The Unexpectedly Large Impacts Of Small Hydropower

In 2008, Switzerland introduced a feed-in tariff to promote the expansion of renewable energy sources. While the law incentivized sources such as wind and solar, the developers of small hydropower projects were the biggest beneficiaries: following passage of the feed-in tariff, 116 small hydropower dams have been constructed across streams all over Switzerland.
Although these small dams don’t flood whole valleys the way large hydropower dams often do, they still fragment streams, prevent fish from moving upstream and, by diverting most of the water out of the channel and towards a powerhouse, leave long stretches of stream with dramatically reduced flow during much of the year. In most cases, they also degrade the aesthetic beauty of a free-flowing stream in a bucolic valley.

And what did Switzerland gain for dotting its beautiful landscape with more than a hundred small dams and fragmented streams? The new small hydropower projects generate 498 gigawatt hours (GWh) per year, less than 1% of the country’s annual generation. In comparison, a project to rebuild an existing large hydropower dam on the Rhine with a new design added more than 400 GWh, nearly equivalent to the generation produced by the 116 new dams.

And it’s not just Switzerland - a recent study found that there are at least 83,000 small hydropower dams around the world (more than 10 times the number of large hydropower dams), with tens of thousands more in the planning pipeline.

But the Swiss example does effectively illustrate three major issues when it comes to small hydropower. First, small hydropower is generally assumed to be a low—or even no—impact source of low-carbon electricity. But, as discussed below, this assumption is often not true.

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Second, due in part to the presumption of low impact, small hydropower is often incentivized in policies to promote renewables under climate change objectives.

Finally, these incentives can trigger investment that leads to a proliferation of small dams that collectively make an insignificant contribution to the national grid, even as they may cause substantial cumulative environmental impacts.
These issues underscore that decision makers and energy planners should evaluate small hydropower on its actual impacts and realistic contributions to energy and development gains, not on overly simplistic (and often inaccurate) assumptions. In most cases, subsidies or incentives for small hydropower dams would be better directed at other renewable options, ranging from new solar to modernizing existing hydropower plants and adding turbines to non-powered dams (e.g., irrigation dams).

This is not to say that small hydropower is never an appropriate solution. In fact, small hydropower (or even micro-hydropower) can provide electricity to remote communities or contribute to decentralized mini-grids serving areas outside primary grids. And companies are finding innovative ways to deploy small hydropower that are truly low or no impact, such as adding turbines to irrigation dams or canals.

But these examples remain a small portion of investment in small hydropower; the majority of small hydropower should receive much greater scrutiny based on the three issues highlighted above.

A 9.9 MW hydropower project in Albania that de-waters a stretch of the Rapuni River downstream (from Google Earth).

First, does small hydropower equate to low impact hydropower?
One challenge to answering this question is that the definition of small hydropower varies dramatically. In the European Union, small hydropower refers to power plants with a capacity less than 20 megawatts (MW), but in individual countries the threshold can be lower, such as Sweden where it is 1.5 MW. In India the threshold for small hydropower is 25 MW, but it’s 30 MW for Brazil and 50 MW for China and Canada. In the United States, various states define it as anywhere between 2 and 50 MW.

So, given that the definition of small hydropower is highly variable, what do we know about the impacts of hydropower projects that fall in that range—both as individual dams and through the cumulative impacts of multiple dams?

In terms of individual impacts, an important concept is that the “small” in “small hydropower” almost always refers to the capacity of the turbines, not the size of the dam. To illustrate what this means in practice, consider two hydropower dams on the Elwha River in Washington – the Elwha Dam (15 MW) and the Glines Canyon Dam (13 MW). These would have qualified as small hydropower according to most definitions yet, to any observer, there was nothing small about them. Standing 108 feet (33 m) and 210 feet (64 m), respectively, they were substantial structures that completely filled the canyon of the Elwha (see photo below). Their impacts were not small either, as together they caused a 99 percent reduction in the Elwha’s salmon numbers, previously upwards of 400,000 per year across five species of salmon. The U.S. has now invested $350 million to remove the dams and restore the salmon.

