Calix News

August 2023

Highlights

P2 Welcome from the CEO

Latest news

P4
Sustainable lithium demonstration plant passes Financial Investment Decision

P6
Early results propel low emissions iron and steel development

P8
US delegation hosted by the Great Plains Institute visit Leilac-1

P9
Expanding our US presence

P10
Decarbonising shipping: Developing sustainable fuels and CO_2 capture solutions

P12
New lab facilities open at Bacchus Marsh

P13
R&D leadership appointments

P14
Adopting circular economy practices

P15 Meet some of the team

Mars is for quitters

Phil Hodgson
CEO

Welcome to
Issue 45 of the Calix Newsletter

As we chalk up another financial year at Calix, we reflect on a year of dramatic growth in the footprint and capability of the company and look forward to what is set to be another landmark year in the Calix story.

The first half of the financial year contained a flurry of activity. We signed a first-of-a-kind licence agreement with Heidelberg Materials for cement decarbonisation; secured ARENA funding for further work on decarbonising iron and steel; executed a joint venture with Pilbara Minerals; and raised the capital required to continue developing our decarbonisation solutions. In the second half of the financial year, we also announced two exciting new applications: Direct Air Capture of atmospheric CO_2 in partnership with Heirloom, and provision of captured industrial CO_2 for sustainable transport fuels as part of the HyGATE funded Solar Methanol Project.

In more recent months, our focus has been firmly on the development and execution of our core projects. Our joint venture with Pilbara Minerals has moved full-steam ahead to construct a mid-stream demonstration plant for the sustainable production of a lithium salt here in Australia. We are delighted that the project has now passed its Financial Investment Decision point. The rapid progress of the project is testament to the talent and dedication of the Calix and Pilbara Minerals teams, and I am thankful for their huge effort over the past few months.

Our Zero Emissions Steel Technology or “ZESTY” R&D program continues our early, highly promising pilot-scale trials with a greatly expanded range of ore types from Australia and abroad. A recent visit of leaders from US industry, government and NGOs to our Leilac-1 pilot plant highlighted the increasing interest in cement decarbonisation and industrial carbon capture solutions following the passing of the Inflation Reduction Act. You can read more on this visit, our progress with ZESTY and the development of decarbonisation solutions for the hard-to-abate shipping sector in the newsletter.

This edition of the newsletter also reports significant expansion of the US Water business. Two new hydration plants are near completion and will support new customers across several new states in the US. This growth continues to be driven by strong regulatory tailwinds that demand more sustainable solutions for water and wastewater treatment.

The Calix team has grown significantly over the 2023 Financial Year, and we continue to look for talented new recruits who share our passion and purpose. The growth of the company has also extended to new R&D facilities. A new laboratory, supported by a $1m grant from the Australian Government, is now up and running. It will provide a significant increase to our R&D capabilities, helping to relieve bottlenecks in our assessment of an ever-expanding pipeline of materials testing from interested counterparties across all our lines of business. FY23 also contained several notable internal sustainability initiatives, and this newsletter’s feature on the re-purposing of broken intermediate bulk containers in pursuit of our ambition to have 100% sustainable inputs is one such example.

Although FY23 contained many significant achievements and milestones for Calix, it looks like even more opportunities are emerging in FY24. I thank every member of our remarkable team for their continued effort to realise our potential, as well as our shareholders and partners for their support.

Calix and Pilbara Minerals' sustainable lithium demonstration plant passes Financial Investment Decision

A demonstration plant, developed by Calix and Pilbara Minerals, will use Calix's electric calciner to produce a low-carbon and low-waste lithium salt.

An innovative 'mid-stream' refining process for sustainable lithium, developed in a joint venture (JV) between Calix and Pilbara Minerals, moved a step closer following a successful financial investment decision on a demonstration plant at Pilbara Minerals' Pilgangoora Project.

The demonstration plant will use Calix's patented electric calcination technology and is supported by $20m in Australian Government funding announced under the Modern Manufacturing Initiative.

Calix CEO and Managing Director, Phil Hodgson said:

"We are delighted that the Project has passed the FID milestone, and we thank the Australian Government for their support.

"Together with Pilbara Minerals, we look forward to demonstrating the potential of our electric calcination technology to dramatically reduce the carbon footprint of Australian lithium. The success of the joint venture will also showcase the opportunity of combining Australian mineral and renewable resources with innovative Australian technology to enable the reliable and sustainable supply of value-added critical minerals to the world."

