Research Article

The use of hydroelectric plants in Brazil - brief overview

Background

Given the huge number of rivers in Brazil, the country is based on its energy generation using large hydroelectric plants and the so-called small hydroelectric plants that use the waterfall as a movement that is transformed into mechanical energy and generates. This article presents a brief overview of the country's hydropower use as a sustainable energy source.

Keywords: hydroelectric plants, power generation, Brazil, small hydroelectric plants

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Abbreviations: PCH, pequenas centrais hidrelétricas; MWh, megawatt hours; SHP, small power plants; MW, megawatts

Introduction

Brazil ranks second in the world's hydropower production, second only to China. The predominance in the use of hydroelectric dams occurs due to the ease and quantity of waterfalls in the national territory, which is a differential in relation to consumption based on fossil fuels from other Countries. The graph in Figure 1 shows the relevance of this source when compared to other energy generators in the Country.

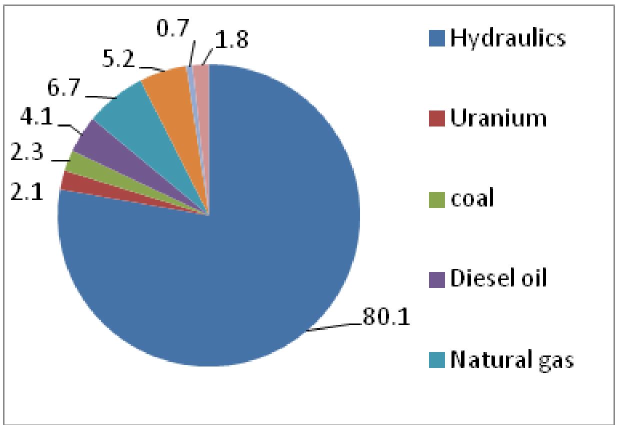

Figure 1 Share of each power source (%).[4]

About 60% of the installed hydroelectric capacity in the country is located in the Paraná River Basin and other important basins such as São Francisco and Tocantins.[1] The 5units that generate the most energy are: Itaipu Hydroelectric Power Plant, Belo Monte Hydroelectric Power Plant, São Luíz do Tapajós Hydroelectric Power Plant, Tucuruí Hydroelectric Power Plant and Santo Antônio Hydroelectric Power Plant.

In 2016, Itaipu Binacional (Brazil - Paraguay) was the first hydroelectric dam in the world to exceed 100million megawatt hours (MWh) of annual generation. It began construction in 1974 and was completed in mid-1982. It currently has 20 turbines and generates 15% of the energy used in Brazil and 86% of the energy used in Paraguay.[2] Figure 2 exemplifies its complex construction as a major civil work in 1980.

Figure 2 Photo of its construction at the time of 1980.[2]

Material and methods

The article focuses on the importance of using hydroelectric dams for the supply of electricity in the Country and the principles of the so-called small hydroelectric plants (known in Brazil as *pequenas centrais hidrelétricas*, PCH).

Results

There is controversy regarding the hydroelectric power station as a clean alternative due to the region's need for adaptation to the major works required for its construction, flooding the surrounding region and changing the environment. It is worth remembering that Brazil, besides investing in wind and solar energy as sustainable sources, encourages the use of small hydroelectric power plants (PCHs) that don't cause environmental or social interference, and is also part of the sources for the universalization of energy. As explained by the Brazilian Association of Small and Hydroelectric Power Plants (known in Portuguese as ABRAPCH, these projects must have between 5 and 30 megawatts (MW) of power and must have less than 13km² of reservoir area. The PCHs, therefore, would be like a "distributed Itaipu" and of low environmental impacts, due to the diversity of plants spread throughout the Country.[3]

The principle of a PCH can be summarized in: the movement of water is transformed into mechanical energy, passing through turbines, into electrical energy; and reaching the generators, the electric energy is converted into electricity.[2] The requirements of the definition of PCHs are: a hydroelectric generation with a power of more than 1 MW and equal to or less than 30MW, destined to independent production, self-production or independent autonomous production with reservoir area of less than 3.0 km² and the hydropower that doesn't meet the condition for the reservoir area, must meet the formula:[3]

$$A = \left(14.3^{*} P\right) / H_b$$

At where:

P=installed electrical power in (MW)

A=reservoir area in (km²)

H_b=gross drop in (m), defined by the difference between the normal maximum upstream and normal downstream water levels. To meet the above requirement, it is further established that the reservoir area may not exceed 13.0km[2].

Its operation is similar to that of a large plant having the same key components: dam, water collection and supply systems, powerhouse and natural river bed restitution system. The dam of a PCH in general should have one or more bottom gates, with the purpose of: allow the output of a percentage of the total river flow (residual flow); allow the reservoir to discharge (avoiding siltation) and prevent flooding of other dam structures.[3]

The types of PCH, regarding the reservoir regularization capacity, are: water line: those that have water reservoir, but without useful volume; accumulation (with daily/monthly regularization of the reservoir: used in cases where the river drought flows are lower than necessary to supply the demand power of the consumer market. Table 1 presents a summary of the PCH's classification according to their power and design drop. The country has 217 large hydroelectric dams that generate a power of 98,286,811kW and 427 small power plants (SHP) that generate 5,157,380 kW.[4]

Table 1 Classification of small hydroelectric plants[3]

Classification	Power (kW)	Water fall in project (m)		
		low	average	high
Micro	≤100	<10	between 15-50	>50
Mini	between 100-1000	<20	between 20-100	>100
Small	between 1000-3000	<25	between 25-130	>130

Discussion

Hydropower is considered clean as it generates little pollutant emissions. It also uses a resource that in Countries like Brazil, rich and uneven in water, becomes an advantage. The reservoir built for power generation purposes can be used simultaneously for water supply purposes and ultimately represents reliable generation (provided there is no drought). Negative points include the complexity and cost of civil works (which should be amortized over time for gains in power generation); Most of the unevenness's are located at a considerable distance from the major consumer centers (rivers located in the north and mid-west regions and demand centers located in the southeastern region), requiring investments in transmission and distribution networks.

Conclusion

This is the most widespread energy source in the Country, whose construction process combined with civil, electrical and mechanical engineering, is already widely known in the country, unlike wind energy and biomass, which still depend on research and expansion of industries. This, together with the abundance of rivers, makes this source a determining factor for the country and tends to continue to dominate the Brazilian energy matrix in the coming years.

Acknowledgments

None

Conflicts of interest

The author declares that there are no conflicts of interest.

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