ASX Announcement

November 11, 2021

November Quarter Newsletter – Issue 40

Sydney, Australia | November 11, 2021 – Multi-award-winning Australian technology company Calix Limited (ASX: CXL 'Calix' or 'the Company') is pleased to announce it has released a comprehensive update on activities across its business segments. The newsletter is attached overleaf.

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

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About Calix

Calix is a team of dedicated people developing a unique, patented technology to provide industrial solutions that address global sustainability challenges.

The core technology is being used to develop more environmentally friendly solutions for advanced batteries, crop protection, aquaculture, wastewater and carbon reduction.

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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calix

Innovating for the Earth

Calix News

November 2021

In this issue:

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

Welcome to Issue 40 of the Calix Newsletter

Phil Hodgson
CEO

"In this first quarter of the new financial year, Calix completed one of the most important commercial deals since listing the company in July 2018 – the investment by US-based Impact Fund Carbon Direct into our LEILAC (Low Emissions Intensity Lime And Cement) Technology. The investment of 15m euro for a 7% equity in the technology puts a significant value stake-in-the[1]ground, and is a testament to the hard work in technical development and value creation the Calix team have put into this exciting technology, at a time when there is accelerating interest and investment in global climate solutions. Please explore this deal a bit further in our article in this newsletter, as well as an in-depth look at our development projects in Europe – the LEILAC-1 and LEILAC-2 projects.

To support this important phase of growth, I am also very pleased to confirm that a seasoned Calix executive – Daniel Rennie – has been promoted to lead our CO_2 business as CEO. Dan has been instrumental in winning grant funding for, and co-ordinating, both our LEILAC-1 and LEILAC-2 projects, and in raising the profile of Calix's LEILAC technology from an unknown new technology only a few years ago to the European and then world stage.

In response to the growing interest in our technology and in line with our March 2021 capital raise, we have continued to recruit some great new talent into our organisation – our engineering and R&D teams have been bolstered by the addition of Ruth, Chris, Rana and Andrea – read about their impressive backgrounds in this newsletter also. And we also feature one of our longer-serving loyal staff members in Joshua Menzies on the back page.

In our water business, off the base of our AQUA-Cal+ solution to prawn farm pollution, we are launching a new project to look at whether AQUA-Cal+ can help with the environmental pressures associated with salmon farming – particularly on the sea bed of salmon pens and also typical salmon diseases. We look forward to the results from this program, given the environmental pressures the industry is beginning to face. We also take a look at a customer case study in the US, where our US team continues to expand the business based upon technical expertise, customer service and great product. We also share a link through to an interview I conducted with Nick Chiarelli of the Ocean Impact Organisation, of which Calix is now a sponsor. Click the link to hear about Nick's vision for a cleaner ocean and help get behind this great initiative.

An article on our Biotech business features the on-going successful testing our marine coatings developments. Again, global pressure to reduce environmental impact is a great tailwind for this potential business, where our safe, environmentally friendly very high surface area magnesium oxide coating additives are dramatically improving the performance and life of existing marine coatings.

Our R&D update features two projects based upon our LEILAC Technology, both of which are helping to address the UN Sustainable Development Goals ("SDG's") through a novel energy storage system "SOCRATCES" powered by concentrated solar radiation, and a "calcium looping" system "ANICA" which is looking at the wider application of the LEILAC Technology in more general flue gas CO_2 capture. As always, we continue to very much appreciate the support of all our shareholders and stakeholders as we continue another year of significant development for the company."

The Calix Team is Growing!

Meet **Ruth Barajas**

BATMn Plant Coordinator

Ruth Barajas joined Calix in July 2021 as a R&D pilot plant coordinator. She brings to the company over 8 years of experience in the petrochemical, and oil and gas fields. Over her professional career she has worked as a process engineer, applying state-of-the-art modelling systems, to develop new revenue streams and cost reduction projects that resulted in annual savings of more than US$5 million.

Prior to joining Calix, Ruth completed her PhD in Chemical Engineering with her thesis titled "Engineered nanocellulose superabsorbents for application in agricultural soils" at Monash University, Australia. During her time at Monash University, she was part of the COVID-19 task force team developing PPE Medical Gowns from laminated paper. Passionate about the environment, Ruth looks forward to working with Calix on creating novel, sustainable and safe solutions for future generations.

Meet **Rana Hawly**

Project Engineer

Rana graduated in 2018 as a Material Engineer from Polytech Sorbonne University in Paris. She also has a bachelor's degree in chemistry from Sorbonne University. Rana started her professional career by working as a Cost Analyst at Renault, a French automobile company, for two years.

She recently joined Calix Europe as a Project Engineer, and will be supporting the engineering team, especially Project Managers and Senior Project Engineers, on all aspects of the LEILAC-2 project, from early design phases through to detailed engineering, procurement, construction, and commissioning.

In her free time she enjoys being around the kitchen and trying new recipes, especially Asian cuisine. "I believe that cooking is a rewarding and satisfying experience; it highlights my creativity skills. It's also a perfect way to connect with one another and to share great moments with family and friends."

Meet **Chris Song**

Battery Materials Laboratory Technician

Chris recently joined Calix as a Laboratory Technician, having previously completed his studies at Monash University with a Bachelor of Chemical Engineering and Pharmaceutical Science. He is working as part of the Research and Development team developing and scaling production of active electrode materials for lithium ion battery applications.

During his studies at Monash University, Chris worked with leading researchers in the Chemical Engineering department on the development of ultrasound responsive pH nanosensors.

Meet **Andrea Passariello**

Senior Mechanical Engineer

Andrea obtained a BSc and a MSc in Aerospace Engineering at the University of Pisa, specialising in Structural Analyses and Fluid Dynamics. His BSc thesis involved the development of software for the preliminary design of Shell and Tube Heat exchangers for ENEL ENERGIA SpA. His MSc thesis involved the publication of a well renowned AIAA journal article about understanding non-linear buckling behaviour of anisotropic structures.

Andrea worked mainly in the Aerospace industry, with the majority of his experience developing and maintaining the safe operation of Rolls-Royce aeroengine fleets as a Structural Analysis Specialist.

He worked also for other companies in different roles such as Mechanical Designer and Aerothermal Engineer on flight control systems, avionics cooling systems, composite impact tests, pressure vessels and their testing, innovative heat exchanger technologies and new thermodynamic cycles research.

Andrea joined Calix to contribute to reducing greenhouse emissions to try to mitigate climate change, by analysing and developing the components which operate for long periods of time at very high temperatures. He will be contributing to the future development of the core components that make up Calix's core technology.

WE ARE HIRING FOR OUR GLOBAL ENGINEERING TEAM.
To learn more and apply, contact us or check out our LinkedIn page:
https://www.linkedin.com/company/calix-limited/

Carbon Direct invests €15M ($A24.5M) for a 7% stake in Calix's LEILAC business

Calix will use these funds to accelerate deployment of its lime and cement decarbonisation technology

Calix is pleased to announce global decarbonisation investor Carbon Direct Capital Management has invested €15m for a 6.98% equity stake in Calix's subsidiary, the LEILAC Group, which is dedicated to the commercialisation and ongoing development of Calix's LEILAC CO_2 capture technology.

Calix will continue to own the remaining 93% of the LEILAC Group.

