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S11D: largest iron ore project in Vale's history

60% of physical work has now been completed on the project, which will start up in the second half of 2016

Located in the municipality of Canaã dos Carajás, in southeast Pará, S11D is the largest iron ore project in Vale's history, with an estimated production capacity of 90 million metric tons per year. Sixty per cent of the physical construction work on the project - which includes a mine, plant, and railway and port logistics - has now been completed, and the project will start up in the second half of 2016. Seventy-five per cent of the physical work at the mine has been completed, while 50% of the logistics work has been conclude¹. Total investment will be US\$14.4 billion: US\$6.5 billion in the mine and plant, and US\$7.9 billion in building a 101-km railway branch line, double-tracking the Carajás Railway and expanding Ponta da Madeira Maritime Terminal in São Luís, Maranhão². S11D is the largest private sector investment in Brazil this decade. It will have a positive impact on the country's balance of trade and further boost economic and social development in the states of Pará and Maranhão. The project has been designed to interfere minimally with the Amazon biome. For example, a large part of the operation will be outside Carajás National Forest, an official Conservation Unit that Vale has been helping to protect since it was created in February 1988.

Alongside other new projects and expansion work in Pará and Minas Gerais, S11D will help Vale to increase its production of high-quality, low-cost iron ore. It is estimated that the company's annual output will grow by 35% in the next four years, from 340 million metric tons in 2015 to 459 million in 2019. Of this total, 230 million metric tons will be produced in Pará, practically double the amount produced in 2014.

Thanks to S11D, the operating costs in Vale's North System, which includes Carajás, will fall below the current level of US\$10 per dry metric ton. These operating costs apply to ore delivered to Ponta da Madeira Maritime Terminal. From there, the product is mainly shipped to Chinese steel mills, which accounted for nearly 40% of the company's gross revenue in 2014. The high quality of Vale's iron ore and the decrease in its operating costs are some key factors in reducing the gap caused by the geographical distance between Vale and its main Australian competitors in relation to China. At the moment, one of Vale's ships takes 45 days to reach Chinese ports, compared with 15 days for the Australians.

During peak construction work, the project will employ 30,000 workers, the overwhelming majority residents of Pará and Maranhão, adding together all the project's work fronts (mine, plant and logistics). Once the mine is operating, as of the second half of 2016, it is expected to create 2,600 direct jobs and at least 7,000 indirect jobs, considering the demands for services generated by the project in the municipality of Canaã dos Carajás.

The project is named after its location: block D of ore body S11, which lies in the Southern Hills of Carajás. To the north is Carajás Mine, operating since 1985 in the neighbouring municipality of Parauapebas. Geologically speaking, S11D is just one block of an ore body, which has been divided up into four parts: A, B, C and D. The mineral potential of the S11 ore body is 10 billion metric tons of iron ore, of which block D alone possesses reserves of 4.24 billion metric tons. The first drilling in the region took place in the 1970s. At the turn of the century, the first technical capacity and financial viability studies were carried out, which led to the project's present configuration. The project's preliminary licence was issued in June 2012 and its installation licence was obtained one year later. The mine's lifespan is currently estimated to be 30 years.

The S11D project entails installing an iron ore mine and processing plant, with three production lines - each one able to process 30 million metric tons per year. The ore will be extracted through open-pit mining and transported from the mine to the plant by a long-distance conveyor belt. The plant, iron ore stockyards and distribution yards, piles of waste rock and overburden (containing iron ore with high phosphorus levels), and train manoeuvre and loading area are all sited in an area of pastureland outside Carajás National Forest. Through this solution, it was possible to reduce the amount of vegetation cleared in the forest by more than 40%, compared with the original master plan, which called for 2,600 hectares to be cleared. Carajás National Forest covers 412,000 hectares, and even after S11D has been fully implemented, just 3% of it will have been affected by mining activities since Vale came to the region 30 years ago. Besides reducing its impacts on the forest, the company has also acquired various areas of degraded pastureland around the plant and the sites for the future iron ore stockyards and distribution yards, adding up to 10,300 hectares. Part of this area will be replanted with native trees to make up the project's "Reserva Legal" (legally mandated minimum area of native habitat), as part of a program to expand tree cover and join up isolated forest fragments.

Technology

One of the main technological solutions that will make the S11D Mine an environmental leader is its adoption of a truckless system, involving a set of structures composed of mobile excavators and crushers interconnected through conveyor belts, in total extending for around 30 km within the mine. This new system will eliminate the need for off-highway trucks, which are commonly used in mining. If it were a conventional mine, S11D would need 100 off-highway trucks, each capable of carrying 240 metric tons. Without these trucks, Vale will reduce its diesel consumption by around 70% and significantly cut its generation of waste, such as worn-out tires, oil filters and lubricants.