Pilbara Minerals CEO, Dale Henderson said:

"Following further studies and pilot test work, we are delighted to be taking the next step in our mid-stream strategy with the construction and operation of a Mid-Stream Demonstration Plant with our JV partner Calix.

"The mid-stream strategy has potential to materially improve the battery materials supply chain for lithium through reduction in carbon energy intensity, reduction in transport volumes and creating more value at the mine site. It has the potential to be a game changer compared to the traditional spodumene to chemicals processing route.

"The demonstration plant with Calix is an important step to further the development of the technology with the aim of commercialising the technology for application at the Pilgangoora operation and across the lithium industry through our commercialisation JV with Calix. This could in time open-up an additional revenue stream for the Company.

"I would like to acknowledge the financial contribution of the Australian Government to the demonstration plant project through a $20M Modern Manufacturing Initiative Grant. It's great to see the Australian Government supporting Australian innovation in the critical minerals industry."

Calix's electric processing technology for sustainable lithium

The proposed mid-stream refining plant is designed to show the potential for renewably powered processing of spodumene at the mine site. With a full production capacity of more than 3,000 tonnes per year of concentrated lithium-phosphate salt product from a feedstock of around 27,000 tonnes per year of spodumene – including lower grade fine spodumene concentrate – the project aims to demonstrate:

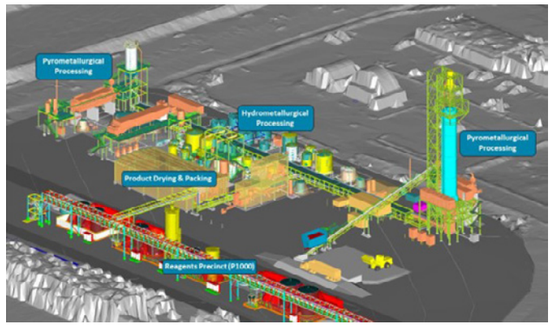
- **Reduced carbon intensity** – electrification of the mid-stream process, including spodumene calcining, can enable the use of up to 100% renewably sourced power and deliver a vast reduction in carbon emission intensity of the lithium product.
- **Reduced waste** – a concentrated and near zero-waste lithium product would allow waste material to be left at the mine site, providing further cost and emissions savings through reduced and simplified transport and logistics.
- **Reduced cost** – lower capital and operating costs with Calix's electric calciner compared with conventional calcining processes.
- **Value add** – a lithium rich product produced at the mine site may enable more value to be captured onshore at the mineral resource.

Market engagement with participants in the battery and chemicals supply chain has encouraged the pursuit of the mid-stream product and confirmed that it has strong potential to be an improved lithium feedstock for the lithium chemicals industry. The strategy of producing a mid-stream product also has the potential to unlock remote global hard-rock assets that would otherwise be limited by long distances to transport infrastructure or customers.

Carbon footprint impact

↓ 90% – carbon emissions intensity of spodumene calcination by renewably powered electric calcination vs a coal-fired rotary kiln

↓ 80% – carbon emissions intensity of spodumene calcination by renewably powered electric calcination vs a natural gas-fired rotary kiln



Mid-Stream Demonstration Plant location and layout

Enabling low-carbon lithium

Life Cycle Assessment studies commissioned by Pilbara Minerals analysed the carbon footprint of the proposed mid-stream lithium phosphate salt product, in addition to comparing β-spodumene produced via electric calcination and conventional rotary kiln calcination[1].

The study found that electric calcination powered entirely by renewable electricity would reduce the carbon emissions intensity of spodumene calcination by more than 90% compared with a conventional coal-fired rotary kiln, and by more than 80% when compared with natural gas.

Significant emissions reductions are also anticipated from the mid-stream product by avoiding the transport of waste associated with spodumene concentrate. Current practices involve shipping spodumene that is approximately 6% lithium and 94% waste from the mine site to be processed overseas. Production of a zero waste, concentrated lithium phosphate product would further reduce aggregate emissions across the lithium supply chain.

Rationalising international supply chains

Demand for lithium to support the rapidly growing global battery market continues to intensify. With the battery market now expected to grow five-fold by 2030, governments around the world are seeking to develop sovereign capabilities and reliable supply chains.