In addition, as part of the transaction, Calix has entered into a licence agreement with the LEILAC Group under which it will retain 30% of royalties earned by the LEILAC Group from deployment of the technology, regardless of Calix's equity stake in the LEILAC Group. The LEILAC Group will operate autonomously, with its own management team and a Board composed of three Calix directors, with one appointee nominated by Carbon Direct, and one independent appointee.

The LEILAC Group, comprising Calix (Europe) Ltd (UK) and its subsidiaries, is the exclusive licensee of Calix's Low Emissions Intensity Lime and Cement (LEILAC) CO_2 capture technology. The LEILAC technology was successfully piloted at 25,000 tonnes per annum scale at HeidelbergCement's plant in Lixhe, Belgium, and is being scaled up to 100,000 tonnes per annum scale in the "LEILAC-2" project for a HeidelbergCement plant in Hannover, Germany. Further commercial pilot plants for lime production are under development with Tarmac, the UK division of CRH, and AdBri in Australia, among others.

US-based Carbon Direct's investment arm, Carbon Direct Capital Management, makes direct investments into leading carbon removal and utilisation technology companies. The firm also operates a scientific advisory business, which advises leading corporations on how to fulfil their carbon removal and utilisation commitments. Carbon Direct's advisory work spans 28 countries and includes clients such as Microsoft and Shopify.

Pottinger (https://www.pottinger.com/) acted as financial and strategic advisor to Calix on this transaction, and Hamilton Locke acted as legal advisor.

Carbon Direct investment to accelerate LEILAC technology uptake

Along with existing capital already invested in the LEILAC Group, Carbon Direct's investment will be used by the LEILAC Group to accelerate and continue to de-risk deployment of the LEILAC technology, both technically and commercially. Technically, additional resources will be deployed in engineering and research to speed optimisation. Commercially, new resourcing in business development, especially project development and CO_2 use or sequestration, will be deployed to help develop complete project solutions for customers.
A new CEO will be appointed to run the business as a stand-alone entity.

The investment marks the conclusion of work led by Pottinger to accelerate commercialisation of the LEILAC technology and identify the optimal financial and strategic partner(s) to support this business' critical next phase of development.

Calix Limited CEO Phil Hodgson said the deal represented a critical milestone in Calix's stated strategy of seeking equity "farm-ins", after initial development undertaken by Calix, to accelerate and deploy its underlying platform technology into each line of business, with Calix remaining head licensor.

“As each of these businesses become independent commercial entities, they will remain "joined at the hip” technically with Calix, which will continue to support development of the core intellectual property. Over time, growing royalty income from these companies will also support the development of new applications of the IP and associated technologies,” Dr Hodgson said.

He said the investment by Carbon Direct will help accelerate the development and deployment of the Calix Technology for cement and lime decarbonisation.

“The recent Intergovernmental Panel on Climate Change (IPCC) report was unequivocal in saying that to reach the stated 2030 goals on climate change, CO_2 emissions have to be reduced. LEILAC Technology is an option that is being deployed now to meet this urgent need."

“Carbon Direct coming on board is a strong vote of confidence in Calix’s LEILAC decarbonising technology, following on from endorsements and partnerships with industry leaders such as HeidelbergCement, Cemex, Lhoist and Solvay."

“The investment will assist us in accelerating the deployment of the technology into the carbon capture and storage landscape, with additional resources covering technology research and development, CO_2 logistics, use and storage, and whole-of-project expertise, while our technology gains more exposure in global markets outside of Europe."

“The deal also represents our first material portfolio transaction in our stated strategy to farm-in equity to deploy our technology commercially. We believe this strategy adds speed and focus at a critical time in the technology commercialisation journey, and leaves the head company to focus on what it does best – supporting our technology and developing the next global, transformational applications.”

Carbon Direct founder and CEO Jonathan Goldberg said Carbon Direct invested in companies that could deliver both commercially viable solutions and solve big climate problems.

“We are very impressed by the technical and commercial rigor of the LEILAC team, and plant partners are outspoken in their excitement about LEILAC. We are delighted to support Phil, Calix, and the LEILAC Group as they seek to scale LEILAC into cement and lime plants around the world,” Mr Goldberg said.

“Both Carbon Direct’s investment team and its scientific advisory team, which now includes 46 globally renowned CO_2 scientists and project managers, are available to assist the LEILAC Group on subjects including capital markets, regulations, commercial development, and technical development. Our entire firm is dedicated to helping technologies such as LEILAC to scale.”

Pottinger Executive Chairman Nigel Lake added: “Great engineering and technology alone are not enough: to have a transformational impact on an entire global industry takes a dedicated and well-resourced business. The investment by Carbon Direct marks a critical inflexion point for both Calix and the LEILAC Group as decarbonisation of the construction sector begins in earnest.”

Carbon capture is needed to reach the UN climate goals

Global decarbonisation efforts are accelerating. For example, in June 2019, the UK Government became the first major economy to commit to net zero CO_2 by 2050 and is heavily supporting decarbonisation efforts through funding under the UK Department of Business, Energy and Industrial Strategy £1bn Net Zero Innovation Portfolio. In 2021, the European Union unveiled a plan to slash its carbon emissions by 55% before 2030 and impose border tariffs on countries, including Australia, that do not have some form of carbon price.

Cement production is the world's single biggest industrial cause of carbon pollution, responsible for up to 8% of global emissions, producing more than 4 billion tonnes of CO_2 per year. Cement is the primary ingredient in concrete, the second most used material in the world after water. The global production volume of lime was approximately 330 million tonnes in 2020, with myriad applications beyond cement including the manufacture of aluminium, asphalt, copper, glass, gold, lithium, plasterboard, silver, solar-grade silica, steel, table salt and toothpaste. Lime is also used in agriculture and for water and sewage treatment.

About Carbon Direct LLC

Carbon Direct provides both scientific advisory services and investment capital to the carbon removal & utilisation ecosystem. Their advisory business works for clients to fulfill their carbon removal & utilisation commitments. Carbon Direct’s team of world-renowned carbon scientists has a nuanced understanding of the true risks and opportunities of emerging and mature carbon removal & utilisation technologies. Their investment business makes direct investments into leading carbon removal & utilisation companies. Carbon Direct was founded in 2019 by Jonathan Goldberg and has offices in New York City.

To learn more, visit www.carbon-direct.com

Making 1 tonne of lime or cement clinker produces approximately 1 tonne of CO_2

Between 50 to 60% of cement CO_2 emissions derive from the process of heating or “calcination” of limestone, the chemical reaction that converts limestone ($CaCO_3$) into lime (CaO) and CO_2. These emissions are therefore unavoidable and a low-cost capture solution is essential.

The patented LEILAC kiln design separates CO_2 emissions arising during lime and cement production without significant energy penalty. The LEILAC kiln is being developed to use a variety of input fuels and is also easily electrified, enabling complete decarbonisation of production by switching to renewable energy.

Since successfuly implementing the LEILAC-1 project, the scaled up LEILAC-2 project is targeted to be in production by late 2023 / early 2024, and is being funded by €34m from the EU Horizon 2020 scheme and through a combination of cash and in-kind contributions from industrial partners. In addition to HeidelbergCement, industrial partners helping in developing the technology include Cemex, Tarmac, Cimpor, Lhoist, Engie and Solvay.

