brazil has led to more dams being built. Now, aware of the implications of grandiose projects like this has caused not only local, but international controversy over dams like the Belo Monte. Dams around the world, like the Grand Coulee in the United States and the Three Gorges in China are comparable to Itaipu, in terms of the issues they have suffered through and overall construction. Nonetheless, Itaipu is unique in numerous ways and has continuously set the world standard for hydroelectric energy production.

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With Brazil becoming one of the world's most densely populated countries, the demand for energy was rapidly increasing. The country did not have enough oil or gas to meet energy demands or the money to spend on fuel imports. A lightbulb then flickered on for the country, allowing it to realize that it could use for energy what it had in large abundance—water power. 10% of all the freshwater in the world is found in Brazil, with 40,000 kilometers of rivers available for usage; i.e. the perfect scenario for the creation of a cheaper, and cleaner, solution for energy (Largest Dams, 2013). The Itaipu Dam was then transformed from an idea into reality, and is now the most powerful operational hydroelectric energy producer in the world, sitting on the Paraná River on the border between Brazil and Paraguay. It took over a decade to build, and cost a total of $18 billion U.S. dollars. It has 14,000 MW of installed power, supporting 15% of Brazil's energy demands, as well as 75% of Paraguay's (Itaipu Binacional, 2015c). The Itaipu Binacional entity was created to administer the plant's construction, a year after both Brazil and Paraguay signed the Itaipu Treaty. Every aspect of the dam was divided evenly between the two countries—from the land that the dam physically occupies, to the number of employees working at the plant. Of course, even an impressive, well-engineered project like this could not avoid certain problems. Not only did it have negative implications on the ecology and wildlife of the surrounding areas, it created social issues, affecting the communities of people living on the banks of the river.

Hydrology

Hydroelectric plants generate electricity by capturing the energy of moving water. The turbines inside of the plant convert the kinetic energy of the moving water into mechanical energy, and then into electrical energy. The amount of electricity produced depends on how far the water falls, and the amount of water that exists at any given time. Engineers have found ways to determine the power of a dam and how many people it can serve using various formulas and calculations (Wisconsin V. I. P., 2016). The energy generated at Itaipu directly depends on the monitoring of the rivers and climate in the Paraná Basin. Predicting the volume of water that exists in the reservoir at any point in the near future allows for more efficient usage of hydraulic resources (Itaipu Binacional, 2015e).

Dynamics

One of the first steps in the process of construction was diverting the Paraná River around the construction site so that the building area was dry. As the Paraná is the seventh largest river in the world, this diversion was the largest ever attempted, and successfully accomplished. Over 50 million tons of rock and earth were removed for the creation of the channel, taking three years to complete. 40,000 workers were recruited for construction, mostly from Brazil, with 149 of them losing their lives during the process. The dam was eventually completed enough to the point where the diversion channel could be closed, and the reservoir could be filled. The area was experiencing heavy rains at the time, so it only took two weeks to fill the reservoir, which by the end, contained 29 billion tons of water. Two years later, the first power-generating unit was completed and brought on-line, marking the official opening of the dam. The rest of the units would be installed over the next seven years, progressively increasing the capacity of the dam. Inside of the plant, 20 turbines were installed and connected to generators that could each produce 700 megawatts of power. With all 20 turbines, the dam could theoretically generate 14,000 megawatts of power; however, only 18 of the turbines are ever used at one time to keep the water flow at regulation level, which was determined by a treaty with Argentina. As a renewable energy source, the amount of power produced by Itaipu is equivalent to burning 434,000 barrels of oil a day (UnMuseum, 2015).

Implications

As one of the largest projects ever attempted and completed, the Itaipu Dam had many consequences associated with it. This included ramifications for nearby communities, wildlife, and the ecology of the area. Although some implications were unavoidable, volunteers and other groups of people attempted to prevent the loss of wildlife and reduce negative effects as much as possible. Other implications affected the economies of both Brazil and Paraguay, and the creation of the dam has caused a chain reaction in ideas for building more dams in Brazil.