Electrification of mineral processing and the use of locally sourced renewable energy offers significant opportunities for Australian producers to develop highly competitive and future proof downstream processing solutions. By doing so, producers can add value to minerals by converting low-value ores into high-value products, reducing emissions and rationalising supply chains.

Commercialisation to the global spodumene industry

Calix and Pilbara Minerals aim to develop an innovative pathway for Australia to become a reliable supplier of sustainably refined lithium to the world. Successful demonstration of the mid-stream process may lead to its commercialisation, with the JV able to license the technology to Pilbara Minerals' commercial scale plants and the global spodumene processing industry.

[1] Based on cradle-to-gate Life Cycle Assessment studies completed by Minviro Ltd.: evaluating production of Lithium Hydroxide Monohydrate (LHM) from Pilgangoora spodumene concentrate using conventional calcination; and evaluating the production of lithium phosphate from Pilgangoora spodumene concentrate using Calix's electric calcination technology. The assessments calculated the carbon footprint for the production of each chemical from the mine to the factory gate. A further study evaluated the product carbon footprint of β spodumene production via conventional and electric calcination.

Early results propel low emissions iron and steel development

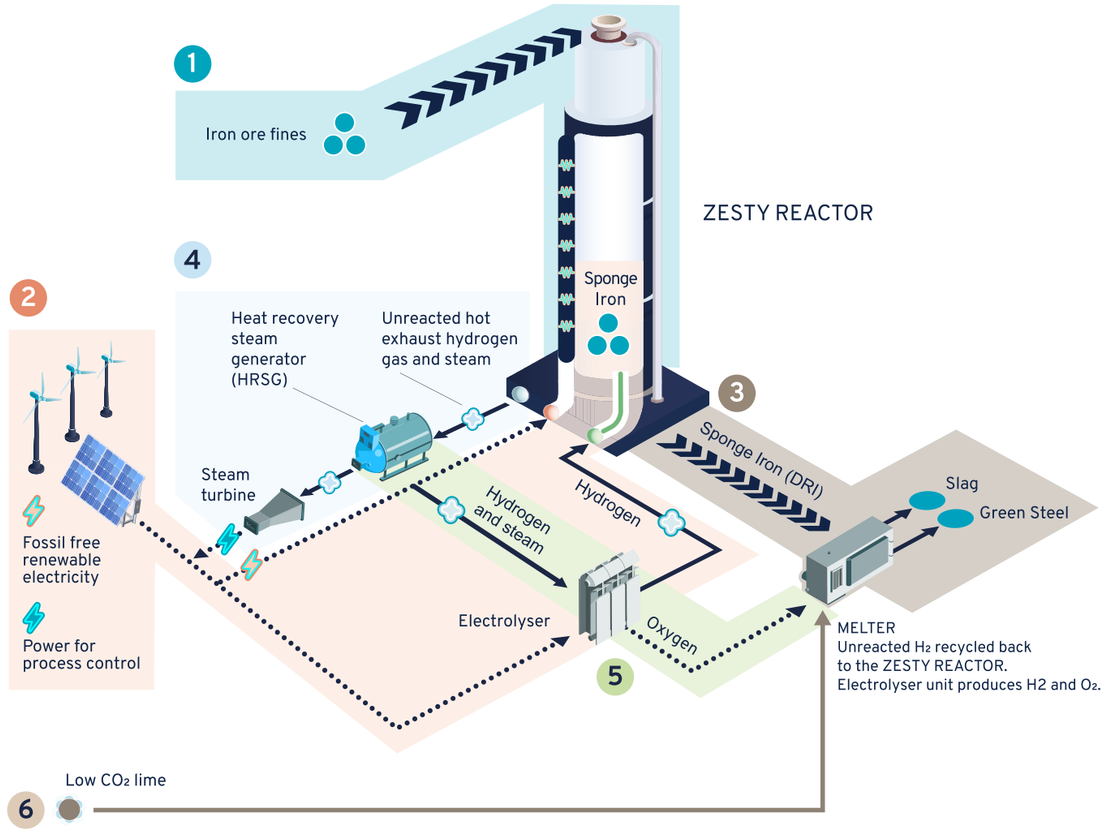
About ZESTY

Calix's Zero Emissions Steel TechnologY (ZESTY) is designed to help decarbonise one of the world's most carbon-intensive industrial processes – iron and steel production. The industry accounts for ~7-9% of global CO_2 emissions, with the majority resulting from the use of metallurgical coal in the reduction of iron ore to metallic iron.