Multiple cement and lime projects are being developed with several interested parties, with two of the projects now moving into more detailed planning under previously announced heads of agreements with CRH’s UK subsidiary Tarmac and Adbri in Australia.

LEILAC

Capturing CO_2 in the cement and lime industries

The adoption of the Paris Agreement, ratified by 175 countries, provided the clear objective of keeping a global temperature rise of well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to below 1.5 degrees Celsius.

In support of those ambitions, the very challenging goal of reaching carbon neutrality by 2050 has been set. These commitments are being made at a variety of levels. 127 countries, 823 cities, 101 regions, and 1,541 companies have committed to decarbonising their activities by 2050 (New Climate Institute 2021).

These commitments are being matched in the cement industry. The Climate Ambition articulated by the members of the Global Cement and Concrete Association, and 2050 Roadmap by Cembureau, and the corresponding wave of individual corporate commitments, all have ambitions for neutrality by 2050.

This is not an easy commitment to reach for the cement or lime industry - responsible for 8% of global CO_2 emissions. Cement and lime provide vital services to our society, with essential products that are low cost and very efficiently produced. Since 1990, major efforts have been made to reduce emissions, including improvements to energy efficiency, use of alternative and waste fuels and clinker substitution.

However, complete decarbonisation of this industrial sector is far harder than many others, as most CO_2 emissions are released directly and unavoidably from the processing of the limestone. These “process emissions” are in addition to the CO_2 released from the combustion of fuels used to power the process (representing around two-thirds of a plant’s total emissions, depending on the fuel used).

Capturing unavoidable carbon

To reach the corporate emissions reductions targets by 2050, these unavoidable process emissions must be addressed. The most effective means is to capture the CO_2, and ensure that it does not reach the atmosphere. Called Carbon Capture Use and Storage (CCUS), this general approach to decarbonisation has been used for decades in the hydrocarbon processing and recovery industries, further developed for the power sector. This will need to be applied to the majority of cement and lime plants due to those process emissions (Cembureau 2050 Carbon Neutrality Roadmap). As noted by the 2018 IPCC report, “CCUS plays a major role in decarbonising the industry sector in the context of 1.5°C and 2°C pathways, especially in industries with higher process emissions, such as cement.”

Capturing carbon from industrial and power generation plants has not yet been widely adopted due to the efficiency and cost penalties of traditional capture technologies, and a lack of meaningful (and universally applied) cost implications for emitting CO_2. However, changes are very rapidly being seen. Globally, 61 carbon pricing initiatives have been introduced covering 22% of all emissions (World Bank Group, 2021). The European Emissions Trading System (EU ETS), the largest carbon market in the world, reached a price of €56 per tonne of CO_2 in 2021.

The current collective objective facing industry and government (creating incentives) is threefold: to maintain economic prosperity; meet cement and lime market demand; while dramatically lowering CO_2 emissions.

Carbon capture

The majority of initiatives to capture carbon are based on processes and techniques developed for the energy and chemical sectors. For 60 years solvents such as amines have been used to strip CO_2 from gases (particularly in refineries and natural gas processing plants), and a lot of work has been recently undertaken to apply them to the cement sector at increasingly lower cost. Sorbents (including calcium looping), membranes, and other gas separation systems are being actively developed to reduce the volumes and/or energy required to separate CO_2 from flue gases. Other approaches, such as oxyfuel, seek to concentrate CO_2 in the flue gas to very high levels to enhance CO_2 recovery.

A very different approach has been invented and patented by Calix. Calix's LEILAC (Low Emissions Intensity Lime and Cement) Technology focuses on separating, for minimal energy or capital penalty, the CO_2 coming from the raw limestone, which is responsible for about 2/3 of the total CO_2 emissions of the cement and lime industries.

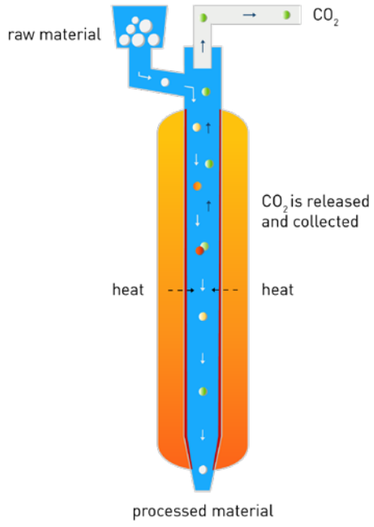


Figure 1

One configuration of Calix's Direct Separation Technology

Figure 2

The completed LEILAC-1 Pilot Plant

It is based on heating the limestone via a special steel tube - with the heat on the outside of the tube and the limestone or raw cement meal on the inside - separating "how" you heat from "what" you heat.

This unique system enables pure CO_2 to be captured as it is released from the limestone, since the furnace exhaust gases are kept separate. Processing raw cement meal by indirect heating (LEILAC) or by direct-heating (conventional cement or lime kiln) can be done in principle with the same specific energy. This practice does not involve any additional processes or chemicals, and simply involves a novel “precalciner” design (or new kiln, in the case of a lime plant).

The LEILAC Technology aims to use any type of fuel or heat source. This makes achieving a very efficient zero-emissions cement or lime kiln possible when using biomass rich fuels, green electricity, or hydrogen.

The LEILAC projects

Supported by the European Union, the LEILAC projects are applying this new type of kiln. Applying the technology to the cement industry will require scale-up of the technology and close integration with a cement plant. And to quickly and effectively apply this technology, the European-Australian collaboration LEILAC projects include consortiums of some of the world’s largest cement, and lime companies, as well as leading research and environmental institutions.

The LEILAC-1 project involved the construction of a Pilot Plant at the HeidelbergCement site in Lixhe, Belgium (CBR Lixhe). Extensive research, development and engineering was necessary to design and construct the first-of-a-kind pilot – involving the dedicated, flexible, and professional inputs from all the project’s partners, particularly the industrial users HeidelbergCement, Lhoist and CEMEX. This enabled the construction of the Pilot Plant on time and within budget in 2019.

Additionally, studies examining integration of the plant in different configurations, and confirmation of the sustainability of the process and outreach activities have also been conducted by the other parties (Imperial, PSE, Quantis and the Carbon Trust). Several challenges were faced in getting the system optimised, particularly the burners, feed and conveying systems. These were eventually overcome, and the system went on to complete over 1500 hours of test runs on multiple feed stocks and under multiple operating conditions.

Within the current configuration, CBR’s Lixhe cement meal has been processed at up to 8tph and briefly at 10 tph, with extents of calcination (conversion of limestone to lime) seen at 85%. Meal for LEILAC-2 (Hannover) has been processed at up to 8tph, with consistent calcination of 91% at 5tph. Calix reactors have obtained 98+% calcination results on pure limestone, using an optimised particle size distribution (PSD). In all runs, separation of CO_2 was undertaken (>95% purity) directly from the reactor and before any clean up steps, with no air ingress or loss of containment.

A number of "mini projects" are currently in train, as part of the LEILAC-2 project, to optimise the throughput and calcination rates. These include alternative burner configurations, additional pre-heat, and feed distribution and product handling studies. The lime cooler is being removed, and a simpler return system is being installed, to improve throughput rates. There are several process configurations also being tested to improve per-tube throughput and calcination rates.

