Climbing the Andes with dual-fuel power

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FCCA's Callao workshops semi-permanently coupled a GE C30-7 loco to a gas tender for operational trials using a mix of natural gas and diesel fuel

Following successful trials at an altitude of 4781m above sea level, Ferrocarril Central Andino of Peru is converting seven locomotives to run on compressed natural gas and diesel fuel, reducing both emissions and the fuel bill

In 2002 Ferrocarril Central Andino SA acquired its first modern motive power since privatisation, in the shape of five rebuilt General Electric C30-7 locomotives with 3000 hp engines. These were followed in 2005 by two GE B39 units with 3900 hp engines.

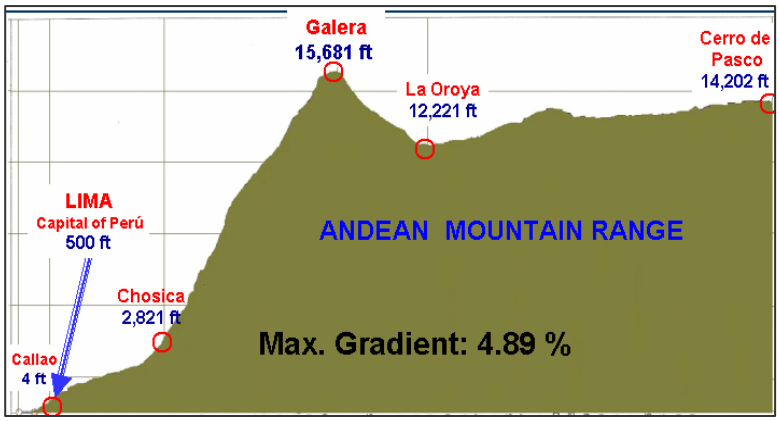
The seven units are now hard at work on FCCA's main line between the port of Callao and Huancayo, whose summit at Galera is 4781m above sea level, hauling consignments of zinc, copper, lead and tin concentrates as well as diesel, fuel oil, cement, sulphuric acid, refined metals and aggregates up gradients as steep as 4·89%.

Our locomotive fleet therefore spends much of its time running on full power, and like every other transport company FCCA has been affected by the relentless rise in fuel prices across the world. Between 1999 and 2005 our fuel costs rose by over 250% from US$0.21 per litre of diesel to US$0.63. The price is now US$0.66 per litre, and expert opinion is unanimous that this upward trend will continue. It should also be mentioned that the quality of diesel fuel used in Peru is well below international norms, with a high sulphur content of 4500parts per million in particular.

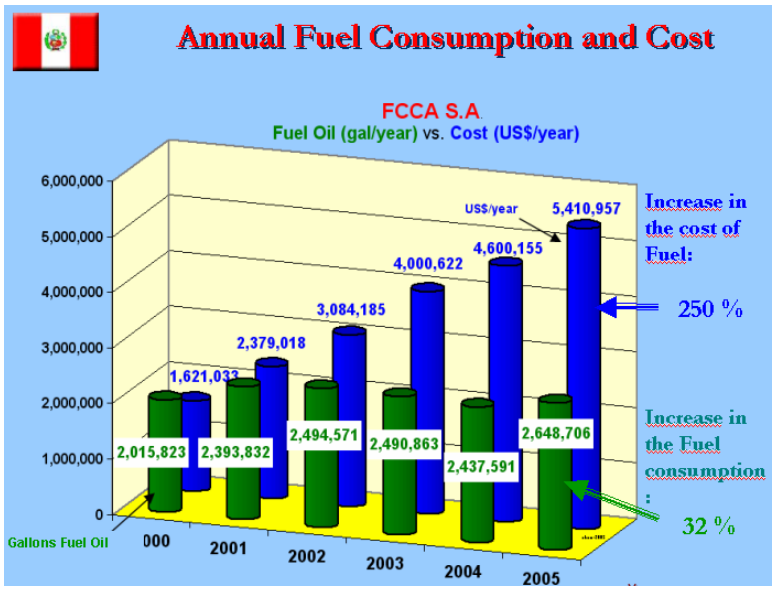
FCCA's business philosophy is focused on safety, innovation, creativity, efficiency and cost reduction. When considering our future fuel policy, we carefully reviewed our locomotive fleet, traffic patterns and gradient profile, keeping four key aims in mind.

We were looking for a solution that would be safe to operate and reduce environmental impact, based on a secure long-term fuel supply and at the lowest possible capital and operating costs. Under my leadership, the FCCA team concluded that the best option was to adopt dual-fuel technology (natural gas and diesel) within the combustion process. This would require an investment US$2m of over a two-year period.

Testing in the field



The programme began with a study of the locomotive fleet's fuel consumption and tonnage ratings on the most steeply-graded sections of our network. This was followed by an assessment of best practice worldwide, which informed the design of equipment, instrumentation and control software. Locomotive No 1004, a GE C30-7 powered by a 3000 hp 7FDL-16 engine, was equipped with energy conversion sensors and a GE electronic control panel. It was semi-permanently coupled to a fuel tender with two racks of tanks containing 1200m3 of compressed natural gas at 20.6 MPa and 2100m3 at 16.5 MPa.



Over the past five years, FCCA's fuel consumption has increased by 32%, but higher oil prices have driven the cost of fuel up by 250% to more than US$5m a year

Performance tests were undertaken both in the workshop and in the field, including fine tuning of the electronic fuel mix control system. A mix of 70% natural gas and 30% diesel was taken as the baseline, with the proportions varying according to altitude. Safety was the primary consideration at every step of the process, followed by securing the most cost-effective fuel mixture to produce the maximum power output. Conversion of the test loco began at FCCA's central workshops in Callao in February 2005, followed by testing during April and May and a programme of field trials in May and June 2005. To

support the trials, during March and April FCCA installed its own natural gas compression plant, the first in Peru.

Operating trials began on May 13, 2005 with a run from San Bartolomé, 1500m above sea level, to Morkill at an altitude of 4200m. The second test run was undertaken on June 24, when a 490 tonne train of seven wagons was hauled up the 4.7% gradient from San Bartolomé to the summit at Galera. This was a great success, demonstrating that the engine could maintain full power on a mixture of diesel and natural gas. Indeed, reference tests conducted before conversion work recorded diesel-only engine power as 2987 hp at 3m above sea level, falling by 20% to 2400 hp at 4781m at Galera. The engine's full output of 3000 hp can only be achieved at altitude through the use of dual natural gas and diesel fuel.

In a trial on June 24, 2005 a seven wagon train was successfully hauled up the 4·7% gradient from San Bartolomé to the line's summit at Galera, 4781m above sea level, demonstrating that the loco could maintain full power on a mixture of diesel and natural gas

Further testing across the FCCA network included measurement of total fuel consumption as well as natural gas consumption per throttle position and radiator water temperature. Gradients and curvature were carefully noted during test runs, as well as weather conditions including temperature and humidity. The success of the trials has led the FCCA board to approve the conversion of its seven-strong GE fleet to dual-fuel operation. This is due to be completed by the end of this year.