ZESTY enables direct hydrogen reduction of iron ore (H-DRI) in a renewably powered reactor to produce green iron and ultimately, green steel. It provides the potential for a zero-carbon route to iron and steel that in turn can help add value to local iron ore exports, future-proof local iron and steel production and support sustainable global development.

ZESTY's indirect heating approach is well suited for electrification, including with renewable and intermittent energy sources. Electrification also means no combustion. With ZESTY, hydrogen is consumed only as a reductant, not as a fuel, and can be simply recycled in the process. This key feature enables ZESTY to target the most efficient and economical use possible of hydrogen.

[2]M. Shahabuddin, G. Brooks, and M. A. Rhamdhani, J Clean Prod, 136391 (2023) 395



Process flow diagram for ZESTY green steel production.

Pilot-scale results

Pilot-scale testing shows that Calix's ZESTY technology can produce a hydrogen direct reduced iron or "H-DRI" product approaching commercial grade.

Excellent metallisation (conversion of iron ore to iron) was achieved for Siderite and Goethite / Hematite ores. ZESTY's compatibility with small particle sizes was found to facilitate fast rates of metallisation, allowing for significantly shorter residence times and lower temperature operation than a conventional blast furnace. Hematite makes up 96% of Australia's exported iron ore and is not otherwise suited to most electric arc furnace (EAF) methods.

Reduction and metallisation extents for the non-porous and dense magnetite sample were lower, reaching a maximum metallisation degree of 54% at 1050°C. An increase in residence time and/or temperature for the processing of dense, non-porous magnetite samples is expected to lead to improved reduction and metallisation of magnetite by ZESTY.

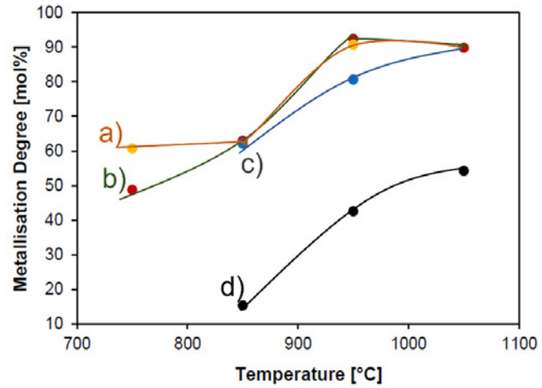
Next steps

An expanded testing program, using a range of ore types from Australia and overseas, has commenced. Further planned pilot-plant modifications will enable continued exploration of critical performance parameters, as well as ore selection and pre- and post-processing requirements.

The ongoing R&D program is informing a Front-End Engineering Design (FEED) study for a 30,000 tonne per annum, zero CO_2 emissions ZESTY-iron demonstration plant. The FEED study is supported by a A$947,035 grant from the Australian Government's Australian Renewable Energy Agency (ARENA) and is expected to be completed by the end of 2023.

[3]Iron Ore | Geoscience Australia

		Fe (Wt %)	D50 (µm)	SSA (m^2/g)	Pore Volume (cm^3/g)
A)	Siderite	43	87	25	0.035
B)	Goethite / Hematite	57	130	15	0.034
C)	Goethite / Hematite	59	129	14	0.039
D)	Magnetite	67.5	38	0.8	0.003



Pilot-scale metallisation results for ZESTY. Multiple ore types tested with semi-continuous operation at throughputs up to 100 kg/h.

US delegation hosted by the Great Plains Institute visit Leilac-1

A US delegation of 21 leaders from business, government and NGOs – organised by the Great Plains Institute – visited our Leilac-1 pilot plant, in Lixhe, Belgium on 7 June 2023. The visit provided a valuable opportunity to share the technology and policy solutions driving the decarbonisation of cement.

In addition to a tour of our purpose-built solution to capture CO_2 released unavoidably during the production of cement and lime, we also shared plans for additional projects, such as Leilac-2, our demonstration plant in Hannover, Germany. Both Leilac-1 and Leilac-2 are supported by the European Union and a consortium of industry partners.

The Great Plains Institute, headquartered in Minneapolis, Minnesota, is working to transform the energy system to benefit the economy and environment. It does so by bringing together disparate interests to broker consensus to create solutions that no one interest group would have come to on their own.