While these optimisation studies are underway as part of the LEILAC-2 project, LEILAC-1 itself has nonetheless successfully demonstrated that both limestone and raw meal can be processed; that the CO_2 is successfully separated; and that (disaggregated from the entire system) the energy penalty for indirect calcination (LEILAC) is not higher than for direct (conventional) calcination. Other major findings are that there was no build-up of material on the reactor’s wall; that the reactor (despite the numerous runs) experienced no significant negative operational deterioration; that there were no negative impacts on the host plant, and no impact on clinker production; and that the pilot was safe and easy to operate, with no safety incidents.

The LEILAC-1 Project has been concluded and the output report - LEILAC Roadmap 2050 - has been endorsed by the consortium members and European Union and released to the public https://www.calix.global/news/leilac-roadmap-2050/. Our thanks go to all the staff at Lixhe, service providers, and consortium members who have worked tirelessly to deliver the LEILAC-1 Project successfully despite the massive challenges arising from the COVID pandemic.

Leilac

LEILAC-2: Towards process integration

A follow-on project – LEILAC-2 – has just started, having been awarded €16m by the EU Horizon 2020 program with additional cash and in-kind industry contributions of €18m. HeidelbergCement has kindly agreed to closely integrate the demonstration plant into their operational facility in Hannover, Germany.

LEILAC-2 will build a demonstration plant that aims to separate around 100,000 tonnes per year of CO_2, in a scalable module. The consortium, comprising Calix, HeidelbergCement, Cimpor, Lhoist, CEMEX, IKN, Certh, Polimi, BGR, GSB, Engie Laborelec and Port of Rotterdam aims to also demonstrate the overall efficiency of the technology, as the reactor will be integrated into the kiln line in a kind of second preheater string configuration, where the material from the LEILAC kiln is directly fed to the existing rotary kiln, and the impact on clinker quality as well as the energy-efficiency can be demonstrated. The demonstration plant will also aim to show the applicability of less carbon intensive heat sources for the required calcination heat, i.e. the use of electricity and alternative (biomass rich and waste) fuels.

Earlier this year, the LEILAC-2 Consortium endorsed the pre FEED[1] study. The criteria for passing this study were that: the demonstration plant's design was technically viable; the operational objectives of the overall project were fulfilled; the plant's design posed low integration risk for the main plant; and it fell within the cost constraints including budgeted CAPEX and OPEX.

The LEILAC-2 plant is a first-of-a-kind retrofit. The CAPEX is expected to be around €16m. Further design work and testing is required – but should the design work as planned - current estimates suggest that LEILAC-2 may separate CO_2 at a cost of around €10/t CO_2 extra OPEX (above the host plant's operating costs). This excludes compression costs and CAPEX retrofit depreciation costs (including foundations, installation, structure), etc., which are expected to be in the region of an additional €10-€15/t CO_2 (compression costs will change greatly depending on what happens to the CO_2).

Therefore, total costs of CO_2 avoided of this first-of-a-kind commercial demonstration scale LEILAC plant is expected to be in the region of €20-25/t CO_2.

Full scale Leilac precalciner

The intention with LEILAC-2 is to start forming a robust, replicable module that can be simply scaled to capture 100% of a cement plant's process emissions (at any scale).

The LEILAC-2 project is the first attempt at closely integrating via retrofitting the technology to a plant. In a future implementation at full scale, the LEILAC process conditions (and costs) will be improved from the current LEILAC-2 projection through the following steps: the use of more heat from the existing cement plant kiln gases; using the heat from the CO_2; enhanced preheat; the use of unprocessed RDF[2] (reducing capture costs to €4/t CO_2); locating the reactors closer to the tower; skin loss reduction through module placement; and increasing the levels of insulation.

A full scale retrofit, depending upon the site in question and capital required to recover and utilise the heat, is expected to be close to best available technology (BAT) efficiency of a modern cement plant.

On a greenfield site - when the LEILAC Technology is part of the planned installation – there is the opportunity for simpler integration, and minimal additional capital costs as a large proportion of the technology's costs are for foundations, structure, and installation.

A sustainable solution using the LEILAC Technology

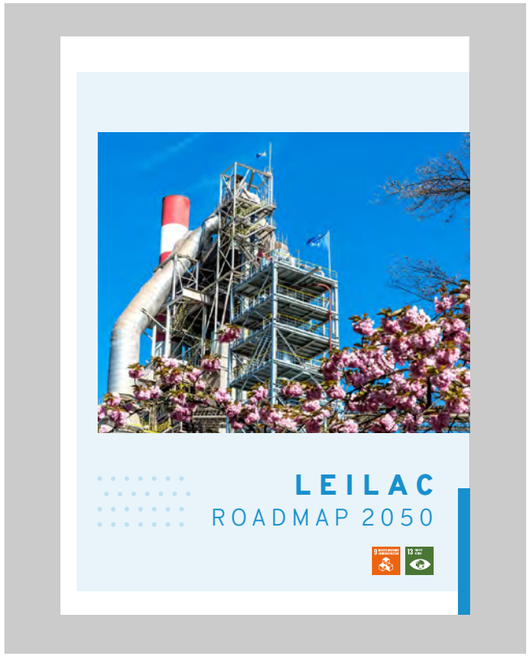
In order to reach the required emission reductions by 2050, carbon capture will need to be applied to a vast majority of cement and lime kilns.

Once tested and scaled up, the LEILAC technology should provide a low cost option for reducing the costs of carbon capture and accelerate the decarbonisation in both the cement and lime industries, enabling society to continue to benefit from these vital products without negatively impacting the environment.

Reference

https://www.worldcement.com/

1 FEED - Front End Engineering Design
2 Refuse-derived fuel



LEILAC Technology Roadmap to 2050

(https://www.calix.global/news/leilac-roadmap-2050/)

Figure 4

LEILAC-1 pilot, sitting to the right of the conventional pre-heater tower at Lixhe.

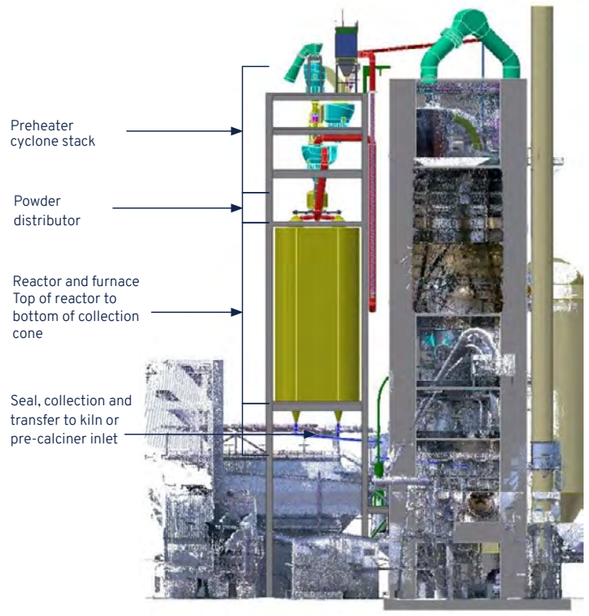


Figure 3

An impression of a retrofit LEILAC-2 module alongside an existing pre-heater tower. Multiple modules (arranged flexibly, including vertically) can be used for a 100% retrofit.

