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**Dams in the Amazon**

The rights and wrongs of Belo Monte  
Having spent heavily to make the world's third-biggest hydroelectric project greener, Brazil risks getting a poor return on its \$14 billion investment

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THE biggest building site in Brazil is neither in the concrete jungle of São Paulo nor in beachside Rio de Janeiro, which is being revamped to host the 2016 Olympics. It lies 3,000km (1,900 miles) north in the state of Pará, deep in the Amazon basin. Some 20,000 labourers are working around the clock at Belo Monte on the Xingu river, the biggest hydropower plant under construction anywhere. When complete, its installed capacity, or theoretical maximum output, of 11,233MW will make it the world's third-largest, behind China's Three Gorges and Itaipu, on the border between Brazil and Paraguay.

Everything about Belo Monte is outsized, from the budget (28.9 billion reais, or \$14.4 billion), to the earthworks—a Panama Canal-worth of soil and rock is being excavated—to the controversy surrounding it. In 2008 a public hearing in Altamira, the nearest town, saw a government engineer cut with a machete. In 2010 court orders threatened to stop the auction for the project. The private-sector bidders pulled out a week before. When officials from Norte Energia, the winning consortium of state-controlled firms and pension funds, left the auction room, they were greeted by protesters—and three tonnes of pig muck.

Since then construction has twice been halted briefly by legal challenges. Greens and Amerindians often stage protests. Xingu Vivo ("Living Xingu"), an anti-Belo Monte campaign group, displays notes from supporters all over the world in its Altamira office. James Cameron, a Hollywood film-maker, has chimed in to compare Brazil's dam-builders to the villains in "Avatar", one of his blockbusters.

But visit the site and Belo Monte now looks both unstoppable and much less damaging to the environment than some of its foes claim. The project has made it through Brazil's labyrinth of planning and environmental rules. Norte Energia has hired a second consortium comprising a roll-call of Brazil's big construction companies, which expects to finish work by 2019. Protected by a temporary cofferdam holding back the river's flow, labourers are digging a 20km canal to funnel water from the river to the site of the main power plant, where dozens of excavators are digging down through 70 metres of rock.

**The appeal of hydropower**

With tens of millions of its citizens moving out of poverty, Brazil can satisfy demand only if it adds around 6,000MW each year for the next decade to its installed generating capacity of 121,000MW. It has plenty of choices. Apart from huge deposits of offshore oil and gas, Brazil has the world's third-biggest hydropower potential (behind China and Russia), and its potential for solar and wind energy is probably among the three biggest, too. The world's largest sugarcane crop provides bagasse, a fibrous residue which burns in high-pressure boilers. The country may also have shale gas. "Brazil is very lucky: it has many choices about how to expand its electricity supply," says Claudio Sales of Acende Brasil, an energy-research institute. "But they are choices, and they need to be made."

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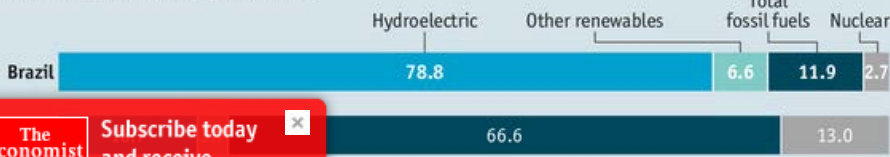
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## Dam good

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Brazil already generates 80% of its electricity from hydro plants—far more than other countries. But two-thirds of its hydro potential is untapped. The snag is that most of it lies in untouched rivers in the Amazon basin. Of 48 planned dams, 30 are in the rainforest (see map). They include the almost completed Jirau and Santo Antônio on the Madeira river, which will add 6,600MW to installed capacity. But it is Belo Monte, the giant among them, that has become the prime target of anti-dams campaigners.

Opponents say that dams only look cheap because the impact on locals is downplayed and the value of other uses of rivers—for fishing, transport and biodiversity—is not counted. They acknowledge that hydropower is low-carbon, but worry that reservoirs in tropical regions can release large amounts of methane, a much more powerful greenhouse gas.