The delegation, representing diverse sectors from across the US, share a keen interest in cement and lime decarbonisation as well as government policymaking, such as the US Inflation Reduction Act and the EU's European Green Deal, both of which are contributing greatly to growing the development of carbon capture, utilisation, and storage (CCUS) initiatives.

Leilac was delighted to host the delegation and grateful for the efforts each member is making to shape our collective future and provide a direction for cement decarbonisation.

Partnerships are critical to the system-level changes needed to reach net zero and we actively seek strategic partnerships at local, regional, national, and international levels.

Leilac-2 update

Meanwhile, our Leilac-2 project in Hannover continues to progress, with the procurement of long lead equipment items underway. Commencement of civil works remains subject to permitting, which has taken longer than expected and is now critical path for the project. We continue to press for a speedy resolution to permitting to minimise impact on the project timeline.

Expanding our US presence

Calix's Water business continues to expand its presence in the US water and wastewater treatment market, with new customers and new "hydration" plants in new regions.

The hydration plant in Lufkin, Texas is undergoing commissioning, and a new plant in Ripon, Wisconsin is under construction and expected to come online later this year. The new plants will support the expansion of sales into new regions, including Wisconsin, Illinois and Texas. Modifications in IER's manufacturing process have resulted in the development of ALKA-Mag+, which has helped to secure new business within the existing hydration plant regions in the Pacific Northwest and Upper Midwest.

The Water business has solidified relationships with two new distributors in the wastewater treatment market, and another in the potable water treatment market. The three distributors share a philosophy of providing world class products, service and technical credibility.

Regulatory tailwinds

Growth in the Water business is being driven by significant regulatory tailwinds in North America. For wastewater, increased regulation regarding nitrogen removal is creating demand for solutions that boost alkalinity and maintain effective microorganism activity. For the potable water market, strengthened regulation on residual lead and copper requires alternative pH control solutions to minimise the corrosivity of water within the distribution system. In both cases, magnesium hydroxide is an effective and sustainable solution to boost and regulate alkalinity.

Effective management of our water and wastewater helps to protect freshwater systems, our oceans and human health by preventing detrimental pathogens, nutrients and other types of pollution from entering the environment. IER's ALKA-Mag+ and Calix's AQUA-Cal+ and ACTI-Mag products provide safe, economical and sustainable solutions for the treatment of water and wastewater.

Decarbonising shipping: Developing sustainable fuels and CO_2 capture solutions

International shipping is the backbone of global trade. It is also a highly carbon-intensive and hard-to-abate sector, responsible for over 2% of global CO_2. What's more, the shipping industry has a critical role to play in a future low-carbon economy; enabling other industries to reach net zero through the clean transportation of low-carbon minerals, fuels and other exports.

The International Maritime Organization's revised strategy to reduce greenhouse gas emissions from international shipping states an ambition to reach net-zero by or around 2050. The strategy also includes targets to reduce the carbon intensity of international shipping by at least 40% by 2030 compared with 2008, and for uptake of zero or near-zero greenhouse gas emission technologies, fuels and/or energy sources to represent 5%, striving for 10%, of the energy used by international shipping by 2030.

Calix is committed to applying its core technology to develop solutions to help decarbonise shipping. These include the production of sustainable transport fuels from captured industrial CO_2 and the use of zero emissions lime for shipborne carbon capture.

Sustainable fuels from captured CO_2

Sustainable alternative transport fuels may enable low carbon fuels for the shipping industry. Capturing CO_2 that is an unavoidable byproduct of other industrial processes, such as cement and lime production, and using that as a feedstock for synthetic fuels offers one potential solution. As well as helping to reduce the carbon intensity of shipping, this approach can aid the decarbonisation of other industries by providing offtake solutions for their process emissions, creating synergies across the carbon value chain.

The use of captured industrial CO_2 and the production of synthetic fuels, such as methanol, continues to gather momentum from both industry and policy makers. As part of its net zero by 2040 strategy, global shipping giant Maersk now has 25 methanol enabled container vessels on order. In the US, the Department of Energy recently announced a US$100m funding program to support the procurement of products derived from converted carbon dioxide emissions.

Closer to home, the Solar Methanol Project, of which Calix is a consortium member, aims to develop the production of sustainable fuels from renewable energy, green hydrogen and captured process CO_2 emissions. The project intends to use the Leilac technology for CO_2 capture and is supported by ~$40m in funding from the German-Australian HyGATE Initiative.