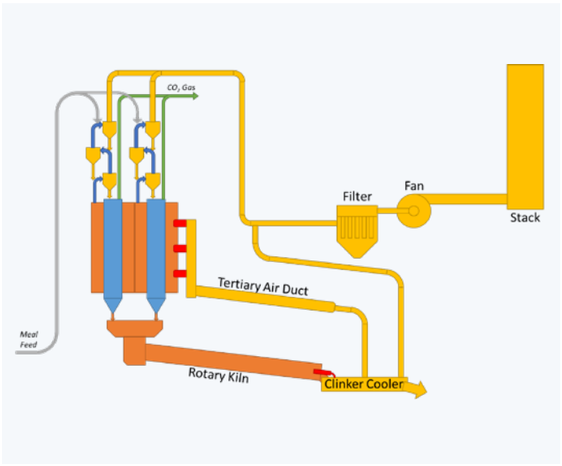


Figure 5

The process flow diagram for a full-scale cement plant with a LEILAC tower instead of the conventional pre-heater tower.

Salmon farming

A potential new application of Calix's AQUA-Cal+

Calix's AQUA-Cal+ is being used successfully in shrimp farming to improve shrimp health, and help reduce the environmental impact of sludge drainage by treating the sludge that builds up in shrimp ponds in-situ.

Calix recently launched "Project Atlantis", targeting the potentially beneficial role of AQUA-Cal+ for the salmon industry in both the health of the fish and the seabed in open pen aquaculture.

Global salmon farming reached a peak of 3.6 million tons worldwide in 2018, the majority being grown in ocean cages. There are several environmental issues associated with salmon aquaculture.

A major problem for the salmon industry is the impact on the sea bed below the salmon pens, where fish waste can quickly build to produce toxic and oxygen-depleted conditions, impacting the natural environment. Calix's AQUA-Cal+ has been shown to dramatically improve such conditions in shrimp ponds, and Project Atlantis aims to investigate whether similar improvements can also be effected in salmon farming.

Another major problem in the industry is the mortality rate, which currently stands around 13% of all salmon production. Disease and and parasites are the major cause of this high mortality rate.

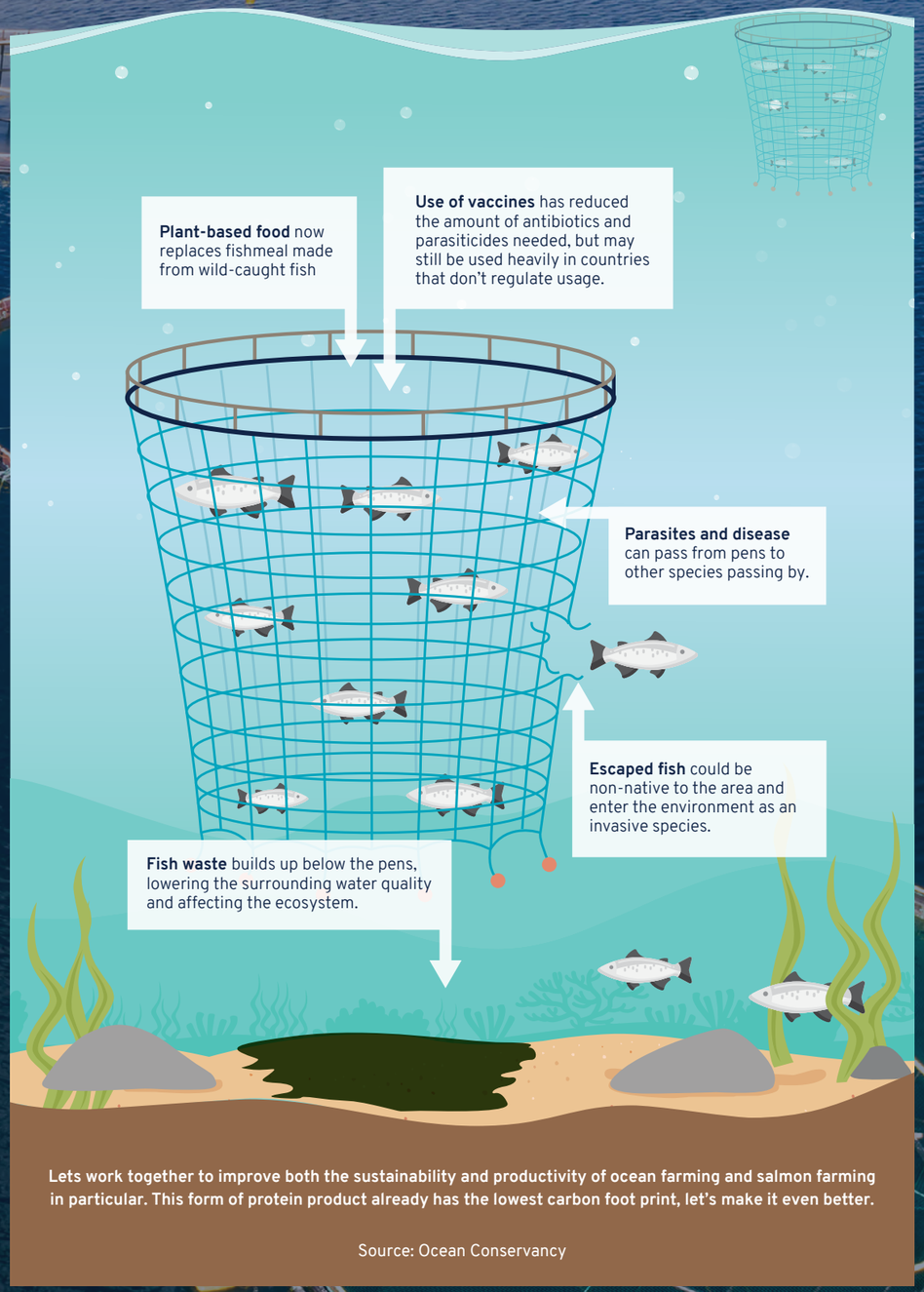
Amoebic Gill Disease (AGD) causes respiratory problems and can cause death through asphyxiation. Sea lice infestations are also abundant in salmon farms, causing skin scale and tissue lesions and ultimately death.

As part of Project Atlantis, Calix is investigating whether AQUA-Cal+ can also help reduce these problems, by helping on the land-based grow-out of salmon stock to create healthier populations prior to stocking the sea pens.