In the 20th century thousands of dams were built around the world. Some were disasters: Brazil's Balbina dam near Manaus, put up in the 1980s, flooded 2,400 square km (930 square miles) of rainforest for a piffling capacity of 250MW. Its vast, stagnant reservoir makes it a "methane factory", says Philip Fearnside of the National Institute for Amazonian Research, a government body in Manaus. Proportionate to output, it emits far more greenhouse gases than even the most inefficient coal plant.

But many dams were worth it (though the losers rarely received fair compensation). Itaipu, built in the 1970s by Brazil's military government, destroyed some of the world's loveliest waterfalls, flooded 1,350 square km and displaced 10,000 families. But it now supplies 17% of Brazil's electricity and 73% of Paraguay's. It is highly efficient, producing more energy than the Three Gorges, despite being smaller.

Of Brazil's total untapped hydropower potential of around 180,000MW, about 80,000MW lies in protected regions, mostly indigenous territories, for which there are no development plans. The government expects to use most of the remaining 100,000MW by 2030, says Mr Ventura. But it will minimise the social and environmental costs, he insists. The new dams will use "run of river" designs, eschewing large reservoirs and relying on the water's natural flow to power the turbines. And they will not flood any Indian reserves.

That approach is being pioneered at Belo Monte. In the 1970s the military government dreamed of a sequence of five dams and huge reservoirs on the Xingu, which would have generated 20,000MW by displacing tens of thousands of people and flooding 18,000 square km, including Indian reserves. In all, it planned to flood 2% of the rainforest for reservoirs.

With democracy restored, the government ordered a rethink. The new plan for the Xingu involves just one dam complex, at the Volta Grande ("Big Bend"), where the river descends 93 metres in 140km—a large drop for Amazonia. Instead of from a reservoir, most of the water to drive the turbines will come by channelling part of the river's flow through a new canal, from Pimental to the main generating station.

That added more than 2 billion reais to the project's cost, but it avoids flooding Indian lands. Belo Monte will flood only 500 square km, mainly at the canal, according to Henrique di Lello Filho of the construction consortium. This area was already largely deforested by the building of the Transamazon Highway in the 1970s. Methane emissions should be small. Only 200 Amerindians



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will be directly affected (by the loss of fishing grounds).

Norte Energia has set aside 3.9 billion reais for mitigation and compensation payments. The constructors must build fish ladders, a boat-hoist to keep the river navigable, homes for 8,000 families (including 700 living in flood-prone *palafitas*, or wooden huts on stilts, by the riverside in Altamira), schools and health-care facilities, sewage connections and much more.

For activists in Altamira and some local Indians, this is not enough. They reject the project's impact on the life of the town, where the population has swollen to 100,000, raising rents and putting pressure on health services and schools. Xingu Vivo claims the cofferdam at Pimental has turned the river below it into stagnant pools of dead fish; it says neither the boat hoist nor the fish ladder will work.

#### More heat than light

Most of the Indian protesters live in villages several days upstream by *voadeira* (fast launch), and will not be directly affected by Belo Monte. But they say they feel threatened by it. Asked if any hydropower project on the Xingu could be acceptable, Juma Xipaia, who now lives in Altamira, replies: "No. It is impossible. For us, the water is everything." Nevertheless, a recent poll of 1,222 Amerindians from 20 tribes across the country found that most wanted the same things as other Brazilians: better health care and education, sanitation and electricity, more income and jobs.

The protesters' legal challenge to Belo Monte is based on the claim that they have not been properly consulted, something the government denies. The constitution says that before exploiting any resource on Amerindian lands, the government must consult the inhabitants. But it is silent on how this should be done. The International Labour Organisation (ILO) has a similar clause in its Convention 169 on indigenous rights, to which Brazil is a signatory.

The government says that since no demarcated territories will be flooded, such formal protections do not apply. "We hold consultations about the projects we're doing not because we have to, but because it is right," says Mr Ventura. Between 2007 and 2010 there were four public hearings and 12 public consultations about Belo Monte, as well as explanatory workshops and 30 visits to Indian villages.

In 2011, in response to a complaint filed by Indian groups, the Inter-American Commission on Human Rights called for a halt to construction pending further consultation. That was "precipitate and unjustified", said the government, refusing the request. The ILO has asked Brazil's government for more information on how it intends to fulfil its legal obligations.

