

Cooperativa Regional de Eletrificação Rural do Alto Uruguai Ltda (CRERAL), Brazil

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Cooperative uses mini hydro to increase electricity supply on local grid

Summary

Cooperative Regional de Eletrificação Rural do Alto Uruguai Ltda (CRERAL) is one of a number of electrification co-operatives supported by the Brazilian Government since 1969, to manage the supply of electrical power to rural areas. Alto Uruguai Gaúcho is a hilly district in Rio Grande do Sul, the southernmost state of Brazil. Although towns such as Erechim are well developed, the rural areas are sparsely populated, with people making a living from arable and livestock farming. The rural population has been declining as young people seek work in the cities in preference to farming.

Despite the low population density, since the mid 1980s most rural houses have a connection to the local section of the electricity grid, which is owned and operated by CRERAL. CRERAL used to buy all the electricity it needed from the local distributor. However, because of the limitation of supply, there were some restrictions on the uses of electricity. The CRERAL members therefore decided to develop small, local hydro plants, in order to increase supply and – equally important – improve reliability. These had to be ‘run-of-river’ plants which do not require significant areas of land to be flooded, so that families did not have to move from their farms. There is considerable concern in Brazil about the environmental and social impact of large-scale hydro.

Two mini hydro schemes have been developed and installed by CRERAL, at Abaúna and Cascata das Andorinhas. The Abaúna scheme has a low-head Kaplan turbine, rated at 720 kW, which generates about 1.7 GWh/year. The larger Andorinhas scheme uses two high-head Francis turbines to give a total capacity of 1,200 MW, and generates about 3.7 GWh/year. Together they supply about 24% of the current CRERAL demand.

CRERAL customers are very pleased with the increased amount of electricity which has been available since the mini hydro schemes started, and also the reduction in power cuts due to better quality of the electricity network. They have been able to install more agricultural equipment, for instance milking machines and refrigerators which have increased sales of milk and cheese. In homes, popular purchases include labour-saving equipment like washing machines and sewing machines, which allow people to spend longer on income-generating activities. The more comfortable living conditions and higher earning potential may encourage people to remain in rural areas.

Both schemes were funded on a commercial basis, without grants. CRERAL funded 60% of the US\$620,000 cost of Abaúna, and 30% of the US\$800,000 cost of Andorinhas from its own resources, and obtained loans from the regional public bank to cover the remainder. With the revenue from electricity sales at the standard tariff of R\$0.23/kWh (US\$0.14/kWh), the cost of the schemes will be paid back within seven or eight years. This rapid payback is due to the low capital cost of the schemes, existing infrastructure, the non-profit operation of the cooperative, and the availability of about 5% additional income from carbon finance.

CRERAL is keen to expand its portfolio of small hydro schemes, especially since demand is growing at an average of 6% per year, and it has plans for an additional 5 MW capacity, in partnership with other cooperatives and private developers. There are many other potential run-of-river hydro sites in the region, which could be brought into use. The CRERAL experience shows that, for a cooperative which owns its own distribution network, the introduction of mini-hydro plants can be very cost-effective.

The organisation

The Cooperative Regional de Eletrificação Rural do Alto Uruguai Ltda (CRERAL) is one of a number of electrification co-operatives supported by the Brazilian Government since 1969, to manage the supply of electrical power to rural areas. CRERAL is owned by 6,200 associates who make up most of its electricity customers, and has 49 employees and 240 volunteers. It has started to work on other aspects of local energy supply as well as electricity, including the study of biogas generation from pig farm waste, and small-scale distillation of ethanol from sugar cane. The turnover of CRERAL was about £1.7 million in 2006.

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Context

Alto Uruguai Gaúcho is a hilly district in Rio Grande do Sul, the southernmost state of Brazil. Although towns such as Erechim are well developed, the rural areas are sparsely populated, with people living in isolated farmhouses on small farms (average 20 hectares each). The warm, temperate climate is good for arable farming, and soya, maize and beans are the main crops. Dairy cattle, chickens and pigs are also common. For 90% of households, wood is the main fuel source for heating and cooking, usually gathered from their own land. Some of the inhabitants are from the indigenous Caingang people; others are descendents of settlers who came mainly from Poland, Italy and Germany in the 19th and early 20th centuries. The rural population has been declining as young people seek work in the cities in preference to farming.