Salmon effected by Sea Lice

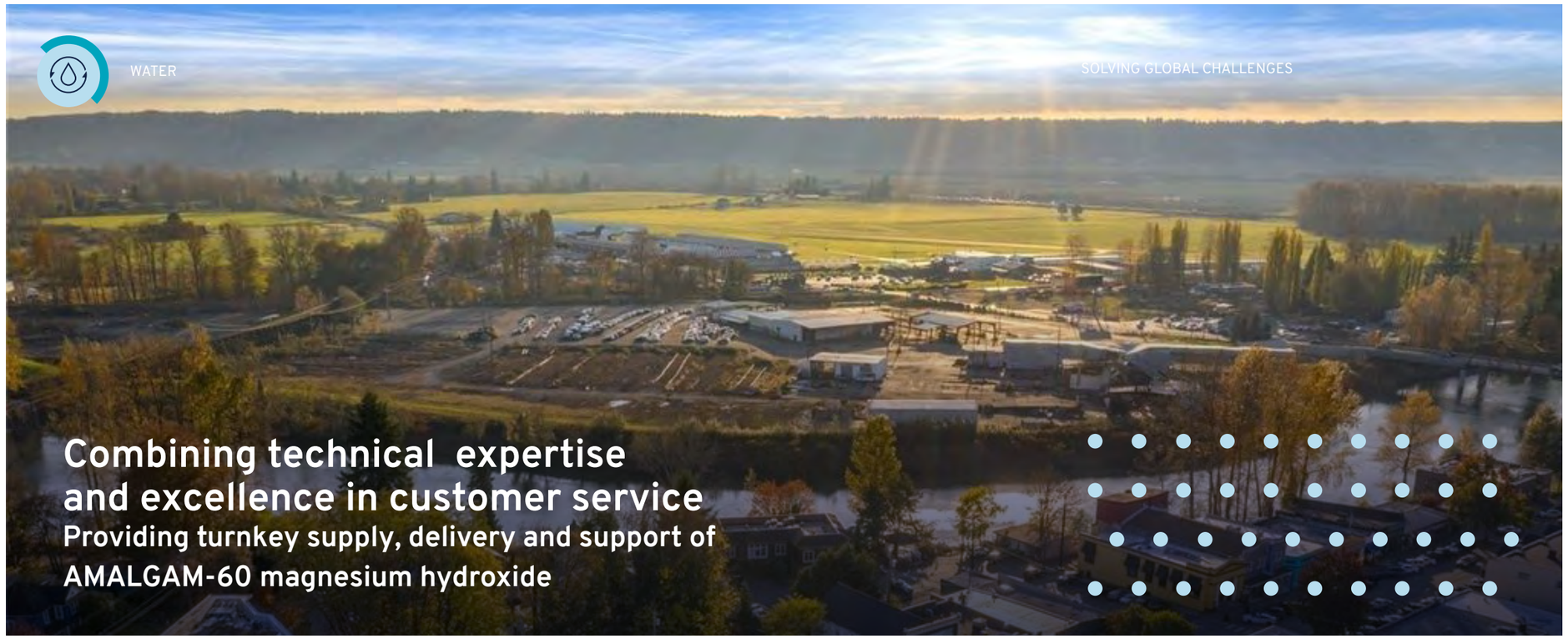
Current treatment methods for sea lice and AGD use harsh chemicals or expensive mechanical methods such as freshwater purging.

Amoebic Gill Disease (AGD)



Lets work together to improve both the sustainability and productivity of ocean farming and salmon farming in particular. This form of protein product already has the lowest carbon foot print, let's make it even better.

Source: Ocean Conservancy



Combining technical expertise and excellence in customer service

Providing turnkey supply, delivery and support of AMALGAM-60 magnesium hydroxide

Snohomish is a city in Snohomish County, in Washington state, US. It is located along the north bank of the Snohomish River near where it is joined by the Pilchuck River. Listed on the National Register of Historic Places, Snohomish is a model of how cities can reinvigorate their business districts by preserving their historic charm. It has conscientiously maintained a balance between its regular businesses in modern facilities, and the specialty shops in the town's historic areas.

The City of Snohomish, Washington Wastewater Treatment Plant is a dual-powered, multi-cellular, aerated lagoon system employing Submerged Fixed-Film Media in order to achieve the necessary quality of water for discharge into the Snohomish River.

The plant's primary tasks are:

- To remove suspended solids and to degrade biodegradable organics.
- To reduce ammonia nitrogen.
- To eliminate pathogenic microorganisms from the wastewater.

The process of ammonia treatment and removal, called nitrification / denitrification, results in a loss in alkalinity passing through the plant.

Because the incoming wastewater to the Snohomish treatment plant is typically very low in alkalinity, an alkaline additive is needed in order to maintain a final pH above the allowed discharge permit limits.

CHALLENGES

- Low pH and alkalinty.
- The need for a reliable feed of magnesium hydroxide.
- The need for a good technical understanding of feeding a slurry product.

SOLUTION

Replacement of the previous feed system and magnesium hydroxide slurry with AMALGAM-60 for handling, operational, and performance benefits.

BENEFITS

A reliable feed of magnesium hydroxide that improved pH and alkalinity stability, resulting in better overall microorganism performance.

Watch our success story

https://youtu.be/76YgFbxa8j0

AMALGAM-60

Continuous customer support is the key to system optimisation

IER's installation expert, John Strong, worked closely with the Snohomish staff to optimise the delivery of Amalgam magnesium hydroxide. The bulk storage tank mixer needed to be re-set in order to optimise dispersion of the slurry in the tank.

Conclusion

John Strong
IER Technical Service Manager

The most obvious difference was that the initial supplier was unwilling or unable to provide assistance, while IER was both willing and able.

By demonstrating our technical credibility in the storage and handling of a slurried product, and willingness to spend multiple days on-site to make sure that their chemical storage and feed system was reliable and robust, the City of Snohomish converted to IER and to our supply of AMALGAM-60 magnesium hydroxide.

R&D Update
Advanced Marine Coatings

Long term bio-fouling control trials continue to show encouraging results with different coatings

Marine biofouling is the natural accumulation of microorganisms, plants, algae or small animals on submerged or wet surfaces. Left unchecked, biofouling increases hull surface roughness, fuel consumption and greenhouse gas emissions.

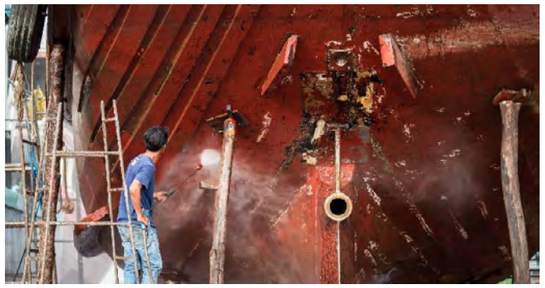
Increased roughness presented by a heavily fouled ship hull can result in powering penalties of up to 86% at cruising speed; even relatively light fouling by diatom 'slimes' can generate a 10–16% penalty. Without effective antifouling (AF) measures, vessel performance, fuel consumption (and therefore greenhouse gas emissions) are negatively affected.

Bio-fouled vessel hulls from around the world can introduce non-indigenous marine organisms which may contaminate marine waters and compete with native species.

It is estimated that 75% of introduced marine species have established in Australian waters as a result of biofouling on marine vessels.

Owners of marine vessels spend considerable time and money to mitigate the effects of fouling on vessel performance and biosecurity.

Barnacle build-up on a propeller



Ships' hulls need constant maintenance to control marine biofouling

The challenge

Anti-foul paints and coatings provide protection against corrosion and contain biocides that slow bio-fouling.
The toxicity of these biocides and their negative effect on the marine environment is well documented.

Anti-fouling agents such as tributyltin oxide (TBT) have been historically used on ships and recreational boats to prevent biofouling. TBT slowly leaches out of coatings into the marine environment where it is highly toxic toward non-target organisms. After it led to the collapse of local populations of organisms, TBT was effectively banned globally.

Today, although the biocides used are less toxic there is still growing concern that they can also contaminate and damage marine eco-systems.

Further, the cost of anti-foul coating application and maintenance can be very high.

