Increasing hydropower capacity without straining the environment

April 29 2013, by Jan Overney

Detail of a small hydropower plant built in 2011 on Aurino river, Aurina valley, Bolzano, Italy. Credit: Agenzia Ambiente - Ufficio tutela Acque della Provincia di Bolzano

With over 800 mini-hydroelectric plants awaiting approval in Switzerland, the biodiversity of Swiss river ecosystems could be at stake. More enlightened policies could help preserve the environment.

As nuclear power production is phased out in several countries in the wake of the accident at the Fukushima nuclear power plants, renewable energy is expected pick up much of the slack. Switzerland expects a 10% increase in its hydropower capacity by 2050 by expanding its existing hydropower installations and authorizing the construction of hundreds of new mini-hydropower plants, leaving few river courses untouched. But what does this mean for the country's river ecosystems? Under current policy this could lead to a dramatic change of biodiversity, argues Paolo Perona, professor in applied hydro-economics and fluvial morphodynamics. In two recent publications, he outlines how a change in policy could help maintain the natural fluctuations in river flow that are fundamental in driving many ecological processes without hampering the economic productivity of existing hydropower installations. We met Paolo Perona for an interview.

How do you expect Swiss hydropower to evolve in the near future?

Because of Switzerland's recent decision to abandon nuclear power and expand hydropower, the population will begin to see exploitation touch almost all rivers. This could be a positive development, provided that we proceed with common sense. Mini-hydropower, using installations with a capacity of less than 10 MW, is one component that is expected to increase, especially given that it is faster and less expensive to implement. In fact, since the Federal Offices for the Environment and Energy, and the Federal Council have decided to invest into hydropower, around 800 new projects have been proposed, to be located in valleys all across the country. Many have already been approved and are now going into construction.

That must have quite an impact on the environment.

To limit the environmental impact, measures have been put in place to ensure that rivers never dry out. But the problem is that these measures kill the natural variability of the river. The challenge is the conciliation of river management from an ecological and an economic point of view. In 1992, the Swiss population voted in a law to protect the environment by imposing a minimum flow on all rivers that are impounded, for instance for the generation of hydropower. Today, this law sets a minimum standard. In many places, for instance, two or more minimum flow rates are imposed, depending on the season.

Why is it so important to preserve the natural variability of the river flow?

A lot of - perhaps even all - river processes are dictated by flow variability initiated by precipitation, and the melting snow and ice within the catchment. Consider sediment transport. Different sediment sizes are moved and deposited by different flow rates. In this way, habitats are moved and created. Through floods, variability also connects the river to its floodplain. This guarantees the renewal of soil moisture, the delivery of nutrients, and the removal of debris, benefitting both flora and fauna.

What happens when we remove this variability?

In the Maggia Valley, a strongly impounded system that is regulated using a two-threshold minimal flow release approach, we observed and modeled the effect of artificially altered flow regimes. One thing that became clear is that this regulation triggered a change in the vegetation and in its renewal dynamics. The problem with this is, once new trees or other vegetation have settled and grown deep roots, uprooting them is not just simply a matter of going back to the natural flow regime. The trees are too old. So you would need to wait a long time to bring back the system to its original state.

So how should we decide how much water to leave to the environment?

We decided to look at the problem using an approach borrowed from economics, called marginal analysis. As an example, say you have two people that are both thirsty, but you only have two liters of water to offer them. One person may need one liter of water to fully quench his thirst while another may need three liters. Marginal theory says that there is a point where these two liters of water are distributed optimally. That point is reached when both people would attribute the same value to the next sip of water they are offered.

How does this apply to river ecosystems?

Using this approach, we can allocate water among economic users and the environment in such a way that both benefit equally. When we do this using a method we recently published, the flow that is released downstream of a diversion point - water that is provided to the environment - is very similar to the flow in a natural river ecosystem, with similar variability, only with a lower magnitude.

What would be the financial impact of varying river flow rates to mimic the natural situation?

Of course we are removing water from the economic user. But if we are able to remove the water in the same amount as current law would have it, for example on a two threshold basis, but make it variable, we can preserve its value for business. At the same time, we greatly improve the ecological benefit thanks to the variability that we obtain. To qualify the ecological benefit more accurately, we are currently running field and lab experiments with Alexandre Buttler from the ECOS lab at EPFL.

Have you been able to test this on a real stream?

In the Canton of Graubünden, there are some mini-hydropower development projects where they plan to divert water from the river using a proportional distribution – a subset of the theoretical model we developed that has already been put into practice in some neighboring countries, such as Italy and Austria. Lorenzo Golra, a PhD student in my group, ran a case study on one of these projects and published his results in a second paper. He analyzed four different distribution scenarios, the natural scenario, and our optimal scenario. The results show that our approach based on a dynamic redistribution policy performs better than approaches based on minimum flow releases and proportional distribution approaches when we compare a number of economic and hydro-ecological indicators.

So will Switzerland be able to expand its hydropower capacity sustainably?

It depends on how we decide to manage water in these ecosystems. We can exploit a river for 40 or 50 years and then decide that we want to bring it back to its natural state, but we don't know how the ecosystem will respond. Does it make sense to invest a lot of money after 50 years for restoration if we could invest a little now, and perturb the environment less? In contrast, our research sends a message that we can move away from a restoration-based to a preservation-based approach. Let's exploit the river economically, but if we can do it with less impact, we will save a lot of money in the future. Ecosystems are only resilient to a certain point. But beyond that point, they are unlikely to bounce back promptly by simply restoring the river.

More information: Perona, P., D. Dürrenmatt and G. Characklis (2013) Obtaining natural-like flow releases in diverted river reaches from simple riparian benefit economic models. *Journal of Environmental Management*, 118: 161-169, dx.doi.org/10.1016/j.jenvman.2013.01.010

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Provided by Ecole Polytechnique Federale de Lausanne