Despite the low population density, since the mid 1980s most rural houses have a connection to the local section of the electricity grid, which is owned and operated by CRERAL. This local section is linked to the main national grid, and CRERAL used to buy all the electricity it needed from the local distributor. However, because of the limitation of supply, there were restrictions on the uses of electricity. The CRERAL members therefore decided to develop small, local hydro plants, in order to increase supply and – equally important – improve reliability. These had to be ‘run-of-river’ plants

which do not require significant areas of land to be flooded, so that families did not have to move from their farms. CRERAL hopes that an improved electricity supply will also encourage young people to stay in the rural areas.

Statistical information - Brazil	
Population (2005)	186.8 million
Urban population	84.2%
GDP per capita US\$ (2005)	\$4271
- at purchasing power parity	\$8402
Population living on less than \$1 a day (2005)	7.5%
Population living on less than \$2 a day (2005)	21.2%
Population with access to grid electricity (2005)	97%
Annual electricity consumption per person (2004)	2340 kWh
Annual CO ₂ emissions per person (2004)	1.8 tonnes
Population undernourished (2002-2004)	7%
Population with access to an improved water supply (2004)	90%
Source: <i>UNDP</i>	

Technology and use

The two small hydro schemes that have been developed and installed by CRERAL are located in Abaúna and Cascata das Andorinhas. They are both 'run of river' schemes, in which a proportion of the river flow is diverted into a canal, or leat, along the contour of a hill, before descending through a steep penstock pipe to the turbine. This type of scheme does not use a large storage dam to maintain the water flow and thus the power output throughout the year, but instead relies on a reasonably constant river flow.

Abaúna scheme

This scheme was commissioned in 2000. It has a small (2 metre high) dam which was adapted from an old hydro plant. A fish stair helps migrating fish to travel upstream. A sluice gate diverts part of the river flow (about 4 m³ per second) into a canal which runs for about 3 km along the contour. The water then falls about 21 m vertically inside a pipe before entering the turbine house. The flowing water drives the turbine and then returns to the river. The Abaúna scheme uses a single 720 kW Kaplan turbine, a propeller-type design which is particularly suitable for relatively low head (= low water fall) applications. The rotating turbine drives an electrical generator, which supplies 3-phase a.c. power at 380 volts. Transformers increase the voltage to 13,800 volts, which is the distribution voltage. The turbine runs close to full capacity for most of the year.

Cascata das Andorinhas scheme

At Cascata das Andorinhas or 'Swallow Waterfall', the river cascades over spectacular cliffs and into a thickly forested valley. Part of the river flow is retained by a 1 m high dam and a small balancing lake. Water flows out via a short pipe to the penstock, where it falls vertically through a 143 m head to the turbine house. Here it drives two 751 kW Francis turbines, which at full capacity (1.05 m³ per second of water flow) generate 1.2 MW of electricity. The Francis turbine is a reaction

turbine, in which high-pressure water impacts on an enclosed runner, and is commonly used for high-head sites. The Andorinhas scheme was commissioned in 2003, and at present operates at capacity for only about 70% of the year due to drought. When the water supply is low, only one turbine operates to give maximum efficiency.

Both plants were designed by Rischbieter Engineering, a Brazilian company specialised in mini-hydro schemes. The design was developed in collaboration with CRERAL and the University of Munich in Germany, which worked on the energy efficiency of the turbines. The turbines were manufactured by Hacker Industrial Company in Xanxerê, a small town about 150 km away. The electrical generating plant was manufactured by Weg Company in Jaraguá do Sul, about 600 km away. Installation was carried out by engineers from CRERAL and the manufacturers, using local people as casual labour.

In addition to the mini-hydro plants, CRERAL owns and manages the local grid which includes 1,717 transformers and 1,800 km of high and low-voltage lines supported on 19,800 posts.

