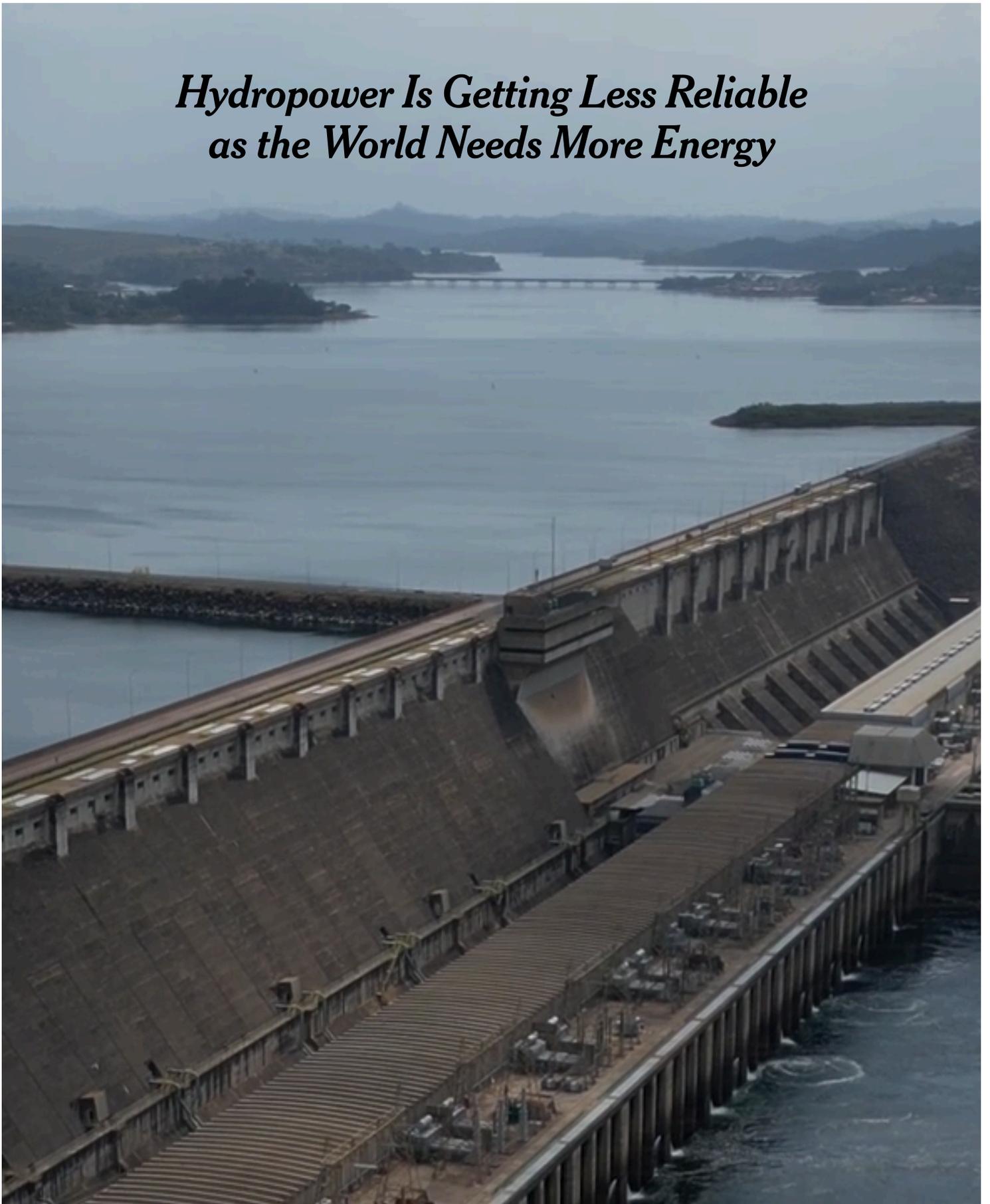


Hydropower Is Getting Less Reliable as the World Needs More Energy



Demand for power is growing fast, but hydro plants, the oldest source of clean energy, are struggling because of droughts, floods and other extreme weather linked to climate change.