Truckless systems are widely used in coal mining, where ore layers are continuous and homogenous. The characteristics of S11D's ore body allowed it to apply this mining configuration, as it is long (9.5 km in length, 1.5 km in width, and 300

metres deep), and relatively homogenous. Without these kinds of dimensions, it would not have been possible to use a truckless system.

Located on top of a hill, 400 metres above the plant site, S11D Mine will have four mobile excavation and crushing systems operating simultaneously. After being crushed, the material collected at the pit face will be transported along conveyor belts to a transfer station, where the iron ore, mineral-rich overburden and waste rock will be separated and directed to either the processing plant or a stockpile. The ore will be sent to the plant along a long-distance conveyor belt, made up of a set of three lines of belts extending for 9 km. Another two lines, each around 5 km in length, will take the waste rock and ore-rich overburden to the stockpile site, also located outside Carajás National Forest. Despite its high level of phosphorus, considered a contaminant in the steelmaking process, this overburden is rich in iron ore, and so it will be deposited in a separate stockpile, and in future it may be used commercially.

S11D's iron ore processing plant will use a system developed by Vale that will cut water consumption by 93% - enough to supply a city of 400,000 inhabitants. Already employed at some other plants in Carajás, dry processing (using iron ore's own natural moisture) at S11D will use 110,000 cubic metres of water per month, compared with nearly 1.7 million cubic metres at a wet plant of the same size. Another advantage of the project is its zero use of tailings ponds, which require strict environmental controls. High grade ultrafine particles, which would otherwise be discharged into ponds, will not be discarded, allowing an extra 300 million metric tons of iron ore to be added to the mine's production over the course of its 30-year lifespan. As a result, Vale will avoid wasting practically as much as its total iron ore output in 2014.

Another innovation at S11D is the modular construction of the plant, similar to the concept employed in offshore platform construction in the oil industry. The plant's structures, containing various items of equipment, have been slotted, welded and bolted together like giant pieces of Lego. This technology has enabled the modules - 109 in all, each weighing between 80 and 1,300 metric tons - to be assembled in advance at a site slightly more than 40 km from the plant's site. A road was specially built and paved to cope with the weight and dimensions of the modules, which will subsequently be donated to the state government of Pará, benefiting the local community. The transfer of the 109 modules ended in August, and they had all been put together at the plant by October.

Thanks to the truckless and dry processing systems, S11D's annual greenhouse gas emissions will be at least 50% lower than they otherwise would have been, avoiding around 130,000 metric tons of CO₂ equivalent per year. The project will also save 18,000 MWh of electricity per year, enough to power 10,000 homes. S11D reflects Vale's commitment to reduce its emissions and use of natural resources in its processes.

Logistics

After being processed, S11D's ore will be taken by railway to Ponta da Madeira Maritime Terminal (TMPM) in São Luís. To make this transportation possible, it was necessary to construct an entire logistics system, which will consume nearly 60% of the project's total US\$16.4 billion investment budget. S11D's logistics work consists of the building of a 101-km branch railway line, double-tracking of the Carajás Railway (EFC), and expansion of TMPM.

The construction work on the branch line, to connect S11D's processing plant to EFC, has involved building the first tunnels in Vale's logistics system in northern Brazil. There will be four tunnels, the longest of which will extend for almost 1 km. All this work has been planned to minimize the impacts on Carajás National Forest. Just 3 km of the branch line's 101-km route passes through the national forest. Most of it crosses pastureland acquired by Vale. In addition to the tunnels, four suspension bridges are being built over the region's rivers, in order to leave the areas under the bridges free, enabling them to be naturally re-vegetated after the building work has ended, and also allowing the maintenance of forest connectivity and circulation of animals. Along other stretches of the branch line, wildlife crossings have been installed.

S11D's branch line will link up with the Carajás Railway, in Parauapebas, southeast Pará. Considered one of the most efficient railways in the world³, EFC is 892 km in length but only has a single line, despite running trains in both directions. The railway is interspersed with various rail yards, which allow trains moving in opposite directions to pass each other. By

laying 570 km of new tracks to join up 48 of these yards, it will be possible to double-track the railway. Other 55 yards, a total of 220 km, are being remodeled.