“Typical costs of hull treatment during a drydocking can range from thousands to several million dollars depending on vessel size and the type of coating system applied”

Rob Van Merkestein
Business Manager - Bioactive Materials

"Marine biofouling control is similar in many ways to pest and disease control in agriculture – both rely on toxic or biocidal chemicals and both are under regulatory pressure. The marine coating program aims to develop non-toxic bioactive additives that improve the effectiveness and durability of antifoul coatings to meet operational and environmental requirements. Results from our initial studies in Australia indicate our materials are compatible with common formulations and their inclusion coincides with significantly reduced biofouling. This, and the interest by coating manufacturers undertaking their own studies at various locations around world, is very encouraging.”

References

Trends in the development of environmentally friendly fouling-resistant marine coatings, James A. Callow & Maureen E. Callow, 2011

Biofouling and its Implications on Marine Health, Boat Safety and Australia’s Biosecurity, OceanTimeMarine, 2017

Understanding marine biofouling: How anti-fouling systems prevent growth, by SAFETY4SEA, 2018.

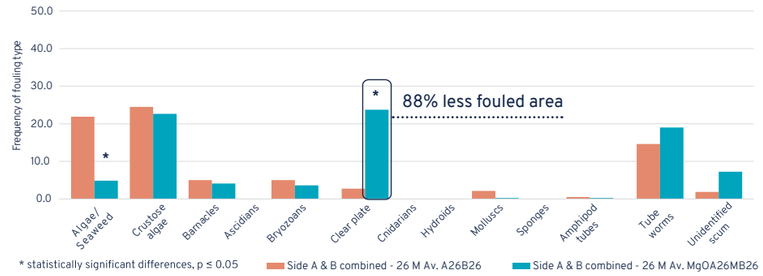
Advances in marine antifouling coatings and technologies, by Claire Hellio and Diego Yebra, 2009.

A solution?

A 26-month study assessing the effect of the addition of Calix bioactive material to an in-market commercial anti-foul paint formulation has been completed.

The submerged exposure study was undertaken in the tropical waters of northern Queensland.

The addition of Calix very high surface area ("bio-active") magnesium oxide (MgO) (200 g/L) to an in-market aluminium compatible anti-foul paint coincided with a significant and consistent increase in clear, essentially un-fouled area.

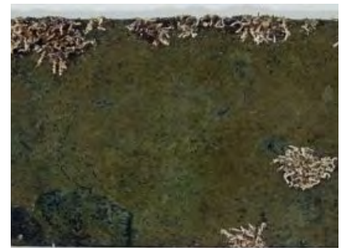


Ablative; copper thiocyanate & zinc pyridimethione -effect of MgO doping, @ 26 months exposure

MgO addition coincided with 88% less fouled area when compared to the in-market paint formulation as well as a substantial reduction in the amount of other fouling organisms including highly problematic barnacles.

Images of anti-foul painted panels after 9 months submerged exposure.

Ablative marine coating – no additive



Ablative marine coating – 200 g /L Calix "bio-active" MgO

Calix's Biotech line of business
focusses on developing novel, safe "bio-active" materials for multiple applications.

Calix's Biotech materials are based on magnesium minerals and derivatives.

Our approach:
Proof of concept → R&D, External engagement & Co-development → Tech. licencing → Manufacturing

Why are Calix's materials exciting?
Calix's Biotech materials are based on magnesium minerals and derivatives.
Magnesium oxide and hydroxide are intrinsically safe to us, and the environment.

- Our materials are non-toxic.
We fine grind natural magnesium minerals to produce particles around the size of plain flour and then heat this to produce "bio-active" MgO powder.
- Our materials are bioactive.
Bioactive: having an effect on a living organism.

(Source: https://www.merriam-webster.com/dictionary/bioactive).

Source of bioactivity

Oxygen reacts on the surface of our materials to produce reactive oxygen or ROS.

ROS is a key component of many immune system responses – it’s a necessary and natural part of life.

Humans, animals and plant immune systems produce ROS to fight-off infection.

ROS inhibits the growth of many pathogenic microorganisms, including it seems, biofouling marine organisms.

Calix’s BIOME (BIOactive Material Engineering) program aims to exploit our core technology and the unique physical and bioactive material properties to develop safe and sustainable materials to address global challenges.

‘Mineral Honeycomb’– a close-up of our unique, highly porous and active magnesium oxide

SDG 17 - Partnering for a better world

Other interesting research & development projects

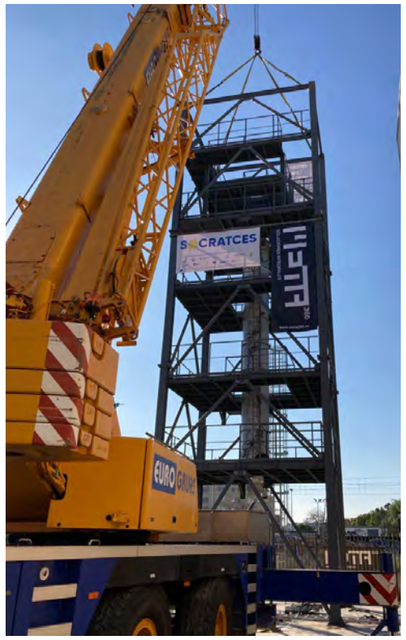
Using lime to store energy: SOCTRATCES

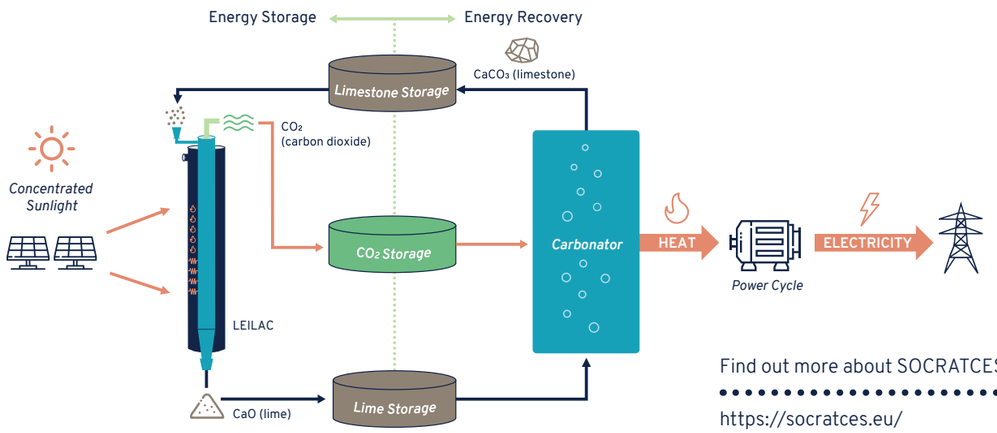
The SOCRATCES Project, of which Calix is a member, is commissioning an exciting new application of Calix's technology at the University of Seville in Spain. Seville is one of the leading locations for concentrated solar power (CSP) research and operation globally.

SOCRATCES is investigating the use of 'calcium looping' as a form of concentrated solar power (CSP) energy storage.

In this concept, energy is stored thermochemically by splitting limestone into lime and carbon dioxide in a LEILAC unit, and storing both products separately. This splitting (called calcining) involves large amounts of high-temperature energy, and in SOCRATCES' case this is provided by CSP. The process is reversible, meaning that when electricity is required, the lime and carbon dioxide are recombined in a carbonator to regenerate the limestone and release the stored energy as heat. This heat is converted to electricity using a turbine. This energy storage concept is valuable in locations with high amounts of solar power on the grid, it provides a way to use CSP at night as well as during the day. There is even the opportunity for inter-seasonal storage.