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By Ivan Penn Visuals by Ruth Fremson

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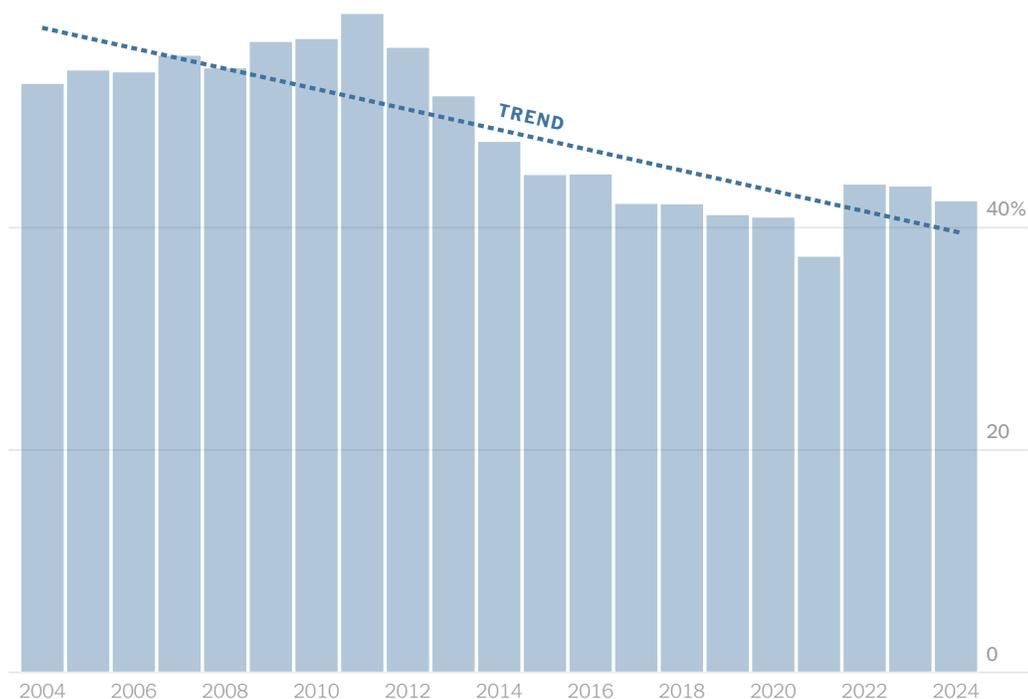
On Brazil’s third-largest river basin, deep in the Amazon, a massive hydroelectric power plant stands as a monument to the world’s oldest source of clean energy — and the big challenges it faces.

Drought and time have taken their toll on the plant, the Tucuruí Dam and hydroelectric power project. Up close, visitors can see leaks that form little, unwanted waterfalls.

Completed around 40 years ago, the Tucuruí plant and hundreds of others worldwide are coming under increasing pressure just as humanity needs a lot more electricity. Droughts and dry spells have made it hard for plants to generate enough energy. Too much rain has also been a problem, because floods can damage their equipment.

Hydro energy production fell 3 percent in Brazil last year, according to Ember Energy Research. And what the country does produce amounts to less than half of its capacity. That may seem small, but it represents a big strain because energy use is growing fast and hydro plants have typically provided more than half of Brazil’s electricity.