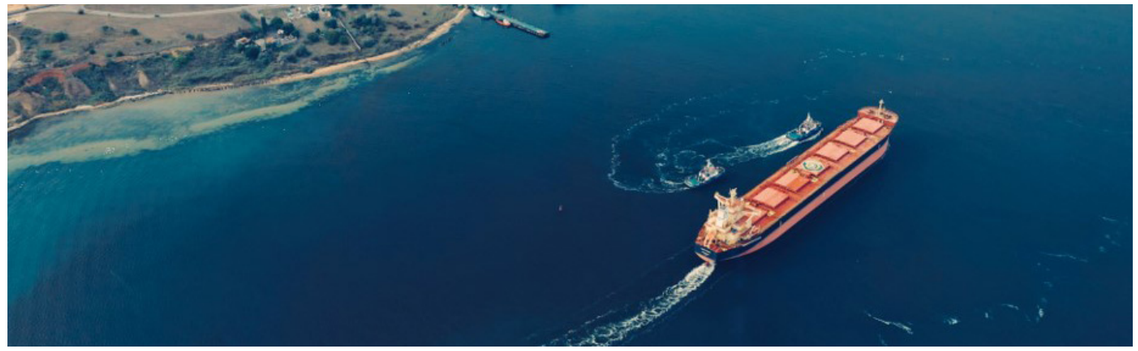
An onboard carbon capture solution for shipping

While more sustainable transport fuel solutions are being developed and scaled, the use of diesel is expected to continue for several decades. For the existing international shipping fleet, carbon capture offers an alternative, near-term decarbonisation solution.

Lime is a highly effective sorbent for the capture of CO_2 and can be used in a carbon capture system for the abatement of emissions from conventional diesel engines. For this solution to provide a net reduction or elimination of emissions, the lime used for capture must be produced with low or zero carbon emissions, using shore-based decarbonisation of the lime. If methanol produced using captured CO_2 from industry is used as a fuel, its combination with a carbon capture solution could deliver net negative emissions from shipping.

Windship withdraws from UK Clean Maritime Demonstration Competition

Calix's participation in a zero-emissions shipping project led by Windship Technology Limited has been paused while Windship explores funding options. Windship advised The UK Department of Transport and Innovate UK, part of UK Research and Innovation, that it does not have the required funding to commence the project in July 2023. As a result, the project and associated grant funding of around £5m (of which Leilac was to be allocated around £1m to help develop CO_2 sorbent systems) will be withdrawn from the UK Government's Clean Maritime Demonstration Competition ("CMDC3"). Calix looks forward to continuing its collaboration with Windship to develop and demonstrate decarbonisation solutions in the future. Leilac continues to develop its CO_2 sorbent technologies through other projects, including with Heirloom for Direct Air Capture.



New lab facilities open at Bacchus Marsh

A new multi-purpose laboratory is now open at Calix's Bacchus Marsh facility in Victoria, Australia. The new laboratory provides a significant increase to the company's research and development capabilities and capacity, helping to speed up project development and drive new innovative applications of Calix's core technology platform.

Supported by a $1m grant from the Australian Government, the new facilities are helping to transform Calix's manufacturing capability for agriculture, marine and antimicrobial resistance applications, as well as freeing up existing resources for other applications across the Company, including developing Calix's Advanced Batteries and Zero Emissions Steel TechnologY. Further new equipment will add significant additional testing capacity to assess materials from prospective partners and customers for all lines of business. The ability to test and analyse materials on site supports rapid learning and feedback cycles across Calix's research programs, propelling the development of the technology and its applications.

The new laboratory has supported the creation of six new jobs at the Bacchus Marsh site, with further recruitment planned in the coming months. In addition to its in-house facilities, Calix continues to collaborate with world-class research teams across the world, including through our partners at the Future Battery Industries Cooperative Research Centre (CRC), Solving Antimicrobial Resistance in Agribusiness, Food, and Environments CRC, Heavy Industry Low-carbon Transition CRC, the Deakin University Battery Research and Innovation Hub, and the Deakin University Recycling and Clean Energy Commercialisation Hub.

