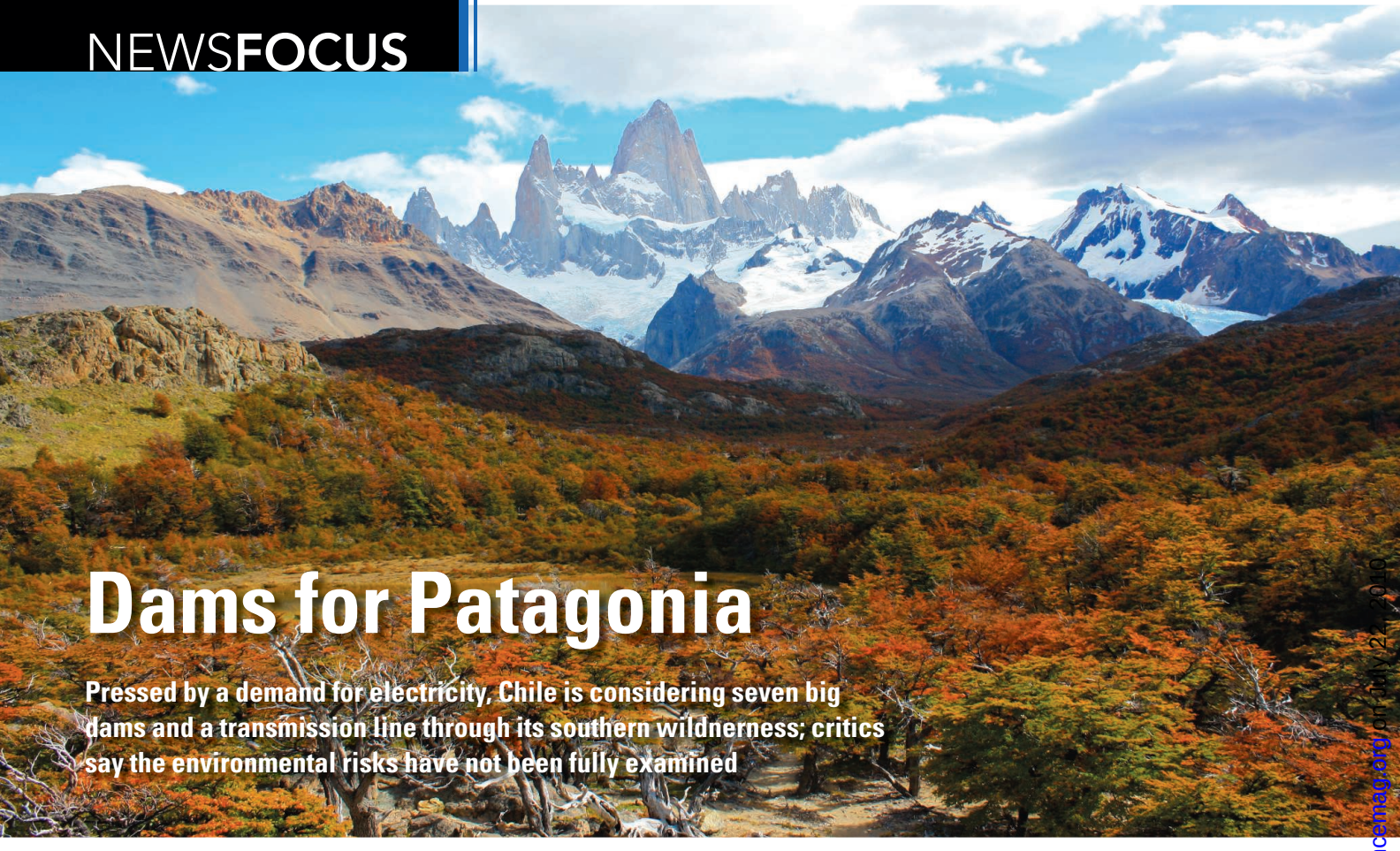

Dams for Patagonia

Pressed by a demand for electricity, Chile is considering seven big dams and a transmission line through its southern wildnerness; critics say the environmental risks have not been fully examined

