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## Vale invests in science and technology to develop the mining of the future

When Vale began producing iron ore in the 1940s in the state of Minas Gerais, Brazil, the blocks of ore were broken with sledgehammers and pickaxes, transported by cart to small trucks, and then transferred onto train wagons. Developing to the point where Vale is now - with cutting-edge technology to produce ore with the highest concentration of iron in the world and other minerals essential to our everyday lives - has required heavy investment in innovation and research. And such investment continues to be necessary. In 2010, Vale invested US\$1.136 billion in R&D and it will invest a further US\$1.986 billion in 2011. Find out about some of Vale's main projects in the area of innovation and technology:

**Vale Technology Institute (ITV)** - A nonprofit organization established in 2009, ITV aims to contribute to technology-based economic development in Brazil by increasing scientific research output production in the fields of sustainable development and mining. Since it was created, the institute has entered into 97 research and development agreements, provided more than 50 research scholarships, and created partnerships with 36 Brazilian and international institutions, including Brazil's agriCultural research institute, Embrapa, the National Council for Scientific and Technological Development (CNPq), the Massachusetts Institute of Technology (MIT) and the École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland.

In addition to its research partnerships, ITV is building a series of facilities across Brazil to be staffed by world-class researchers. Initially, the institute will invest R\$350 million in two research centers in the states of Minas Gerais (Ouro Preto) and Pará (Belém).

Both centers will focus on a specific theme: the mining of the future in Minas Gerais and sustainable development in Pará. They will each accommodate an average of 300 professionals, including professors and students, of whom at least 60 will be researchers with doctorates and post-doctorates.

**Research centers** - Vale has three large laboratories, which are responsible for developing technological solutions for its mining projects. Two of them are located in Brazil - the Mining Development Center (CDM) and the Ferrous Metals Technology Center (CTF) - while the third, Vale Technical Services Limited (VTSL), is in Canada. Established in 1965, CDM was responsible for the first major technological advances made by Vale, as it developed new technology for processing low-grade iron ore, raising the lifespan of Vale's mines and helping the company to arrive at its current position as the world's second largest mining company.

Vale's oldest research center, VTSL is a global leader in nickel technology. At CTF, Vale conducts research into iron ore-related production processes, from extraction at the mine up to the manufacture of steel products. Using physical and statistical simulations, the center's researchers test a wide range of processes, from different ore processing techniques to the behavior of ore in steel mills. CTF has state-of-the-art equipment, such as a Mössbauer spectrometer, capable of classifying the various types of ore that are partly composed of iron. To this end, the equipment uses the effects of gamma ray emissions to investigate each sample's chemical and physical properties. A prototype Mössbauer spectrometer similar to those used at CTF was sent to Mars by NASA to study the planet's soil. Only six of these models are in existence - two of them on Mars. The use of technology has enabled the company to add value to its products, boosting its competitiveness in the sector.

**Engineering Center** - Established in 2009, the Vale Engineering Center in Vitória, Espírito Santo, brings together facilities required for technical training in railroad, port and shipping operations in one location. The center's five-story building is equipped with simulators of trains, train car loaders and reclaimers (giant pieces of machinery designed to remove iron ore from a stockyard and place it onto conveyor belts to be taken to a ship docked at a port). More than 3,000 employees have received training at the Engineering Center.

**Natural moisture ore processing** - The Carajás mines account for 36% of the iron ore produced by Vale every year. Once extracted, the ore is screened, which adds value by separating out various products. In order to do this, the use of water has always been fundamental. However, a new technology developed entirely by Vale is revolutionizing the way we arrive at final products: screening using moisture from the rock itself.

There are no records of this type of technology having been used before in ore processing. Besides cutting annual water consumption by the equivalent of that used by a city of 430,000 inhabitants (19.7 million m<sup>3</sup> per year), the technology also reduces annual power use by more than 18,000 MW and means that tailings dams do not have to be built.

**Reusing iron ore** - Vale has begun a pioneering, industrial scale project at its iron mines in Brazil, which could change the operating model for this activity across the world, increasing the lifespan of reserves and reducing the environmental impact. The initiative involves reusing leftovers from the mining process that until now were deposited in piles of overburden or in tailings pools (reservoirs). Piles of overburden contain all the unused waste rock extracted from the mining site, while tailings pools are used to store waste produced in ore processing plants.