Similarly, three dams on the Penobscot River in Maine have been removed to restore migratory fish populations, costing approximately $50 million. Fully blocking the most important river in New England for fish such as Atlantic salmon and shad, the only thing small about these dams was their generation capacity, averaging 6 MW per dam. Similar to the Elwha, these dams would have qualified as “small hydropower” by nearly all definitions, yet each one had substantial environmental and social impacts.

The Penobscot and Elwha dams were quite old and today it is unlikely that such large and damaging dams would be built for such small gains in electricity. But
considering that some countries would define a 50 MW dam as “small hydropower”, it is worth noting that even individual small hydropower dams, if built in the wrong place, could have impacts on fisheries or other values that could affect whole regions.

![Removal of the 13 MW Glines Canyon Dam on the Elwha River (Washington state, US) JOEL ROGERS](image)

More likely, it is the cumulative impacts of small hydropower that should draw the concern of decision makers and energy planners, as illustrated by the proliferation of small hydropower dams in Switzerland. Though each of these dams may have a much smaller impact than the examples from the Penobscot and Elwha, what about hundreds of them, particularly when scaled to their energy contribution?

Three recent studies—from Norway, Spain, and China—have all concluded that small hydropower projects have larger impact per megawatt than do large projects. For example, in the Duero River Basin in Spain, small hydropower projects (defined as less than 10 MW) caused nearly one-third of the total hydropower impacts in the basin, such as length of degraded channel and area of flooded land, but produced only 7% of the total generation. Further, with 140
small projects compared to 17 large, small hydropower created more than seven times as many barriers (e.g., for fish movement) compared to large hydropower. Meanwhile, the energy generated by small hydropower was 15% more expensive and was less flexible in terms of meeting grid demands.

Similarly, a study on the Willamette River basin in Oregon found that a set of small hydropower dams contributed less than 2% of the basin’s total generation but caused nearly half the total loss of channel length available to salmon.

Thus, the presumption that small hydropower is low impact does not stand up to scrutiny.

But, globally, policies for small hydropower reflect the presumption, not the reality.

We now turn to the second and third issues and examine the policies that incentivize small hydropower and then consider whether those policies spur substantial contributions to clean energy and climate objectives.

In the US, several states with Renewable Portfolio Standards (which mandate a higher proportion of renewables in the state’s electricity generation mix) don’t include electricity from large hydropower dams but embrace power produced from small projects (defined inconsistently as a megawatt capacity less than 30, 50, or even 100).

The Clean Development Mechanism, launched under the Kyoto Protocol and intended to reduce greenhouse gas emissions, promotes small hydropower and streamlines its review due to perceived lower environmental impacts.
Countries across the globe—from China to Brazil to the Balkan countries of southeast Europe—have passed policies promoting small hydropower and subject its development to far less planning and regulatory oversight compared to large projects.

Thus, climate and energy policies are promoting investment in small hydropower. But how much will the subsequent investment contribute to climate and energy objectives? The case of India is instructive. India’s renewable energy objective does not count large hydropower toward its total goal, but it does include small hydropower, defined as projects less than 25 MW of capacity. The policy seems to anticipate what the experience in Switzerland already demonstrated: the total contribution from small hydropower will be, well, small.

India plans for 5 GW of small hydropower out of a total renewable goal of 175 GW. Even if each project built was the maximum 25 MW, that would require 200 new dams to provide just 3% of the renewable goal; because the proliferation of dams following incentives will likely include many that are much smaller than 25 MW, India could see thousands of new dams for what will amount to a rounding error in its national energy supply, even as studies show that small hydropower dams are having larger than expected environmental impacts.
Taken together, these results and trends suggest that much greater caution and consideration is needed to guide planning and policy for small hydropower.