Hydropower dams in Brazil are running below historical capacity



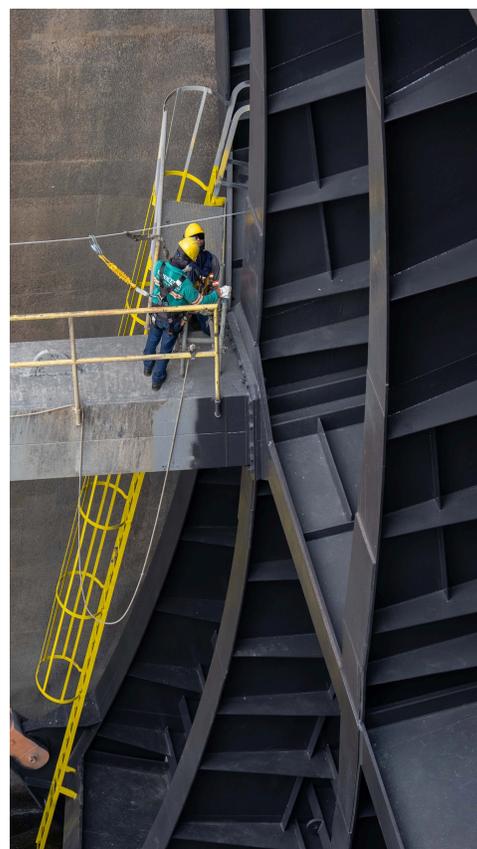
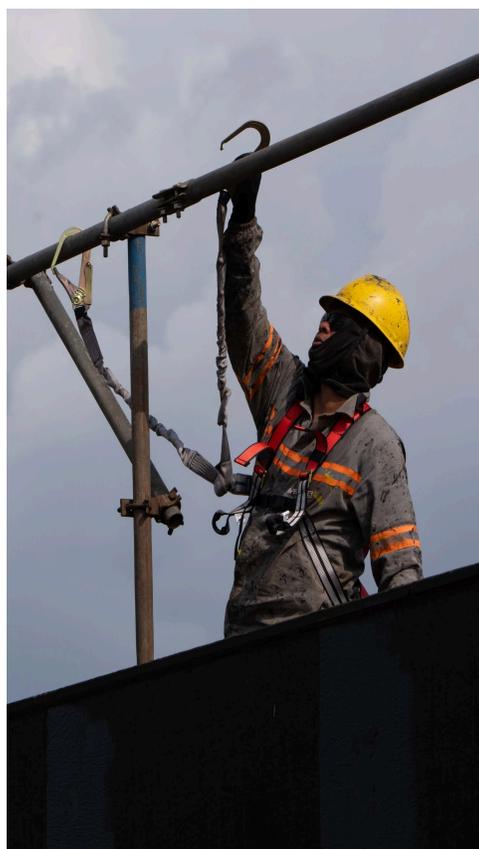
Note: Hydropower capacity factors are based on annual totals at the fleet level, and do not account for exact dates when new capacity is added. Source: International Energy Agency. Mira Rojanasakul/The New York Times

Canada, China, the United States and other countries have also struggled with low hydroelectric production in recent years. How to make up for those shortfalls while achieving ambitious emissions and economic goals will be on the agenda at the United Nations' annual climate conference in Belém, a six-hour drive from Tucuruí.

Extreme weather has hit Brazil hard. In 2014 and early 2015, the country nearly had to ration electricity because some reservoirs were running low. Drought and deforestation in the Amazon — home to about 60 percent of the planet's remaining rainforests — have contributed to lower water levels. Last year, there was so little rainfall that wildfires consumed an area of the Amazon as big as California. And flooding and landslides have occasionally forced hydroelectric plants in southern Brazil to close.

"I do believe that we crossed the line," said Ivan de Souza Monteiro, chief executive of AXIA Energia, Brazil's largest power provider and owner of the Tucuruí plant. "Climate change is something that came and it's going to be forever."

Mr. Monteiro's company is spending \$270 million to modernize Tucuruí, extend its life and undo some of the damage that age and weather have inflicted on it. Brazil is also increasing its use of wind turbines and solar panels.