However, both contain ore that, until now, was not exploited due to its low iron content. Using new technology, Vale is reprocessing this material and incorporating it into the production of iron ore, which is then sold on the global market. As a result, the company has been overturning the belief that it is only possible to extract iron from rock a single time. Besides the economic gain, the technology reduces the environmental impact, as smaller areas are needed for tailings pools and overburden piles, which require environmental licenses to create.

**Remote Control of Port Operations** - In April 2010, Vale inaugurated its remote control system for port stockyard operations, which is now used at Ponta da Madeira Port Terminal in Maranhão and Tubarão Complex in Espírito Santo. The system uses software that enables machinery to be controlled from the port's control center.

In this center, the operators have their own individual control terminals. This means that they do not have to move to another terminal to operate a different machine, but only activate a command. The terminals' operating system and layout is the same as that used at major European ports such as the Port of Rotterdam in the Netherlands.

**Online mapping of port stockyard** - The stockyard at Tubarão, one of the world's most efficient ports, capable of storing 3.3 million metric tons of ore, is being completely scanned and will soon fit on a computer screen, making it possible to control its inventory online. This unprecedented technology will further improve the operational safety of stockyard movements, raise loading productivity and enhance the quality of inventory data collection.

Online mapping is part of the second phase of the port's remote control project, which already allows the massive machinery installed at the stockyard to be operated from inside a control center some distance away. In all, R\$500,000 has been invested to implement the pilot project and develop the technology.

**Biodiesel** - Vale's investments in producing biodiesel are part of its strategic priority to be a global agent for sustainability and to obtain an ever higher share of its energy needs from renewable fuels. In this context, in April 2009, Vale formed a consortium with Biopalma to produce palm oil.

The company started to produce palm oil earlier this year, and expects to reach annual production of 500,000 metric tons in 2019, when the trees reach maturity. Most of the oil will be used by Vale to make biodiesel to power its fleet of locomotives and heavy-duty machinery and equipment in its Brazilian operations, using "B20" (a blend of 20% biodiesel and 80% regular diesel).

Biopalma is now implementing six production clusters in the Vale do Acará / Baixo Tocantins region of Pará. By 2013, the company will have 60,000 hectares of palm trees and 75,000 hectares used to restore and regenerate native forest. So far, 18,400 hectares have been planted, and a further 14,400 hectares are scheduled for planting in the this year. All areas used to grow palm trees are first mapped and demarcated by the Brazilian government as degraded areas. As part of Vale's strategy, which is underpinned by the principle of sustainability, Biopalma will contribute to preserving areas of native forest and restoring degraded areas.

Biopalma presently employs around 3,200 people, including employees and contractors, but as the business grows more jobs will be created. In addition, a family farming program has been designed to cover 2,000 families from the region, who will grow palm trees and other crops on their land. The company will monitor the practices used by these farmers and has guaranteed to purchase their output.

**Green Train** - In 2009, Vale launched Green Train, an unprecedented project to use a mixture of natural gas and diesel to power its locomotives. Tests began on the Vitória-Minas Railroad (EFVM), one of the most productive and efficient railroads in the world. In the initial phase, gas concentrations of between 50% and 70% are being tested. Converting locomotive engines to run on natural gas will cut CO2 emissions.

**Vale Soluções em Energy** - Created in 2007 through a partnership between Vale and Brazil's national development bank, BNDES, Vale Soluções em Energy has the mission of developing, industrializing and commercializing comprehensive distributed energy (on-site generation) systems using renewable and less polluting raw materials. Such systems are designed to be installed close to locations that need power, to be fueled by inputs available in the region, such as ethanol, natural gas, waste and biomass. VSE's research is focused on three main areas: multi-fuel motor-generators, turbo-generators and biomass gasifiers.

**Tecnored** - In September 2011, following extensive research that began more than 35 years ago, Tecnored Desenvolvimento Tecnológico S.A., a Vale company, in partnership with Brazil's development bank, BNDES, and Logos Tecnom, started up the first pig iron demonstration plant that does not use traditional blast furnace methods, in Pindamonhangaba, São Paulo state. Pig iron is a fundamental element in steel production. The innovation enables higher productivity, lower emissions of CO2 and particulate matter, the flexible use of raw materials, and a reduction of up to 30% in the cost of steel production.

The technology, called Tecnored, may help to extend the lifespan of Vale's mines and reduce their environmental impact, as it enables pig iron to be produced from iron ore of different grades and quality, and even ultrafine iron ore, which is currently deposited in tailings ponds. By using iron ore fines, it is possible to reduce the need to open up new areas for tailings ponds, which require environmental licenses to be created.

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