Environmental Implications

One of the most significant, but detrimental, parts of creating a dam is the need for a reservoir to hold a massive volume of water. This meant that the entire Paraná River Valley must be flooded for the reservoir to exist. One of the reasons this valley was chosen was because of its sparse population; however, thousands of acres of farms on the Brazilian side and thousands more acres of rainforest on the Paraguayan side were still in danger. Environmental consultants were drafted to assess the number of wild animals and plants that would be affected and/or lost by the flood. They began surveying as soon as the construction of the dam was underway, as it was a race against time to save as many species as possible. Over 300 conservationists, volunteers, and rescue teams from Brazil and Paraguay were a part of the effort. Around 30,000 different species of animals were saved and either relocated to other areas or placed into sanctuaries. Although trees and other various plants could not be saved in the same way that the animals were, thousands of new trees were planted around the reservoir's edge to replace the ones lost underwater (Largest Dams, 2013). Another natural feature that was lost in the flood was the Guaira Falls. Before construction of the dam, it was a popular tourist spot and was considered even more magnificent than Iguacu Falls. The rocks over which the falls fell had to be dynamited to allow for safe navigation of the river. It had a height two times that of Niagara Falls, with a water flow more than double (UnMuseum, 2015).

As grandiose as the Itaipu project was, many worried that it would somehow disturb the climate in the region. However, a study conducted by a team of meteorologists showed that the reservoir did not influence the climate in this area. Itaipu continuously monitors all climatic events, with the data showing that no alterations in the climate have happened since the creation of the reservoir in the 1980s (Itaipu Binacional, 2015a).

Social Implications

Not only were plants and wildlife affected by the flood, so were 40,000 people that lived on the extensive farmlands along the river. These people had to be relocated, but they would be compensated for their losses. A thorough assessment of exactly how much these families would lose had to be done, with every stool and table photographed, and documented. This would end up becoming one of the world's largest real estate evaluations. Most compensations were accepted, but a number of people did pose legal challenges. Contrastingly, as these people were being moved out, many more communities were built around the dam's construction area to support the influx of workers coming in. This resulted in new settlements and rapid growth of cities near the dam. In Iguacu, most workers had to be brought in from cities thousands of miles away. Since the town itself was not developed enough to accommodate this many people, houses, schools, and churches had to be constructed. Additionally, thousands of new jobs provided opportunities for people to settle and earn a living (Largest Dams, 2013).

Economic Implications

Initially, the project boosted Paraguay's economy and allowed for the development of an electricity market, benefitting both Paraguay and Brazil. The electricity itself, however, did not help Paraguay's economy, as the upper class prevented the transition to industrialization. This meant the focus would stay on farming, and as the dam was being completed, Paraguay's main crops plummeted in value worldwide. There was also much controversy about Paraguay selling excess energy back to Brazil, but these concerns were drowned out in the government's signing of the Itaipu Treaty of 1973. The treaty allowed Paraguay to export most of its energy due to lack of consumption, and Brazil was able to have first rights in buying back the excess energy at a highly-discounted price (Mina, 2011).

Controversy Over Belo Monte

The construction of Itaipu gave way to more ideas being turned into realities in terms of the number of dams being created within the country of Brazil. There are hundreds of rivers that can be utilized, but the implications have caused severe controversy among critics. One of the dams in question is the Belo Monte Dam, currently under construction on the Xingu River in the state of Pará in Brazil. The planned installed capacity would be 11,233 MW—almost half that of what Itaipu currently produces. Brazil's rapid economic growth over the last decade has created a large demand for new and reusable sources of energy to supply its growing industries. The controversies lie mainly in the environmental impacts. The possible adverse effects include the loss of vegetation and natural species, changes in quality and path of the water supply, and fish migration routes, and temporary disruption of the water supply in the Xingu River for almost an entire year. The Brazilian environmental agency IBAMA granted a license for the construction of the dam despite major opposition from within the agency due to incomplete assessments and information regarding problems associated with the dam (Duffy, 2010). Reports have also calculated that during its first ten years, the dam would emit 11.2 million metric tons of carbon dioxide equivalent. This study estimates that greenhouse gas emissions of that amount would require 41 years of optimal energy production in order to reach environmental sustainability over fossil fuel energy (Fearnside, 2010). Dams in Brazil emit large amounts of methane due to the jungles that end up underwater after the reservoirs fill. As the carbon becomes trapped by foliage in the water, it eventually converts into methane, a more potent greenhouse gas than carbon dioxide (Rowe, 2005). Also, the treatment of affected indigenous groups by the Brazilian government has been greatly criticized internationally. The UN Human Rights Council has denounced Brazil's careless methods of construction and pointed out that it was in violation of the Indigenous and Tribal Peoples Convention. The Indigenous groups have called out the government over their actions, but their situation remains ignored by the authorities (Cabanes, 2016).

