8 November 2022

Calix awarded ARENA funding for further development of Zero Emissions Steel Technology

Sydney, Australia | 8 November 2022 – Australian environmental technology company, Calix Limited (ASX: CXL) ("Calix" or "the Company") announces today it has been awarded a $947,035 grant by the Australian Renewable Energy Agency (ARENA) to help fund a Basis of Design ("BOD") and Front-End Engineering and Design ("FEED") study for a renewably powered demonstration plant for its Zero Emissions Steel TechnologY (ZESTY).

Highlights

- The $947,035 grant from ARENA will help to fund an eleven-month BOD and FEED study for a 30,000 tonne per annum, zero CO_2 emissions ZESTY-iron demonstration plant.
- Calix's ZESTY uses hydrogen in a renewably powered reactor to produce green iron and ultimately, green steel.
- ZESTY reduces iron ore at significantly lower temperatures than conventional blast furnaces (BF) and can enable minimal consumption of hydrogen in the production of green steel.
- Iron ore is Australia's largest export, with Australia providing over half the global supply in 2021. Calix's ZESTY is compatible with multiple iron ore types, including haematite, providing pathways for one of Australia's most important exports to become sustainable in a low carbon world.
- ZESTY seeks to facilitate the transition to green steel, adding value to local iron ore exports as well as future-proofing local iron and steel production.

The ZESTY demonstration plant

The $947,035 grant from ARENA will provide approximately 48% of the funding for an eleven-month study for a 30,000 tonne per annum ZESTY-iron demonstration plant.

The proposed renewably powered ZESTY-iron plant will produce green hydrogen for the direct reduction of iron ore to sponge iron. With no carbon involved throughout the process, the proposed ZESTY reactor will demonstrate a new approach to zero emissions iron and steel.

Calix's ZESTY demonstration plant will also be compatible with intermittent operation, enabling economical use of low cost renewable power and will be compatible with load balancing applications for the energy grid.

The project will cover both the BOD and the FEED study required to determine the final location, specification and cost of the demonstration plant before a Final Investment Decision is taken.

The project will also further establish key partnerships in industry across the hydrogen, iron ore and renewables sectors, in addition to possible end users of green iron through the Heavy Industry Low-carbon Transition Cooperative Research Centre (HILT CRC), facilitating knowledge sharing and the ongoing development of an ecosystem for sustainable heavy industry in Australia.

Calix's ZESTY iron process

ZESTY iron aims to enable steel producers to add green iron directly into their existing processes to provide a simple and efficient route to emissions reduction.

Calix's ZESTY iron process uses an adaptation of Calix's core "kiln" technology to reduce iron ore to iron in a hydrogen atmosphere at less than 1000°C. ZESTY can be electrically heated and is compatible with intermittent sources of renewable generation and grid load balancing applications. The unique, indirect heating approach not only enables efficient electrification, but also removes sources of combustion and the generation of hydrogen-oxygen flames, allowing a simpler design and processing at significantly lower temperatures than conventional BFs.

Unlike other direct reduced iron (DRI) technologies, Calix's indirect heating of the reduction reaction with renewable power means hydrogen is not consumed as a fuel, only as a reductant, and is easily recycled in the process. As such, ZESTY is targeting the minimum hydrogen use of 54kg of hydrogen per tonne of iron, enabling more efficient and economical production of green iron and steel.

ZESTY's ability to handle small particle sizes has the potential to more easily remove impurities compared with other (DRI) processes, which require pelletised and typically higher grade iron ores. Further testing and validation of this potential is underway.

Calix's ZESTY steel process

Calix's ZESTY steel aims to enable steel producers to add ZESTY directly into their process to produce lower carbon, and ultimately zero emissions steel products.

Calix's ZESTY steel process involves the use of the ZESTY iron process feeding a standard (continuous) electric arc furnace (C-EAF), with the addition of a Leilac kiln to produce zero-emissions lime. No pelletisation of the lime is required, while the lime can also be used to scrub excess carbon dioxide as well as other pollutants from the exhaust gases.

ZESTY's development

Since filing a new patent application in October 2021, Calix has worked to develop ZESTY to reach technology readiness level (TRL) four. Following theoretical modelling of reduction kinetics with ZESTY, Calix modified its fully electric calciner at Bacchus Marsh, Victoria to complete pilot scale testing of iron ore processing with hydrogen.

The pilot studies confirmed the calciner performance under various temperatures and hydrogen atmosphere conditions, as well as successfully processing several iron ore types. Importantly, early results on multiple ore types included very high conversion of haematite to metallic iron under increasingly lower operating temperatures.

Green iron and steel – a unique Australian opportunity

Australia supplied over 53% of the world's iron ore in 2021[1], contributing nearly 44% of Australia's total export earnings[2]. Haematite, however, makes up 96% of Australia's exported iron ore[3] and is not suited to most electric arc furnace (EAF) methods. Compatibility of future green steel processes with the various iron ore grades currently used in conventional BFs will be essential to the efficient decarbonisation of the steel industry, and potentially vital to Australia's future economic prosperity.

