

Hydroelectric power plants have to be adapted for climate change

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Grande Dixence dam. This hydroelectric power complex generates some 2 billion kWh of power per year. Credit: LMH

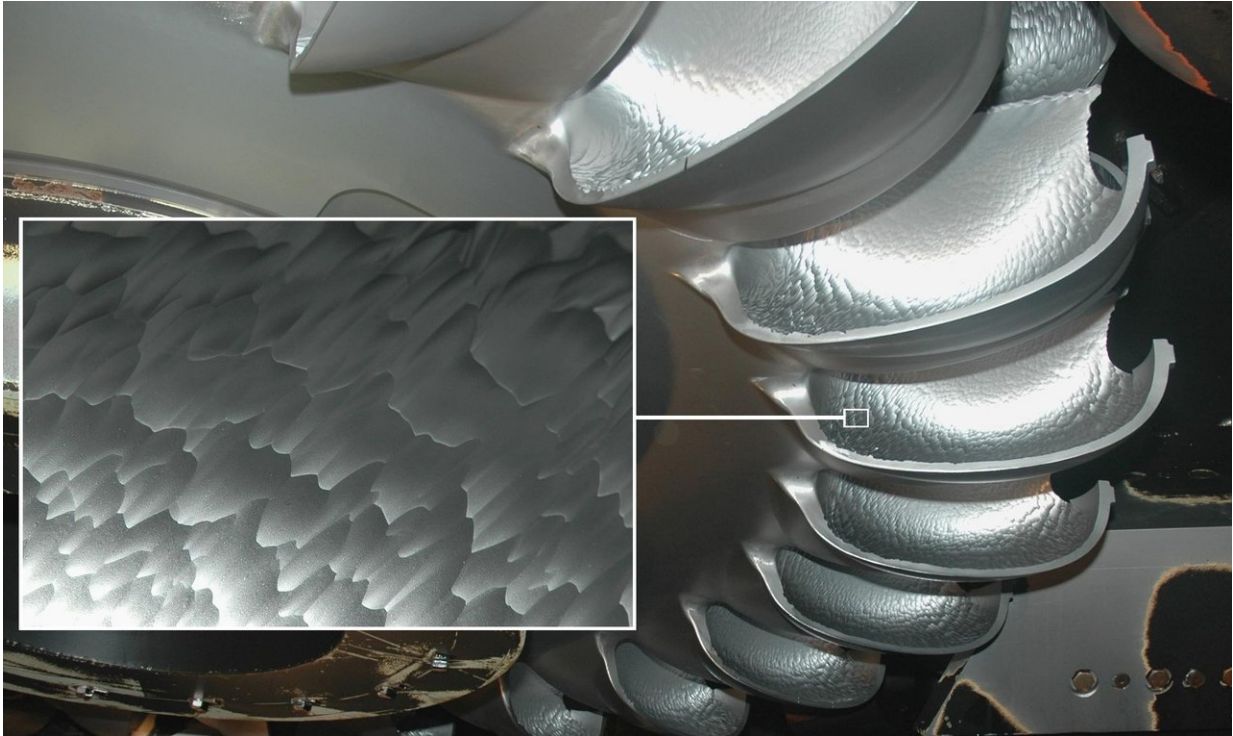
Of all the electricity produced in Switzerland, 56 percent comes from hydropower. The life span of hydroelectric plants, which are massive and expensive to build and maintain, is measured in decades, yet the rivers and streams they depend on and the surrounding environment are ever-changing. These changes affect the machinery and thus the amount of electricity that can be revised. EPFL's Laboratory for Hydraulic Machines (LMH) is working on an issue that will be very important in the coming years: the impact of sediment erosion on turbines, which are the main component of this machinery. The laboratory's work could help prolong these plants' ability to produce electricity for Switzerland's more than eight million residents.

One of the aims of Switzerland's 2050 Energy Strategy is to increase hydroelectric production. The Swiss government therefore also needs to predict the environment in which these power plants will operate so that the underlying technology can keep pace with changing needs and future conditions. "In Switzerland, the glaciers and snow are melting more and more quickly. This affects the quality of the water, with a sharp rise in the content of sediments," says François Avellan, who heads the LMH and is one of the study's authors. "The sediments are very aggressive and erode the turbines." This undermines the plants' efficiency, leaves cavities in the equipment and leads to an increase in vibrations – and in the frequency and cost of repairs. To top things off, the turbines' useful life is reduced. Under the umbrella of the Swiss Competence Center for Energy Research - Supply of Electricity (SCCER-SoE) and with the support of the Commission for Technology and Innovation (CTI), EPFL

has teamed up with General Electric Renewable Energy in an effort to better understand and predict the process of sediment erosion. The aim is to lengthen the hydropower plants' [life span](#) through improved turbines and more effective operating strategies.

Tiny particles with an outsized impact

One of the challenges facing researchers in the field of hydropower is that they cannot run experiments directly on [power plants](#) because of the impact and cost of a plant's outage. They must therefore limit their investigations to simulations and reduced-scale physical model tests. In response to this challenge, the LMH has come up with a novel multiscale computer model that predicts [sediment](#) erosion in turbines with much greater accuracy than other approaches. The results have been published in the scientific journal *Wear*. "Sediment erosion, like many other problems in nature, is a multiscale phenomenon. It means that behavior observed at the macroscopic level is the result of a series of interactions at the [microscopic level](#)," says Sebastián Leguizamón, an EPFL doctoral student and lead author of the study. "The sediments are extremely small and move very fast, and their impact lasts less than a microsecond. On the other hand, the erosion process we see is gradual, taking place over the course of many operating hours and affecting all the [turbine](#)."



LMH Pelton turbine eroded by silt after one sediment season. Credit: Ecole Polytechnique Federale de Lausanne

A multiscale solution

The researchers therefore opted for a multiscale solution and modeled the two processes involved in erosion separately. At the microscopic level, they focused on the extremely brief impact of the minuscule sediments that strike the turbines, taking into account parameters such as the angle, speed, size, shape – and even composition – of the slurry. At the [macroscopic level](#), they looked at how the sediments are transported by water flow, as this affects the flux, distribution and density of sediments reaching the walls of the turbine flow passages. The results were then combined in order to develop erosion predictions. "It's not possible to study the entire process of erosion as a whole. The sediments

are so small and the period of time over which the process takes place so long that replicating the process would take hundreds of years of calculations and require a computer that doesn't exist yet," says Leguizamón. "But the problem becomes manageable when you decouple the different phases."

Adapting to the future

With conclusive results in hand, the LMH has now moved on to the next phase, which consists in characterizing the materials used in the turbines. Following this step, the researchers will be able to apply the new model to existing hydroelectric facilities. The stakes are global when it comes to retrofitting turbines in response to climate change, as hydropower accounts for 17 percent of the world's electricity production. Turbines offer little leeway and have to operate in a wide range of environments – including monsoon regions and anything from tropical to alpine climates. If turbines are to last, changes will have to be made to both their underlying design and how they are operated. "While I was evaluating a hydro plant in the Himalayas, my contacts there told me that if a turbine made it through more than one monsoon season, that was a success," says Avellan.

More information: Sebastián Leguizamón et al. A multiscale model for sediment impact erosion simulation using the finite volume particle method, *Wear* (2017). [DOI: 10.1016/j.wear.2017.10.002](https://doi.org/10.1016/j.wear.2017.10.002)

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