Join us - We're hiring

Latest Calix job opportunities

Latest Leilac job opportunities

R&D leadership appointments

Calix is delighted to announce the appointment of Dr Matt Boot-Handford to the role of Chief Scientist – Calix Ventures, replacing Dr Louise Keyte as head of Calix's technology development. Dr Keyte has left Calix to purse new opportunities and we thank her for her great contribution. Dr Boot-Handford's previous role as General Manager, Research and Development has been filled by Dr Salwan Al-Assafi, whom we warmly welcome to the team.

Together with Dr Mark Sceats, Calix Group Chief Scientist and Cofounder, Calix looks forward to progressing its impressive track record in technology development with these new management appointees.

Dr Matt Boot-Handford
Chief Scientist – Calix Ventures

Dr Salwan Al-Assafi
GM, Research & Development

Repurposing in action: used intermediate bulk containers are recovered, refitted or repurposed.

Adopting circular economy practices

Calix is committed to incorporating circular economy models into every aspect of our operations. To reduce our operational waste, we have taken steps to repurpose broken intermediate bulk containers (IBCs) that would otherwise have ended up as landfill. At our Bacchus Marsh site, we have recovered and refitted 17 IBCs and recirculated them into our fleet. 10 additional IBCs that could not be refitted have been repurposed into dog kennels, shower blocks and planter boxes.

At our Nerang site, we donated IBCs to Gold Coast Kokoda Challenge event, raising money for the Kokoda Youth Foundation.

Repurposing offers a sustainable solution to reducing landfill waste. In giving new life to otherwise discarded items, we conserve resources and minimise our environmental impact.

To learn more about our Sustainability commitments, visit https://calix.global/sustainability/

calix | SUSTAINABLE DEVELOPMENT GOALS

Calix supports the Sustainable Development Goals

Meet some of the Leilac team

Youssef Aaraj

Project Manager/Process Engineer

Career at Leilac Meet Youssef Aaraj

"Working on the LEILAC technology is an opportunity to work with a motivated team that dares to innovate. We can be proud that our work in Calix positively impacts us and the rest of the world."

Youssef Aaraj is a Process Engineer with experience in energy processes development and integration. Youssef has a PhD from the "Ecole des Mines" in Paris in Energy Processes Optimisation.

He joined Leilac in 2019. Previously to Leilac, Youssef worked on the development of a process for the purification and treatment of biogas.

Currently Youssef is working on the development of the combustion system and the material selection for LEILAC-2, in addition to participating in scoping studies concerning the installation of the LEILAC technology at different cement plants around the world.

Aoife Budge

Process Engineer

Career at Leilac Meet Aoife Budge

Passionate about ensuring intergenerational equity, so that the same standard of living and opportunities can be available for future generations, she hopes to aid in creating more sustainable industrial processes by looking at the whole supply chain and not just a process alone.

Prior to joining Leilac, Aoife worked at Imperial College, where she completed empirical assessments for a proprietary pre-combustion carbon capture process. She also completed an internship for Catalysis Consulting Ltd, where she developed a series of process and technical information sheets on 'clean' processes such as waste to energy and the use of hydrogen as a fuel.

Tom Hills

Technical Lead - Process Development

Career at Leilac Meet Tom Hills

Nowadays, I think there's a great opportunity for engineers to make a real and positive difference to society, to the Earth and to biodiversity. We have got a unique opportunity now to make history reducing carbon and making the world a more sustainable place. "

Tom joined Leilac in 2017 as a research engineer. He has worked across a range of projects, including Leilac-1, Leilac-2, ASCENT, ANICA, and SOCRATCES, helping to drive concepts from rough sketches to detailed models and ultimately operational plants.

As the technical lead for process development, Tom participates in internal projects where Leilac technology is strategically developed, as well as supporting delivery-focused projects with rapid development and solution prototypes. He also leads the early-stage innovation and technoeconomic activities for the company.

Tom attended Imperial College in London, where he earned Master of Engineering (MEng) in chemical and nuclear engineering and a PhD in carbon capture in the cement industry, with a specific focus on the calcium looping process. During his studies he also worked as a consultant on industrial decarbonisation for a broad range of private and government clients.

Tom is based in the UK, where he enjoys gardening and spending time with his young family.

calix

Join us
Calix and Leilac are hiring

The Calix team continues to grow across the globe. Discover new opportunities or register your interest at the links below.

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Latest Leilac job opportunities

Mars is for quitters.

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