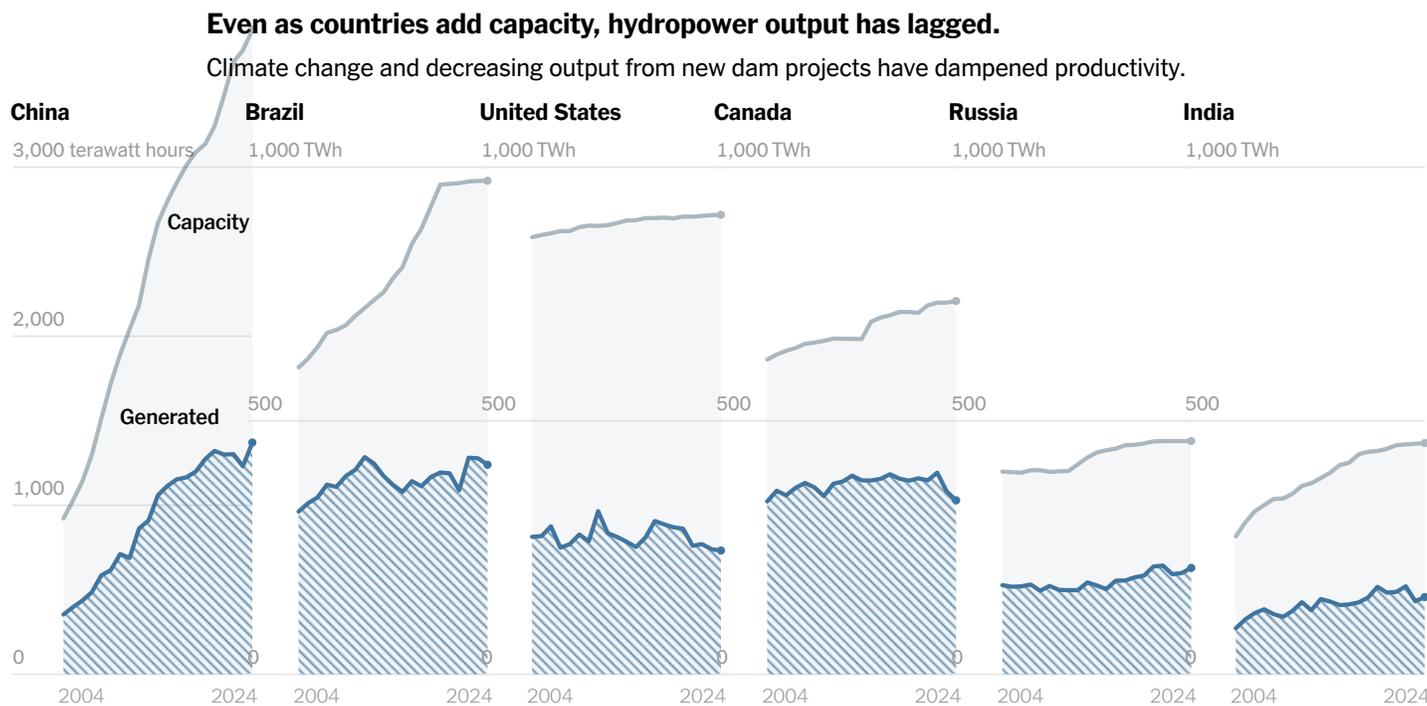
Workers are trying to extend the life of Tucuruí Dam and hydroelectric power project and undo some of the damage it has suffered as a result of a changing climate.

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Often overshadowed by newer forms of energy, hydroelectric power remains an enormous workhorse. It's the world's third-largest source of electricity after coal and natural gas.

But it is becoming less reliable. In 2023, electricity production from hydroelectric plants worldwide dropped by the equivalent of the power consumed in a year by Chile or the Philippines — the biggest annual decline as far back as 1965. The next largest dip occurred in 2021. The International Energy Agency says extreme weather is largely responsible.

“The fact that it is happening so widely is pretty alarming,” said Robert McCullough, principal of McCullough Research, an energy consulting firm based in Portland, Ore. “The reality is so profound and so little understood.”



Source: International Energy Agency. Mira Rojasakul/The New York Times

Despite these challenges and longstanding environmental and social concerns about dams, some governments and energy companies are pushing to build more of them. China is working on the world's largest hydropower project in Tibet, raising concerns about water scarcity in India and Bangladesh.

“As decision makers around the world contend with how to meet renewed strong growth in electricity consumption, I believe it’s high time to give hydropower the attention it deserves,” Fatih Birol, the executive director of the International Energy Agency, wrote in a newsletter published by his Paris-based multilateral organization in October.

Plans to Adapt and Find Alternatives



The landscape near the Tucuruí Dam. AXIA and the government are concerned about the health of the rainforest near the dam.

Tucuruí sits on the Tocantins River, a four-hour drive on the Trans-Amazonian Highway from the nearest airport.