COYHAIQUE, CHILE—In rolling hills at the foot of a basalt massif, the people of this compact, ordered town live mainly by fishing and cattle ranching. For many, life is not dramatically different from that experienced by the pioneers who first cleared the valley nearly a century ago and built timber homes. But graffiti around town reveal a new disquiet. "Patagonia Sin Represas!" ("Patagonia Without Dams!") is perhaps the politest of the slogans sprayed across the walls and buildings of this place, the capital of the Aysén region in Patagonia. They reflect anger over plans to build at least seven major hydropower dams in the area.

Home to condors and alpaca-like guanacos, puma, and blue whales, Patagonia is the tail end of the Americas, one of the last accessible nowhere lands on the planet. It contains the Southern Ice Field, the world's third most important reserve of freshwater after Antarctica and Greenland. And in its untamed wilderness of glaciers and mountain peaks, companies are preparing to raise not just hydrodams but also a 70-meter-high transmission line to transport power more than 2400 kilometers north to Santiago, Chile's capital, and the energy-hungry mines beyond. The line would require one of the world's biggest clear-cuts, a 120-meter-wide corridor through ancient forests—fragmenting ecosystems—and the installation of more than 5000 transmission towers.

Proponents of the dams argue that hydroelectricity is a clean source of energy, that Chile needs the 3500 MW/yr of power to meet its development goals and, lacking oil or coal reserves, has no viable alternative (see sidebar, p. 384). But more than 50 international environmental groups have come together to try to block dam construction under the umbrella organization that uses the slogan "Patagonia Sin Represas" as its name.

"People feel strongly about these dams," says Peter Hartmann, regional head of Chilean Friends of the Earth, one of the main opposition groups. "The megadam projects would change this region radically and ruin the valleys." So unpopular are the construction schemes that Chile's second biggest bank, BBVA, announced in January that it would not be assisting the power company, HidroAysén, with loans for hydroprojects, citing environmental and social concerns.

The controversy raises questions about the goals of economic development and about the definition of environmentally clean energy—issues that divide the entire nation. National surveys show that about 53% to 57% of respondents are against the dams. This ensures that the government, which in the coming months is supposed to rule on the viability of initial projects, will face trouble no matter what it decides. Questions have been asked and answered by the thousands; still, key information is lacking.

Online
sciencemag.org
Podcast interview with author Gaia Vince.

Hydroelectric gold. Patagonia's glaciers hold one of the planet's largest freshwater reserves.

CREDIT: NICK PATTINSON

Unquiet land

In August 2008, HidroAysén, the company behind five of the proposed dams, submitted its environmental impact assessment (EIA) to Chile's national environmental authority CONAMA for regulatory approval. It is one of 32 government departments charged with assessing the EIA; reviewers found the document so wanting that CONAMA instructed the company to address more than 3000 comments and gave a 9-month extension.

In October 2009, HidroAysén submitted its response, a 5000-page document that brought more critical comments. These included criticisms that the EIA lacked data on seismic risks in an area known for earthquakes and volcanoes; gave no accounting of glacial lake outburst floods (GLOFs); and had insufficient information on impacts to key natural habitats, biosphere reserves of

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global importance, and wetlands and aquifers. The departments issued another 1000 comments in January 2010; HidroAysén's response—after another extension—is due in October.

According to Hartmann and his supporters, the EIAs submitted so far have overlooked entire areas of impact. "Many of the places to be assessed are inaccessible without a helicopter, so the assessors fly in, stay one night and see no wildlife and conclude there's nothing there. But that's no way to study an area," Hartmann says. Among the diverse species threatened by the dams, he says, are endangered huemul deer (the Chilean national symbol), native fish otter, and unique cold-water corals that are only now being discovered by marine biologists at river outlets.