The legal uncertainty surrounding Belo Monte is bad for both the Indians and contractors, says Mr Sales—not to mention Brazil as a whole. A draft law detailing how to consult indigenous people is expected by the end of the year. But before Congress legislates, ground is likely to have been broken on most of the new dams.

Run-of-river hydropower has a much smaller environmental impact than big reservoirs. But it is also less efficient. Belo Monte is an extreme example. The Xingu's highly seasonal flow means it will produce just 4,500MW on average, only 40% of its installed capacity. In the two driest months it will barely produce 1,000MW.

As run-of-river projects proliferate, generation will increasingly be at the mercy of rainfall. After successive dry years, in 2001-02 Brazilians lived through an *apagão* ("big blackout"), when electricity was rationed, hitting the economy hard. To prevent a repeat, the government commissioned thermal-power plants, fuelled by oil, coal and gas. They now make up a sixth of Brazil's total installed capacity, and supply around a tenth of its electricity.

But rising demand and the declining proportion of reservoirs mean this is no longer enough. "The capacity to store energy—that is, water—is now small for the size of the system," says Mauricio Tolmasquim of the Energy Research Agency, an arm of the energy ministry. "The country has started to run risks." A lack of rain meant that Brazil's reservoirs finished last year at just 30.5% of capacity, lower even than in the run-up to the *apagão*. This year the rains were more abundant; even so the national-grid operator has kept the thermal plants on right through the rainy season. That is costly: plants intended for irregular use are generally inefficient, and buying fuel at short notice is expensive. But the reservoirs must be kept as full as possible for 2014, when Brazil will host the football World Cup. A repeat of the *apagão* then would bring national humiliation.

#### Reservoirs or gas?

In the longer term Brazil plans to increase reliability by building more gas-powered plants, to be run permanently. An auction of up to five promising areas for shale gas is planned for December. "In about three years we'll have a clearer idea of the role non-conventional gas can play," says Mr Tolmasquim. "But from whatever source, thermal power is going to have to grow to at least 20% of our supply. The only other option would be more big reservoirs."

This would be a better option, argue some energy experts. Antonio Dias Leite, a minister of mines and energy during the military government, thinks that run-of-river hydropower constitutes an unjustifiable waste of energy. "It's strange the way people protest against reservoirs and not against gas-powered plants," he says. "I think there is still an argument for building some big reservoirs, chosen prudently."

Some greens argue that the choice between reservoirs and gas is a false one. Reducing transmission losses and modernising older hydropower plants would cut the need for both, says Célio Bermann, a hydropower specialist at the University of São Paulo. He thinks the rest of the gap could be filled with sugarcane bagasse—20,000MW could be added quickly—and windpower. Conveniently, the winds in Brazil's north-east, where many wind farms are being installed, are strongest during the dry season, when hydro output falls. Current plans involve using only a small fraction of Brazil's potential windpower of 143,000MW.

Such disagreements are best settled by estimating costs accurately. Brazil's institutions are ill-suited to this. Planning and environmental laws are Byzantine: getting licences and fighting legal challenges routinely adds years to schedules and billions to budgets. The result is more like an obstacle course than a cost-benefit analysis. The environment ministry and regulator play almost no part in deciding which projects go ahead: their main role is harm-reduction after the energy ministry has decided what to do. Both have seen bosses resign rather than sign up to infrastructure projects in the Amazon. These failures mean that the most important question—whether Belo Monte is really cheaper than the alternatives—has never been satisfactorily answered.

Recent windpower auctions, with hundreds of private-sector bidders, produced winning bids of 90-100 reais per megawatt-hour (MWh), a price that is hard to beat. Belo Monte was given an initial budget of 16 billion reais, which had risen to 19 billion reais by the time of the auction. Norte Energia's winning bid for Belo Monte offered a price of 77.97 reais/MWh. Since then, its budget has risen by a third.

Officials insist that the costs are Norte Energia's problem. That looks disingenuous. The group is almost wholly state-owned. In November, the national development bank gave Norte Energia a loan of 22.5 billion reais—its largest-ever credit. If Belo Monte turns out to be a white elephant, the bill will fall on the taxpayer.

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