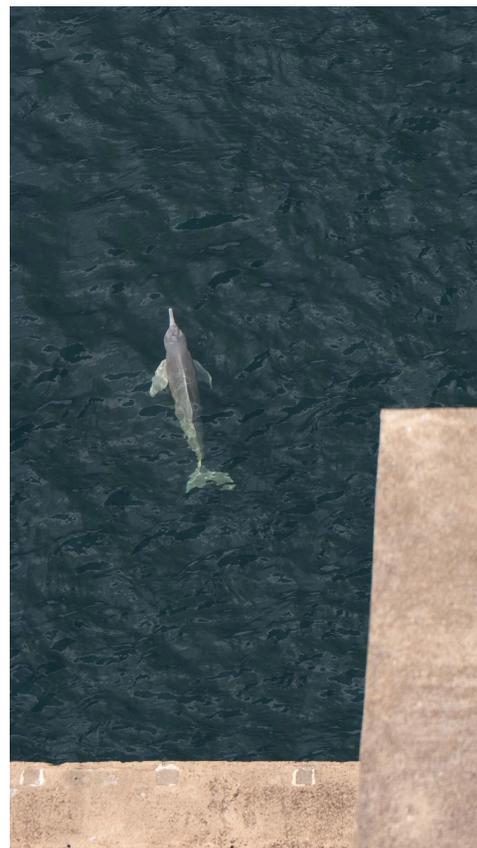
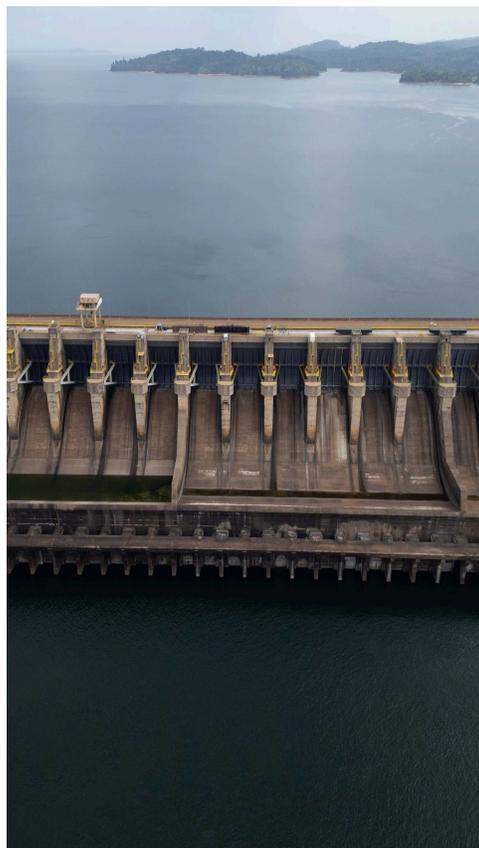
The drive offers a portrait of two Amazons. In many places, rolling hills are shrouded beneath palm and fruit trees, aggressive vines and other native species. But in some places, on the opposite side of the highway, the land is charred where farmers have set fires to clear forests to create cattle pastures.

Those blazes can grow furiously. At times, fire and smoke can be seen in the distance from the towering walls of the Tucuruí Dam — a vivid reminder of threats to the rainforest, its rivers and Brazil's dominant power source.

AXIA Energia, formerly known as Eletrobras, sees Tucuruí as one of its most important assets and critical to powering the country, even as the company adds more wind and solar energy.

Tucuruí is the third-largest electricity generator in Brazil and the eighth in the world. It can produce about 20 percent more electricity than the largest U.S. hydro plant, the Grand Coulee Dam in Washington State.

AXIA and the government are very concerned about the health of the rainforest and the waters held behind the nearly two dozen massive gates of the Tucuruí spillway. Authorities use boat patrols to monitor the health and safety of the rainforest, river and wildlife, including the dolphins that live in these waters. As many as 600 people work at the plant every day.



A dolphin swimming near the Tucuruí Dam. Hydropower, the world's third-largest source of electricity after coal and natural gas, is becoming more unreliable. The International Energy Agency says extreme weather is largely responsible.

A five-year upgrade project is well underway. Workers are replacing transformers and five of its 25 generators, upgrading a substation and automating equipment. The company is also working to make the plant more efficient and flexible as volatile weather conditions make electricity production from hydropower more challenging.

“This is a one-of-a-kind modernization that we’re doing,” said Allan Almeida de Lima, an operations and maintenance executive manager at the power plant.

Hydropower produced 48 percent of Brazil’s electricity in August, according to Ember, its lowest level in four years. As hydropower has become more erratic, the country has increasingly relied on solar and wind energy. In August, those two sources provided more than a third of the nation’s electricity for the first time.

Solar energy in particular has grown rapidly. At the end of last year, solar generated about 10 percent of Brazil’s electricity, roughly 10 times what it did toward the end of 2019, according to Ember.

Mr. Monteiro, who joined the power company from the finance and oil and gas industries, said he was pushing AXIA to diversify to ensure the grid stability and reduce the risks posed by extreme weather.

“I cannot control if it’s going to rain or not, but I can build scenarios based on a lot of rain, less rain,” Mr. Monteiro said. “You have Contingency One, Contingency Two, and, in some situations, you have three. The best insurance policy that you have is contingency plans.”