One of the three dam sites proposed by the company XSTRATA on the river Cuervo lies directly above the Liquiñe-Ofqui fault that runs northward from a triple junction where the Nazca, South American, and Antarctic plates meet. The plates move relatively slowly here, about 2 cm per year, compared with farther north near Concepción where the rate averages 10 cm per year, and the friction is less, says geologist Fabien Bourlon of the Research Center of Patagonian Ecosystems (CIEP) in Coyhaique. That means that the likelihood of a massive magnitude-8.8 earthquake, as occurred at Concepción in February, is less, but nevertheless, there is no study to support this, he adds.

Chile's National Geology and Minerals Service agrees, saying that proper seismic studies need to be carried out before a hydrodam is approved at the site. In 2007, 1 month after XSTRATA submitted its EIA declaring the Cuervo siting to be on a seismically inactive zone, the area experienced a massive earthquake that dislodged boulders into the fjord below, triggering a tidal wave that killed people on the opposite bank. "The government threw out their report," Hartmann laughs.

"Actually, what we're seeing at the point where the three plates meet is an opening process—a rift—so volcanic or magmatic material could rise there," Bourlon says. "And there's a volcanic gap at the dam sites. A line of volcanoes stops north of the site at Chaltén, and then there are none until Hudsen to the south. So it's likely there's an undiscovered volcano there," he adds, maybe smack in between at Mount Arenales. "This area is very little studied because it's between two ice fields."

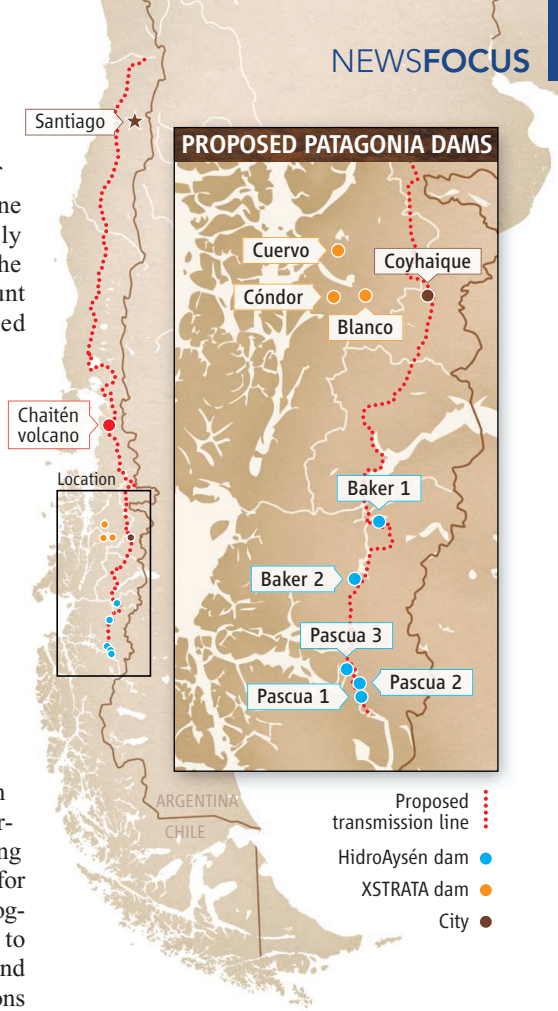
Known volcanoes could be serious trouble for a dam, too, Bourlon says. If Hudsen were to erupt, large pieces of rock and debris could rupture the turbines, and volcanic ash could quickly silt it up. No one has looked at these risks, he adds. The transmission line for the project was originally planned to run right over Chaitén, the volcano that erupted so spectacularly in May 2008, with plumes of ash that rose 16,700 meters and buried the village. HidroAysén now plans to reroute the line, most probably via the coast.