Though small hydropower may be appropriate for some situations—and there is considerable potential for innovation for small hydropower added within existing infrastructure—policies that promote the proliferation of small hydropower with limited oversight will likely produce significant cumulative impacts for insignificant increments of additional generation, while potentially diverting resources away from more effective solutions. Failure to improve policies that govern small hydropower risks the loss of tens of thousands of kilometers of healthy streams and rivers with very little electricity to show for it.

As global lead scientist for freshwater, I work across WWF’s network and with external partners to integrate scientific research into strategies for river conservation and sustainable energy development. My recent research has focused on the economic, financial and environ...

My book, Floodplains, can be found here.

How Financial Services Executives Can Stay Competitive In Today's Changing Landscape

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Three key trends are reshaping financial services. An increasingly stringent regulatory environment is shifting organizations’ focus from managing risk to protecting consumer data. FinTech companies are giving traditional banks a run for their money—literally—with new business models and innovative products.
And disruptive technologies, such as artificial intelligence and blockchain, are enabling faster transactions while eliminating intermediaries.

Together, these trends are setting new standards for those in the industry, from the C-suite to general counsel. In fact, 91% of financial services executives recently surveyed by Forbes Insights believe the role of general counsel has significantly changed over the past three years. C-level executives are no exception as they grapple with issues of increased competition and digital disruption.

To succeed, those working in the sector must possess the right combination of industry knowledge and technical know-how. Here are the three most sought-after skills.

1. **A tight rein on regulatory developments:**

Today’s regulatory environment is more challenging than ever. The recently introduced General Data Protection Regulation (GDPR) requires companies handling the data of EU citizens to comply with strict data privacy regulations. At
the same time, issues around consumer protection, anti-bribery, corruption and cross-jurisdictional variability are putting increasing pressure on financial services executives and general counsel to respond rapidly to regulatory risks.

“They really need to be completely up on all the new regulatory developments,” says Helen Howard, director of Taylor Root North America, a recruitment agency for global legal, compliance and risk professionals. “It’s not enough that someone has skill sets in general banking, capital markets or securities. They also need exposure to SEC regulatory matters.”

Indeed, the regulatory environment was cited as the most important trend for organizations over the next three years in the Forbes Insights survey. Fifty-seven percent also cite regulatory compliance as an area of legal expertise that will be most needed over the next three years.

In addition to having a deep understanding of regulatory issues, Howard says general counsel and those in the industry must also “heavily network” to forge “relationships with regulatory bodies”—connections that allow for informal information-gathering and opinion seeking.

2. A comprehensive understanding of technology:

Disruptive technologies are a double-edged sword for many working in financial services. While automation and artificial intelligence tools can introduce streamlined processes and innovative business models, others, like blockchain, present significant legal risks.

Fortunately, online courses, seminars and trade journals can improve technological fluency. In the case of general counsel, Howard says, they must also be willing to “broaden the view of their role. A general counsel isn’t just there to advise on legal matters. They’re there to work with the CIO to see what kind of technologies the legal team might need.” In turn, the C-suite must create a seat at the table for leaders from all business units.

3. An agile mindset:
Fast-moving FinTechs are challenging the more legacy business models in banking. In fact, 48% of survey respondents are currently partnering and/or collaborating with FinTechs. At the same time, virtual currencies and cryptocurrencies are redefining the role of banks as they eliminate the need for middlemen in transactions.

To thrive in this challenging marketplace, Howard says, many financial institutions, particularly startups, are looking for employees, which includes lawyers, who “are intellectually nimble and can pivot quickly.” The best candidates, she adds, are those who have worked for multiple corporations and industries, and therefore know that there’s more than one way to tackle a challenge.

Another desirable trait: the ability to anticipate change. “Having an understanding of cryptocurrencies and blockchain and of what those innovations might bring in terms of change are much sought-after skills,” says Howard.

Regulatory changes, disruptive technologies and a fluid competitive landscape are redefining what it means to work in the financial services sector. To stay relevant, those in the industry must embrace continuous learning while opening themselves up to new roles and partnerships.
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