How users pay

£1 = 3.336 Brazilian Reals (R\$) [April 2008]

The small hydro schemes feed power directly into the CRERAL local grid. The price which CRERAL charges for electricity is the same regardless of the source. However, urban households, commercial and industrial business, and public sector organisations pay more than rural customers. This is because they pay an additional tax, which CRERAL collects through the electricity bill and passes on to the government.

At present, 85% of the CRERAL customers (mostly farmers) are classed as rural, and they pay R\$0.23 (£0.07) per kWh, while urban customers pay R\$0.47 (£0.14) per kWh. The typical consumption of a rural household is about 250 kWh per month, and therefore costs about R\$58 per month, or about 10% of the average income in the rural areas. Customers take their own meter readings and are invoiced accordingly. The CRERAL verification team checks these readings annually by sending staff to read the meters.

Training, support and quality control

The plant operators and engineers have been on hydro training courses and have appropriate professional qualifications. Operators live locally and have a regular servicing and maintenance routine, including a daily check on each scheme. The part of the hydro plant which needs regular replacement is the turbine blades, which have an expected life of about three years. However, the blades at Abaúna which has been operating for eight years have been replaced only once. Both plants have proved very reliable, although there is a problem with oil seals at Abaúna. Customers call out CRERAL in the event of electricity supply problems.

One key role of CRERAL is encouraging customers to use energy efficiently, in order to limit the growth in demand and maintain the reliability of the system. This efficiency programme includes distributing guides, charts and cardboard 'calculators', and holding training sessions at meetings of the cooperative.

Benefits

During 2006, the Abaúna scheme generated 1,995 MWh and Andorinhas 3,589 MWh, a total of 5,584 MWh or 25.7% of the overall CRERAL demand. During 2007, generation was lower at 1,497

and 3,849 MWh, because of lower rainfall. Total demand increased by 7% between 2006 and 2007, so the 5,346 MWh generated by the hydro schemes in 2007 was only 22.9% of CRERAL demand.

The total demand from CRERAL customers has increased steadily from 13,500 MWh in 1999 (before the first plant was commissioned) to 19,900 MWh in 2007, so the mini hydro has provided for all the increase in demand over this period.

Direct benefits to users

The reason for the growth in demand is that customers are investing in more electrical equipment, because there is a more reliable grid electricity supply, and also because more families are joining (500 extra families during the past five years). Both of these reasons indicate that users are pleased with the outcome of the hydro schemes.

The new appliances purchased for the farms include refrigerators, freezers, feed mixers and milking machines. The additional supply capacity has made it easier for people to remain in rural food production, because the equipment speeds up production. Often the quality of products is also better. In particular, reliable refrigeration allows farmers to store milk, meat and cheese safely, and to sell more. Some farmers have seen their incomes rise by 50% as a result.

In homes, the purchases include sewing machines, irons, bread makers, toasters, washing machines and electric showers. Labour saving equipment, such as washing machines, is enormously popular, and allows people to spend longer on income-generating activities. A key benefit is being able to operate several devices at once. The more comfortable living conditions and higher earning potential may encourage people to remain in rural areas.

Environmental benefits

These hydro plants displace a significant amount of electricity that might otherwise have been generated by fossil fuelled plants. A study by SGS do Brasil Ltda estimated that the electricity generated by Cascata das Andorinhas from when it was commissioned in October 2003 up to May 2007 had saved 4,832 tonnes of CO₂. The calculation was based on an average of 0.265 kg CO₂ saved per kWh of grid electricity replaced. (This low value of CO₂ per kWh is because only about 20% of the national electricity supply in Brazil is generated from fossil fuels: most comes from large scale hydro schemes.) On the same basis, CRERAL calculated that the Abaúna plant had saved 4,777 tonnes of CO₂ up to May 2007. Because very little land was flooded to construct the mini-hydro schemes, there is no release of methane (a potent greenhouse gas) from decaying vegetation.

In parallel with the mini hydro schemes, CRERAL is working in collaboration with local authorities and landowners to manage the rivers and their rain catchment area. Starting in 2000, a re-forestation project has planted 18,000 native species of trees along the edge of the water courses. This has helped to improve the water quality and reduce soil erosion. The CRERAL biologist monitors the water quality and biodiversity every six months. CRERAL also works with local communities and municipal authorities to improve sanitation and reduce sewage pollution of the rivers.