The Resistance to Dams

Completed 40 years ago, Brazil's Tucuruí Dam is the third-largest electricity generator in Brazil and the eighth in the world.

Hydropower plants are marvels of engineering, not only because they are large but also for their designs. These giant structures often rise above rivers in remote and environmentally sensitive places.

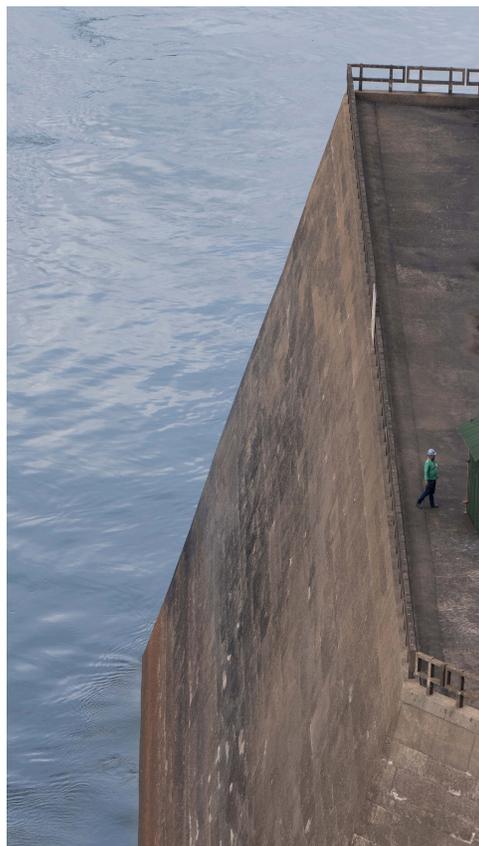
Some countries are exploring building even bigger, more challenging dams. China's latest project, on the Yarlung Tsangpo River in Tibet, is expected to be the world's largest power plant when it starts producing electricity in 2030.

China has offered few details about the plan, which could have significant ramifications downriver: for India, where the river is known as the Brahmaputra, and for Bangladesh, where it is called the Jamuna.

Critics, including many environmental groups, have long argued that hydroelectric projects impede rivers, endanger wildlife and contribute to deforestation that harms locals.

“The environmental and social impacts of large dams have been really well documented for decades at this point,” said Joshua Klemm, executive director of International Rivers, an environmental group based in Oakland, Calif. “I think there’s been a kind of collective amnesia about the toll from hydropower plants.”

Villagers along the Xingu River in Brazil have fought against hydroelectric dams after thousands were displaced by the construction of Tucuruí and another power plant, Belo Monte.



Hydroelectric technology is needed to meet growing energy demand, including from the roughly 600 million people worldwide who don't have access to electricity, the head of a hydropower industry group said.

Environmental activists say world leaders should focus on restoring aging dams rather than constructing new ones.

“If the dam is built and producing the juice, use it but don't build new hydro given the hullabaloo of clearing new miles of land,” said Bill Powers, a San Diego engineer and energy consultant. “Brazil is case in point. They cleared out village after village.”

In response to concerns about Tucuruí and other hydropower plants, AXIA said it compensated displaced people and worked to restore affected lands.

In a statement, the company said the completion of the Tucuruí plant “was conducted with the participation of local communities, who were included in a range of programs and initiatives designed to mitigate and compensate for the project’s impacts.” It added that government officials closely monitored its compliance with regulations and laws.

Conflicts over hydro power exist around the world.

Eddie Rich, chief executive of the International Hydropower Association, an industry group, acknowledged that some dams had harmed communities and the environment. But he added that the technology was needed to meet the growing energy demand, including from the roughly 600 million people worldwide without access to electricity.

Mr. Rich said newer forms of hydroelectric power could have a smaller environmental and social impact. Such plants include pumped hydropower plants, which utilities can use to store energy by moving water from a lower reservoir to an upper reservoir — a process that can be reversed to generate electricity. He said the world would need twice as much hydropower by 2050 as it had now, though reaching that goal might be impossible.

“We’ve got to mitigate the impact on communities,” Mr. Rich said. “I’ve got sympathy. It is really important that people understand we’ve been working on these issues and learned lessons over a long time.”

Ivan Penn is a reporter based in Los Angeles and covers the energy industry. His work has included reporting on clean energy, failures in the electric grid and the economics of utility services.

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