XSTRATA points out that most of Chile is seismically or volcanically active, which has not prevented the country's numerous other hydroelectric projects from going ahead. "The Environmental Impact Study for Cuervo Hydroelectric Plant includes geological baseline studies with specific studies to establish the seismic and volcanological conditions and geological hazards in the project area," says Christian Nuñez, environmental manager for Energía Austral, which runs the XSTRATA project. "To ensure the safety of the project, an engineering design was chosen that took into account the most extreme probable seismic scenario and the accelerations and landslides that could occur in this type of event. The Macá and Cay volcanoes, among others, have been incorporated into the risk evaluations," Nuñez adds.

Activist. An opponent of dams, Peter Hartmann wants Patagonia to be a "reserve for life."

Ice floods

The threat is not only from below ground. In Patagonia, glacial lakes often overrun their banks and send meltwater surging downstream; such GLOFs are becoming more frequent with global warming, according to the country's climate scientists. There are currently five GLOFs in the North Patagonian ice field, with a large one spilling at the headwaters of the Baker River since 2008.



Powering up. Companies plan to send electricity north to Santiago on more than 5000 towers.

"They are preparing to construct dams on what is probably the most unstable river system on the planet," says Brian Reid, a limnologist at CIEP in the University of Austral, Valdivia. "To what extent it is active we don't know because it's never been studied."

The GLOF analysis submitted in HidroAysén's EIA was "utter nonsense," says Claudio Meier, a hydrological engineer at the University of Concepción. "They looked at water-level data for 1963 to 2007—less than 50 years—and extrapolated to obtain a 1-per-1000-year GLOF risk," Meier says. "In fact, the peaks that they saw during the data period were just normal seasonal floods. The major GLOFs that occurred in that region were in 1962 and 2008; we've had six events there in the past 2 years." The company needs to look at megaflood occurrences and come up with a risk for 1-in-5000-year and 1-in-10,000-year events, he says. GLOFs "have been much larger in the past than anything we're experiencing now" and have been known to flow at the extreme rate of 15,000 m^3/s.

Reid also questions whether the dam could withstand the sediments a GLOF dumps, which both increase the flood levels

CREDITS: (MAP SOURCE) XSTRATA; HIDROAYSÉN; AND D. TOMPKINS *ET AL.*, *PATAGONIA SIN REPRESAS*; NICK PATTINSON

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A Craving for Hydropower

The reason Chile must build at least seven new hydrodams, sponsors of the projects say, is that forecasts show that the country desperately needs more electricity—and that it must come from Chilean sources. Environmentalists and independent energy analysts have challenged this view; they argue that by improving efficiency and investing in renewable energy, Chile could find more than enough power within its borders for at least a decade—and without more dams. So far, however, energy planners have not been persuaded.

To meet future energy demands, according to April 2008 government projections, Chile needs to double its installed energy-generating capacity over the next decade and triple it by 2025. With virtually no coal and no oil or gas, the country imports more than 95% of its fossil fuels. This is one reason Chile has the most expensive energy on the continent and why leaders want to expand domestic energy production. Half the country's electricity comes from plants fueled by Argentinean oil or gas and Columbian coal. The other half comes from existing hydropower schemes, many of them in the central zone around the Biobío River.

Only one option. Government energy adviser Claudio Zaror believes Chile must embrace the hydrodams.

In the summer of 2008–09, Argentina cut off gas supply to Chile at a time when months of drought had reduced Chile's hydropower capacity. The nation was plunged into blackouts. A powerful earthquake near Concepción in February again caused blackouts across the central grid after a single transmitter went down. Developing a new southern source of electricity became an attractive goal.

"The earthquake definitely boosted our chances of approval. … We may have another year's delay, but we'll be approved," predicts an employee of HidroAysén, the company proposing to build five of the dams, speaking on condition of anonymity.