Comparisons Around the World

Itaipu Dam deserves its bragging rights, but there are hydroelectric dams comparable to Itaipu in other countries as well. All designs of the dams differ based on where they are located, the geology of that area, and the demand for energy. However, although these dams are different from Itaipu, they also have many similarities.

Grand Coulee Dam

The Grand Coulee Dam is the largest hydroelectric power-producing facility in the United States. It was built in 1942, and is located in the state of Washington. Its main purpose was to provide power and irrigation water. Today, the Columbia Basin irrigates 670,000 acres, with a potential for 1.1 million. The dam has four different power houses containing 33 hydroelectric generators, and produces approximately 7,000 MW of electricity annually (U.S. Energy I. A., (2016). Creation of the dam and reservoir forced 3,000 from their homes, including Native Americans whose ancestral lands and burial grounds were now underwater. The dam also blocked the migration of salmon and other fish spawning upstream (Harden, 1996). Grand Coulee is a gravity dam, just like Itaipu, utilizing its own weight to resist the pressure of water pushing against it.

Three Gorges Dam

The Three Gorges Dam in China is the world's largest power station with an installed capacity of 22,500 MW, but has, year after year, lost to Itaipu in leading annual worldwide production (Itaipu Binacional, 2015d). It took 17 years to build, and cost around $24 billion dollars, but critics state the actual cost could have been much more. The main purpose of the dam was to control flooding, even though severe floods were only known to happen once in a century. The reservoir flooded an expanse of 244 square miles of land, and displaced 1.3 million people. Dozens of architectural and cultural sites have also disappeared under the reservoir. Although the power produced by the dam reduces coal consumption by 31 million tons per year, there are other significant environmental factors that it affects. Environmentalists have reported that the dam has reduced downstream nutrient and sediment flow, impacting neighboring river and seacoast ecosystems. This change has harmed coastal fishing grounds and subjected tidal wetlands to increased erosion (National Geographic, 2006). This erosion has also caused frequent major landslides, leading to a disturbance in the reservoir surface.

Why Itaipu is Unique

The design of Itaipu and the way in which it was constructed has many similarities to the Grand Coulee and the Three Gorges. However, certain distinctions have allowed for the uniqueness to shine through for Itaipu. The design was one of the key components of this dam. The geology around the river and the type of rock upon which it sat could be used and manipulated to allow for a gravity dam to be built, allowing the weight of the dam to work for itself without requiring more support to be held up. Also, Itaipu had valiant efforts in saving not only the wildlife whose homes would be underwater due to the flooding of the reservoir, but also offered compensation for the people that would be displaced in one of the largest real estate evaluations ever recorded. This was quite unlike the behavior of the U.S. and Chinese governments. The U.S., for example, kept promising compensation for the tribes who suffered from the dam's impacts, but their requests were continually ignored, and even when they ended up receiving money decades after, the amount was nothing compared to what they had lost.

Furthermore, Itaipu Binacional is a hallmark for the electricity sector of both countries. Before its institution, the Paraguayans had only a small-sized hydroelectric power plant—Acaray, and in Brazil, the power plant basically doubled the country's electricity generation capacity. In 2016, Itaipu was the first hydroelectric dam in the world to exceed 100 million MWh of annual generation. With a total of 103.1 million MWh, the plant surpassed the record of 98.8 million MWh established by China's Three Gorges Dam in 2014, and regained first place in the world's annual production of clean and renewable energy. Itaipu is also the world's largest hydropower plant in accumulated production. Since it began operating in 1984, it has generated more than 2.4 billion MWh. This is only possible due to the Paraná River's constant flow of 14,181 m^3/s, the operation of the power plant, continuous maintenance to maintain or improve efficiency, and the electricity demand coming from both Brazil and Paraguay (Itaipu Binacional, 2015b).

Conclusion

Do the pros outweigh the cons? This is the concluding question that must be asked in terms of dam construction. While there are many advantages to a hydroelectric dam in a country that has a high demand for power, the benefits may only outweigh the disadvantages if the design of the dam takes into account every single detail and accounts for every implication. Since the environment and native tribes are usually the ones put on the backburner during construction, it is important to mitigate the toll on them avoid international backlash over the project. It is also important to understand why the dam is being built, and if its sole purpose requires such a grandiose measure to be taken in order to resolve the issue at stake. If, for example, the dam was built to control flooding, but severe floods only happen once in a century, does the possibility of a breach in the dam make it more dangerous to build one? All dam projects come with their own advantages and consequences, but whether or not they will be beneficial depends on what the priorities are of the people in that region, and what they can afford to lose in order to gain.

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