Climate change is making hydropower less reliable

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As drought settled in over the Pacific Northwest this year, some electric utility managers did something unusual: They looked to California for hydropower.

While the Golden State's reservoirs retained an abundant supply of water after an abnormally wet winter, in Washington, the nation's leading producer of hydropower, some systems saw less water than expected.

The hydropower variability this year represents one example of some of the changes the country can expect in a warming world, according to a new report from Stanford researchers.

The report challenges the notion that hydropower will carry the Northwest into its clean energy future. Instead, it found that as climate change has driven worsening drought in the Western U.S., utility operators have increased electricity generation from fossil fuels.

The report suggests that without meaningful modeling for climate change in energy resource planning, the West will be ill-prepared to meet demand and its ambitious clean-energy goals.

At the turn of the 20th century, settlers encroached on Indigenous people's homelands of the West and began building dams to make rivers run like machines—a series of stagnant pools and turbines. Dams transformed the free-flowing freshwater highways that once supported abundant salmon runs, lamprey and other life. They were harnessed to instead light up homes and businesses, and fire up lumber, pulp and paper mills.

In 2022, hydropower accounted for 67% of Washington's energy generation. But many of the pieces of these dammed rivers are approaching or have passed their 100th birthdays and some operators are faced with expensive upgrades and with choices about their future. For some utilities, the benefits of removal outweigh the costs of keeping them running.

Since 2000, the Western U.S. has seen record-breaking droughts and a

decline in total runoff coming through the region's dammed rivers. In times of drought, utilities have fired up coal and gas facilities, driving up greenhouse gas emissions, and increasing methane leaks and air quality-related deaths, Stanford researchers reported in the *Proceedings of the National Academy of Sciences* in July.

The decline in hydropower generation in the Western U.S. led to an extra 121 million metric tons of carbon emissions from 2001 to 2021. Electricity generation from fossil fuel plants was 35% higher in the driest months in California. In the Northwest, that generation crept up about 11% in the driest months.

In 2019, for example, Washington's greenhouse gas emissions reached their highest levels in over a decade. That largely stemmed from a higher reliance on fossil fuels—mainly coal and natural gas—for electricity because of poor hydropower production, according to the state. The state electricity sector's emissions rose from 16.5 million metric tons in 2018 to 21.9 million metric tons in 2019, the equivalent of adding more than 1 million gas-powered cars on the road.

This, the researchers found, is an unaccounted cost of climate change, one that amounted to $20 billion in the Western U.S. from 2001 to 2021. Greenhouse gas emissions from these power plants, researchers suggest, cost $14 billion, while deaths associated with pollution accounted for $5.1 billion and methane leaks were responsible for just under $1 billion, according to the study.

Even when up and running at full speed, hydropower isn't carbon neutral. Reservoirs of all sorts are sources of the potent greenhouse-gas methane. The gas is produced by decomposing organic material underwater.

The Northwest isn't experiencing anything like the bathtub rings on the drought-stricken Colorado River. But hydropower, like wind and solar,

depends on the weather. Sometimes that makes for swings in power supply, but it often won't hit all of the West's major hydropower systems at one time.

"What this study shows is that there is just this increasing vulnerability of the hydropower systems that we need to account for in the energy-grid transitions," said lead researcher Minghao Qiu.

For some Washington utilities, the current drought is a reminder of what's to come.

Seattle City Light relies on hydropower for more than three-quarters of its electricity generation, with about half coming from its dams on the Skagit River and Boundary Dam on the Pend Oreille River. Much of the rest is purchased from the Bonneville Power Administration, which sells the power generated from the dams in the Columbia River Basin.

"If you just flicked up the data back in March, snowpack would be pretty good," said Mike Haynes, interim general manager at Seattle City Light.

Then, Haynes said, the runoff came hard and fast. It was abnormally hot in May and June and it's been dry ever since, so a lot of the precipitation didn't make it into Ross Lake, the utility's largest reservoir, he said.

Utilities including City Light and BPA historically relied on data spanning from the 1920s as the baseline for power generation. But as the regional climate continues to warm, older data becomes less relevant.

Bonneville is now using the three most recent decades of hydrologic data to inform future generation estimates. The federal agency noted that the effects of climate change felt in the Pacific Northwest include warming, earlier spring snowmelt, higher winter and early spring flows, earlier

spring runoff and longer periods of low summer flows.

As Puget Sound Energy builds its clean energy portfolio to meet Washington's target of nearly carbon-free electricity generation by 2045, it's factoring in the need for backup generation from other renewables, namely solar and wind. Currently, the investor-owned utility gets about half of its electricity from coal and gas power plants. PSE serves 1.2 million electric customers and 850,000 natural gas customers, mostly in northwest Washington. In 2020, the utility relied on coal and natural gas for half of its electricity generation.

Hydropower has always been variable, largely at the whims of rainfall and snowpack, said Elizabeth Hossner, manager of resource planning and analysis at PSE. But the utility is planning for more hydropower generation in the winter, lower generation in the summer and a need to ensure there's more water stored in reservoirs.

"We're paying close attention to climate as a whole," Haynes said. "And just challenging all of our historic assumptions and trying to remind people it's not always the way it's been, that is not always the way it's going to happen going forward."

For some, hydropower's renewable value is often eclipsed by its effects on salmon recovery.

"How are we looking at energy into the future?" Nez Perce Chair Shannon Wheeler said. "Are we just looking at it from an economic standpoint? Are we looking at it from a holistic view? Both the damage that is caused through emissions or through the hydro system that is causing environmental issues for the salmon themselves."

More information: Minghao Qiu et al, Drought impacts on the electricity system, emissions, and air quality in the western United

States, *Proceedings of the National Academy of Sciences* (2023). DOI: 10.1073/pnas.2300395120