But a 2009 study by a consortium of Canadian and Chilean energy analysts disagrees. In their report, titled *Are Dams Necessary in Patagonia?*, Stephen Hall and his colleagues say that the country's projected electricity requirements to 2025 can be met by newly approved plans for coal plants. Even without the plants, they argue, Chile could obtain the 3500 megawatts per year promised from new Patagonian dams through energy-efficiency measures (3041 MW, they calculate) and renewable energy development (4383 MW). The total gain would be twice that generated from the Patagonian dams, they say.

The green energy–conservation pitch has not persuaded Claudio Zaror, a chemical engineer at the University of Concepción and an energy adviser to the government. "Every year, the country needs an extra 500-MW capacity—another 8% a year," Zaror says. "We have to get that energy from somewhere. Environmentally and economically, hydropower is our only feasible option."

The situation is more perilous than some realize, Zaror says, because droughts are predicted to become more frequent and more severe across the central region, which includes the Biobío River, source of most of the nation's hydropower. Studies by the Global Change Research Center in Santiago completed in May 2009 predicted that average rainfall would decline in this region by 15% from the present by 2050 and that by 2065 the flow of the Maipo River would drop 70%—from an average of 170 m^3/s to 60 m^3/s. These conditions have already arrived, thanks to a severe drought that began in 2008 and from which Chile has yet to recover. Already, Zaror says, the drier climate caused by an El Niña ocean-current shift is affecting the region between Concepción and Santiago. "During the 2008 drought, less than 15% of the baseload was met by hydro, and we had to import diesel for the power plants at $118 per barrel," Zaror says. He argues that Patagonia won't be affected as severely by drought: With 92% of the country's glaciers retreating, he predicts, the south will continue to enjoy strong river flow.

For Zaror, the issue is clear-cut. "Per capita income correlates closely with per capita energy consumption, so for a developing country, consumption will rise," Zaror says. "We have nearly 20% of the population living in extreme poverty at the moment. I want that number to decline, and we need energy for that." **–G.V.**

Icy flow. One of two glaciers in Patagonia that is not retreating, Perito Moreno supplies the Baker River with meltwater.

CREDITS: NICK PATTINSON

and reduce the hydrodam's life span by raising the reservoir bed and clogging the turbines. "A GLOF in Iceland in 1996 deposited 1% of the world's sediment load for a year in a 12-hour period, making it the second largest river in the world during that time. Would the HidroAysén dam cope with this? Could they open the gates in time?" Reid asks. He doesn't think there is a clear answer, noting that "I am the only person who's even studied suspended sediments during a GLOF."

HidroAysén says it is confident that its planned dam would withstand a GLOF, because it is designed to support a flow of 7000 m^3/s. HidroAysén's experts—a range of in-house experts and contractors—calculate that a GLOF occurring during peak flow would double the rate to no more than 6000 m^3/s, comfortably within the dam's margins.

Breaking the wilderness

One of scientists' big worries is that hydrodams and other development could mar unique, unstudied areas. For example, on the Baker River, one of the proposed dams "would flood large areas of peat bog based on volcanic ash soils and destroy a lot of unique wetland habitat that hasn't even been studied," Reid says. These areas are important habitats for fish and vulnerable to the practice of "hydropeaking," flooding and draining a reservoir. "Artificial water level fluctuations disturb the natural seasonal synchronicity in a lake," Meier says.

The effect of artificial daily pulses on fish can be devastating, says Evelyn Habit, a native fish biologist at the University of Concepción. "All the important spawning areas are in the wetland zone of daily flood and drop; if you lose spawning areas, you lose the species. Adults live in very deep layers

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Vanishing. Large areas of unstudied ancient peat bog would be flooded by proposed dams.

and use the signal of water levels to know when to feed and reproduce, so if it's changing daily, it's unpredictable."