At the moment, 56 trains (iron ore trains, general cargo and passenger) travel along the Carajás Railway at the same time, including one of the world's longest freight trains to operate regularly, with 330 railcars and extending for 3.3 km. This train can transport 33,000 metric tons of iron ore at a time - equivalent to 1,000 trucks. By double-tracking EFC, Vale will be able to operate 69 trains along it simultaneously, making it possible to transport the increased iron ore output to result from S11D and expansion projects at Carajás Mining Complex.

Expansion of Ponta da Madeira

The final part of S11D's logistics work is the expansion of Ponta da Madeira Maritime Terminal, which is now nearly 70% complete. By the end of 2015, Vale will complete its expansion of the railway terminal inside the port, thereby raising TMPM's nominal capacity to 230 million metric tons per year. This production level will not be reached immediately, however. This is because the port's output also depends on the other stages of the S11D project - the completion of the railway branch line and double-tracking of EFC, as well as the building of the processing plant and opening of the mine in Canaã dos Carajás.

The work at TMPM includes onshore and offshore expansion, as well as an extension of its railway terminal inside the port. The offshore work includes building a new berth at Pier IV, called the Northern Berth, equipped with a ship loader, replicating the Southern Berth's existing design. Pier IV's advantage over other Brazilian ports is its capacity to accommodate large ships such as Valemaxes, the world's largest ore carriers, which can carry up to 400,000 metric tons and measure 362 metres long and 65 metres across. As it is unsheltered (i.e. lacking any breakwaters), the pier's construction has required Vale to take extra safety precautions.

"Pier IV's mooring system is the only one of its kind in the world for ships able to carry 400,000 metric tons, like Valemaxes. Because of the strong tidal currents and lack of a breakwater, the pier has land cables that help to moor ships to the berths," explains Marcelo Cardozo, Vale's nautical engineering manager. According to him, Valemaxes are moored using 36 cables: 16 land cables and 20 ship cables. This system enables these giant vessels to operate without restrictions at the pier.

The berths have two dual quadrant ship loaders able to load 16,000 metric tons per hour - the largest of their category in the world. The work to complete Pier IV's Northern Berth and install the new dual quadrant ship loader is on schedule.

The onshore expansion work involves enlarging the port's logistics area, where four new iron ore stockyards, each able to store 600,000 metric tons, are being installed. They will join the port's nine existing iron ore stockyards. The new stockyards will be equipped with two rotary car dumpers, one stacker, two reclaimers and two stacker-reclaimers.

Finally, Ponta da Madeira's construction work also entails expanding its railway terminal, composed of a locomotive inspection and refuelling station, and a railcar workshop, which includes a rolling stock replacement and maintenance centre. This facility will use new technologies capable of significantly improving the productivity of routine operations. Currently, nearly 15,000 railcars are used to transport iron ore along EFC and in 2018, when S11D is fully operating, this figure will be around 19,000. This increase in the number of railcars circulating on the railway will make the process of replacing them an even more complex task. The new railcar workshop and locomotive refuelling station will therefore play an important role in guaranteeing growth in EFC's capacity.

At the moment, a lot of time is spent on train rearrangement operations to be able to remove a single pair of railcars and send it for maintenance. In the new railcar workshop, which covers an area of 20,000 m², it will be possible to stop an entire 110-railcar train. (Each 330-railcar train that circulates on EFC is in fact made up of three equal parts consisting of 110 railcars driven by one locomotive.) Corrective and preventive maintenance work will be carried out on railcars in the workshop. For example, the process of changing wheels and axles will be completely reformulated. A unit with a defect will halt over a special machine embedded in the ground, which will remove the wheel system and replace it with a new

one, without needing to disconnect the pair of railcars, as is currently the case. In this way, it will be possible to do the same operation in series, saving time in train operations.

The locomotive refuelling station that is being installed at the port is similar to a Formula 1 pit stop, as it is totally integrated with the railway circuit. At the moment, a locomotive has to leave this circuit and be taken to a workshop, where it is refuelled and subjected to corrective and preventive maintenance. At the new locomotive inspection and refuelling station, it will be possible to refuel, inspect and do minor maintenance work on up to 12 locomotives at the same time. By September of this year, 66% of the expansion work on the port's logistics area had been completed, Pier IV's expansion was 64% executed, and the railway terminal was 78% completed.

¹ Data for the third quarter of 2015.

² The initial approved budget was US\$19.7 billion, but the depreciation of the Brazilian real and design optimizations have led to a US\$3.3 billion reduction in the total.

³ According to a 2012 study by the Logistics and Supply Chain Institute (Ilos), the Carajás Railway has the highest productivity in terms of ton-km per year and the lowest average charges out of all Brazilian railways.

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