ZESTY-iron is being developed to enable Australian producers to transition towards exporting higher

[1] https://www.statista.com/statistics/300328/top-exporting-countries-of-iron-ore/
[2] https://www.minerals.org.au/news/record-high-resources-export-revenue
[3] Iron Ore | Geoscience Australia

value green hot briquetted iron (HBI) instead of iron ore. The use of HBI to make steel in both Basic Oxygen Furnaces (BOF) and EAFs is proven, and zero emissions HBI would significantly reduce the emissions footprint of both processes, as the energy demand to reduce iron ore accounts for the vast majority of energy consumption in steelmaking.

Australia's combination of globally leading iron ore and renewable energy resources promises to provide a unique global competitive advantage for green iron production. With current iron prices around three to four times the value of iron ore, the processing of iron ore to metallic iron, and particularly green iron, represents a significant opportunity for Australia to secure and enhance its share of global iron exports, and capture more value from its most exported resource.

Calix Managing Director and CEO, Phil Hodgson said:

"The decarbonisation of iron and steel represents a unique opportunity for Australia. This project aims to further develop a homegrown Australian technology that we believe, together with Australia's leading iron ore and renewable energy resources, can help make Australia a leading exporter of not just iron ore, but green iron and green steel.

"We are grateful to ARENA for their support of our shared vision for decarbonised iron and steel in Australia. We look forward to continuing to work closely with ARENA and our partners in industry and academia towards achieving these environmentally and economically important goals."

ARENA CEO Darren Miller said that ZESTY is a prime example of Australian innovation helping tackle global challenges.

"Decarbonising heavy industries like steel is a big challenge, and a big opportunity, and ARENA is looking to support companies like Calix that are developing potential solutions," Mr Miller said.

"For Australia and the world to meet our net zero targets, we'll need to develop new ways of making materials the world relies on.

Steel is among the most carbon intensive industries, accounting for around 7% of global CO_2-e emissions, and Australia is well positioned to be a leader in this space.

With abundant renewable energy resources and the world's largest iron ore deposits, we have a unique opportunity to decarbonise an industry that is critical to the global economy.

We're looking forward to the outcomes of this study and hope to see ZESTY play an important role in the future of Australian iron and steel."

Background: Decarbonising iron and steel

Iron and steel are materials essential to our economic prosperity and continued development. Responsible for 7% of global CO_2 emissions[4], they are also one of our most carbon intensive and hard-to-abate industries. As the second largest source of industrial emissions after cement and lime, iron and steel producers are under intense pressure to decarbonise.

Currently, approximately 90% of iron is produced by metallurgical coal and coke-fuelled BFs. This conventional method of iron ore reduction is responsible for 80-85% of the industry's CO_2 footprint and produces approximately 1.89 tonnes of CO_2 for every tonne of iron produced[5].

Iron produced via direct reduction of iron ore using a 'syngas' of hydrogen and carbon monoxide (made from natural gas) is a less CO_2 intensive production method, producing around 0.6 tonnes of CO_2 per

[4] Climate change and the production of iron and steel. World Steel Association. 2021
[5] Climate change and the production of iron and steel. World Steel Association. 2021

tonne of iron. This process route, however, has traditionally been more expensive, and accounts for only 10% of the world's iron production. To be economical, the method requires cheap natural gas, as well as pelletisation of iron ores to prevent fines loss.

Today, most approaches to decarbonise iron and steel are considering green hydrogen reduction methods connected to electric arc furnaces (EAF's). Typically, these approaches require higher grade iron ores and will disrupt the traditional BF / BOF production route that constitutes around 75% of today's production and consumes most of Australia's exported iron ores. As with syngas based direct reduction, the iron ore requires pelletisation, and ultimately consumes an estimated 72 kg of hydrogen per tonne of steel.

–ENDS–

This announcement has been authorised for release to the ASX by:

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Appendix: Advancing Renewables Program Funding Agreement terms

The Advancing Renewables Program Funding Agreement ("the Agreement") commences on 7 November 2022 and continues until all obligations under the Agreement have been completed, unless terminated earlier in accordance with its terms.

The total amount of funding provided by ARENA under the Agreement will not exceed $947,035 (excluding GST). The ARENA funding will be provided as milestone payments as specified in the project schedule.

Under the terms of the Agreement, if there is a change in Australian Government policy with respect to ARENA, or funding provided by ARENA, that relates to ARENA's obligations under this Agreement, ARENA may by notice terminate this Agreement or reduce the scope of the Project, effective from the time specified in the notice.

Further information about the Advancing Renewables Program, including program guidelines, are available at:

https://arena.gov.au/funding/advancing-renewables-program/

About Calix

Calix is a team of dedicated people who are urgently developing great businesses, leveraging our patented technology, that deliver positive global impact.

The core technology is being used to develop more environmentally-friendly solutions for water treatment, CO_2 mitigation, biotechnology, advanced batteries, and more sustainable mineral and chemical processing.

Calix develops its technology via a global network of research and development collaborations, including governments, research institutes and universities, some of world's largest companies, and a growing customer base and distributor network for its commercialised products and processes.

Because there's only one Earth – Mars is for Quitters.

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