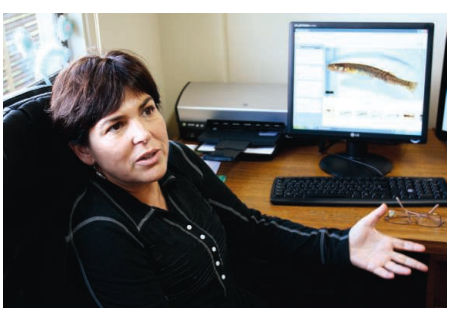
The wetland areas are also an important source of fish food—terrestrial debris—that would be lost if the forests are disconnected from the water by artificial floods and dams. "All our fish are benthos feeders, and they need large, woody debris. There's no information on these impacts in the EIA," Habit says. She's also concerned about how new roads and commercial development could affect unique fish species including, in the Yulton and Meullin lakes, the site of the proposed XSTRATA dam, a genetically distinct *Galaxias platei* species of primitive fish.

XSTRATA maintains that it has voluntarily set operating restrictions for its Cuervo plant to minimize the environmental damage from hydropeaking. "By maintaining variations within ranges that occur naturally in the existing banks, the company aims to limit the potential impact on the bank environment." Nuñez says that simulations indicate that the hydropeaking variations "will be achieved with similar minimum and maximum levels to the current lake system."

The Baker River is the most important river to protect, according to Habit, because of a historical quirk that has infused the system with uniquely rich biodiversity. During the last glacial period, 10,000 to 20,000 years ago, the river reversed direction, now flowing to the Pacific rather than the Atlantic. It contains "a unique population of fish that are endemic to Argentina," such as a diplomystes of a primitive catfish genus and *Odontesthes hatcheri* (silverside), a type of atheriniform, Habit says: "It seems crazy to me to make such a big alteration to such pristine ecosystems."

HidroAysén says it will replant trees elsewhere that are lost in its dam-building and "create an 11,560-hectare conservation area to safeguard the ecosystem and species." XSTRATA is also planning what it describes as "one of the most ambitious programs of reforestation with native species in Chile's history," to plant trees in parts of Patagonia that were burned by fires in the first half of the 20th century.

Nuñez, the company's environmental manager, also points out the greenhouse-gas benefits of hydro- versus fossil fuel–derived energy: "Energía Austral will have



Disruptive flow. Biologist Evelyn Habit fears that "hydropeaking" would devastate fish populations.

the capacity to displace from Chile's Central Interconnected System a total of 2.7 million tons of CO_2/year." HidroAysén has promised Patagonians an economic windfall if dams go forward: a reliable, cheap source of energy for the future.

Hartmann, standing under the three wind turbines that power the town of Coyhaique, says he's skeptical. "The same thing was promised for the people of Biobío before their dam was built; now they have the most expensive energy in the country," he says. "This project is not something to benefit the people of Chile; it is to make a few private companies rich at the expense of our shared environment."

And it is perhaps this more than anything that lies at the heart of the standoff. Those against the megadam projects do not feel that the cause to which they are being asked to sacrifice their shared environment is worth it. Most of the energy generated, they claim, will be used for privately owned mining concessions, which include Barrick Gold's environmentally controversial large new mine at Pascua-Llama, and not for Chilean households.

Thousands took to the streets of Chile's cities last month, from Coyhaique to Santiago, protesting the dams. Their numbers were swelled by those opposed to recent public attempts by HidroAysén to pressure the government into fast-tracking approval for the projects. The company's projected costs are now pegged at $7 billion. Thanks to another delay in the schedule requested by HidroAysén last month, the government will have until the end of the year to accept or reject the projects outright—or ask more questions.

Many believe that the decision ultimately rests with the conservative billionaire president, Sebastián Piñera, who may be as personally divided as his electorate. He is both a conservationist and a supporter of large private-enterprise projects like these. If the dams get the go-ahead, electricity production could begin as early as 2015; if not, Chile will be one of the few developing countries to choose to protect its natural environment over short-term financial gain.

–GAIA VINCE

Gaia Vince writes on environmental issues in the developing world at wanderinggaia.com.

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