Economic and employment benefits

The hydro plants give CRERAL a measure of energy independence and security of supply, which will become increasingly important as demand increases. 100 temporary jobs were created during the construction of the hydro schemes, and six people are employed permanently by CRERAL to operate and maintain the plant. Many customers report increased productivity and income as a result of the reliable hydro supply (see above)

Potential for growth and replication

CRERAL is keen to expand its portfolio of small hydro schemes, especially since the demand is growing at an average of 6% per year. CRERAL belongs to Consórcio Rio da Várzea, a group of five rural electrification co-operatives that are investigating the opportunities for run-of-river hydro schemes on the Rio Várzea, where the estimated generation potential is 42 MW. This work is at the planning stage and is currently waiting for environmental assessments.

CRERAL also has a 10% stake in two companies which intend to construct run-of-river hydro plants in Alto Uruguai Gaúcho. Rio de Lobo Energia Ltda have secured funding to construct a 3 MW hydro plant. The civil engineering work on these will commence shortly. Casa de Pedra Energética was set up to install 8 MW of hydro plant on the Rio dos Índios. The work should begin soon as the finance has now been obtained.

When these schemes are commissioned, CRERAL will own an additional 5 MW of capacity, on top of the current 1.9 MW. This should enable it to meet at least the current demand from its customers and possibly export some to other suppliers. However because of the growing number of customers and use of electrical equipment, demand could soon exceed supply again.

There are many other potential run-of-river hydro sites in the region, which could be brought into use by CRERAL or other cooperatives. The CRERAL experience shows that, for a cooperative which owns its own distribution network, the introduction of mini-hydro plants can be very cost-effective.

Management, finance and partnerships

CRERAL is a co-operative with 6,275 members in 121 communities, headed by an elected Administrative Council and Executive Committee. It is led by Sr João Alderi do Prado, the Managing President.

All key decisions, like the investment in mini-hydro schemes, are made by the membership, through local meetings, general assemblies and a council of leaders. The mini-hydro projects are managed by the CRERAL Vice President, supported by the technical director and operating staff. Detailed decisions on electricity supply are made at local level, for instance how to allocate electricity for a particular event, or whether to waive the bill for a family in financial difficulties.

The two mini hydro schemes were funded on a commercial basis, without grants. CRERAL funded 60% of the US\$620,000 cost of Abaúna, and 30% of the US\$800,000 cost of Andorinhas from its own resources. In both cases commercial loans from the regional public bank, charged at 12% interest rate, covered the difference. The total income from selling the hydro-generated electricity at \$R0.23 per kWh is currently about \$R1.26 million (£380,000 or US\$750,000) per year, and an additional £17,000 (US\$35,000) per year is expected from sales of carbon credits. Allowing for operating costs, distribution costs and bank interest, the loans can be paid back within seven or eight years.

Mini-hydro schemes are often assumed to be commercially unviable, unless high tariffs are charged for the electricity sold. The financial viability of the CRERAL scheme is due to a number of factors.

- The capital costs of equipment are relatively low by international standards (\$860/kW for Abaúna and \$670/kW for Andorinhas: the former is more expensive because it operates at low head).
- The schemes feed into an existing grid, so there is no additional cost of infrastructure for distribution.

- The cooperative ownership means that no profit is made from the schemes.
- The availability of carbon finance increases the scheme income.

Carbon finance is a new development for CRERAL. In 2007, it earned £13,000 on the voluntary carbon market through a deal with Eco-Invest Carbon in São Paulo. The Cascata das Andorinhas scheme is in the process of being certified with the Clean Development Mechanism, and CRERAL is negotiating the sale of £17,000 worth of carbon emission reduction credits.

Several organisations have partnered with CRERAL in promoting the success of the mini-hydro schemes, including the Dutch NGO, Both ENDS and Friends of the Earth, Brazil. Publicity has included a video and website on the Abaúna project. CRERAL also works closely with other electricity cooperatives.

This report is based on information provided to the Ashden Awards judges by CRERAL, and findings from a visit by one of the judging team to see its work in Brazil.

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