The SOCRATCES project involves the design, construction, operation and integration of a pilot plant to test this concept. It comprises a solar field, a hybrid CSP-electric LEILAC unit from Calix, a carbonator reactor, and a power block. The project is funded by the European Commission through the Horizon 2020 scheme.





Find out more about SOCRATCES:
https://socratces.eu/

Using lime to capture CO_2: ANICA

Calix's LEILAC Technology captures the CO_2 emitted when limestone is heated and decomposes to lime. The calcium looping concept uses this reaction along with its reverse counterpart (i.e. CO_2 + lime -> limestone) to capture CO_2 from exhaust gases from a range of industrial processes, including power generation. In ANICA (Advanced Indirectly Heated Carbonate Looping Process), Calix has partnered with other organisations to investigate the capture of the combustion emissions from cement and lime plants, along with the existing capture of process emissions that LEILAC achieves. As with SOCRATCES, CO_2 is captured by lime in a 'carbonator' reactor, generating limestone. This limestone then travels to the LEILAC reactor where the CO_2 is released as a high-purity gas and the lime is regenerated, ready to return to the carbonator. In this method, the combustion emissions from a lime or cement plant – as well as the process emissions – can be captured using Calix's LEILAC Technology, enabling a zero-emission, or even negative-emission, lime plant.

The project is funded by ACT (Accelerating CCS Technologies), an initiative of the G7, and is led by the Technical University of Darmstadt, whose pilot plant is being used to test the process.

Find more about ANICA:
https://act-anica.eu/

Tom Hills, Research Engineer

"Calix's LEILAC Technology is extremely versatile, which enables us, working with our R&D partners, to invent and innovate exciting applications across a wide range of Global Challenges. We leverage our experience and relationships with universities, industry and government to transform these ideas into reality."

Read our whitepaper "FOCUS ON LIME"

SDG Impact

Calix touches virtually all 17 United Nations' Sustainability Development Goals through innovation, development and partnership initiatives, day-to-day operations and social investment opportunities. By aligning innovation and development initiatives with the global goals, Calix is driven to make an impactful and meaningful contribution to solving global challenges.

In embracing multi-stakeholder partnerships that mobilise and share knowledge, expertise, technology and financial resources, Calix meets Goal 17: "Strengthen the means of implementation and revitalize the global partnership for sustainable development."

In addition to the partnerships with the Leilac Consortium, AdBri, Tarmac and others, Calix is proud to also work with these organisations.

Visit calix.global/news for updates on partnerships.

We believe our people are key to achieving our purpose.

Introducing Joshua Menzies

ACTI-Mag Mobile Asset Manager

Originally from Bacchus Marsh, Josh started to work at Calix in 2012 as a tradesman. He has been involved with the construction of most buildings on site and has also helped commission the first ACTI-Mag hydration plant.

Josh has always had a strong interest in the technology, he fell in love with the company's culture, and so he naturally evolved to become a support technician for ACTI-Mag, and provides hands-on expertise and excellent service to Calix customers in Australia.

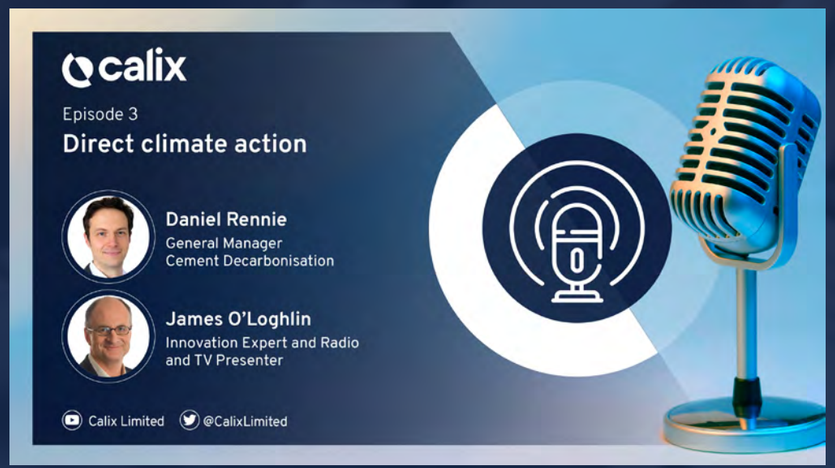
It is his commitment to customer service and his technical know-how that has allowed him to become the ACTI-Mag Mobile Asset Manager, and he is now responsible for managing and building all our dosing equipment.

Outside of work, Joshua has two lovely children, loves to throw on a good Aussie backyard BBQ for his family and friends, and simply loves helping others around him.

"I joined Calix to make a direct positive impact on climate change."

Calix in the media

Podcast

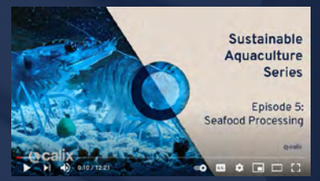


Calix Podcast #3 DIRECT CLIMATE ACTION feat. James O'Loghlin & Daniel Rennie
https://youtu.be/3xdB22IKnuU

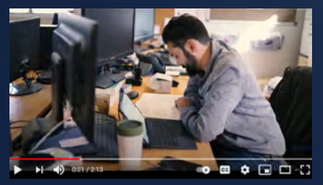
Videos

Developing low-cost, safe & easier to recycle electrode materials for lithium ion battery technology
https://youtu.be/3YFIwpcUpOM

Magnesium Hydroxide Liquid for odour & Ph control - CLIENT STORY at Cassowary Coast Regional Council
https://youtu.be/IagRvMI9Ir4

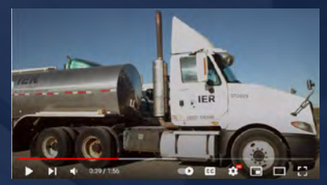


SUSTAINABLE AQUACULTURE SERIES - Seafood Processing - Episode 5
https://youtu.be/t8wIrAzu7Js



Dr Matt Boot-Handford - On the chemistry of Calix materials for lithium-ion batteries
https://youtu.be/vi4_uoU6T5I

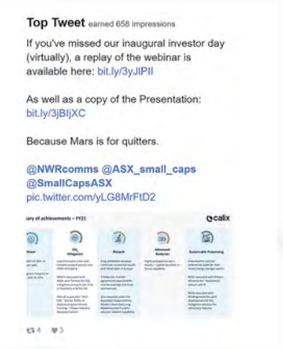
Phil Hodgson - Australian Carbon Capture, Utilisation and Storage Conference
https://youtu.be/zNGjvTDzfLI



Wastewater Management - Production of AMALGAM-60 Magnesium Hydroxide at IER Pasco plant in WA
https://www.youtube.com/watch?v=76YgFbxa8j0

Media highlights

Follow us on Twitter
@CalixLimited



CO_2 Mitigation

Calix (ASX:CXL) backed by global decarbonisation investment group

https://themarketherald.com.au/calix-asxcxl-backed-by-global-decarbonisation-investment-group-2021-09-15/

Innovator in lime and cement carbon removal wins fresh investment round

https://viable.earth/understanding/innovator-in-lime-and-cement-carbon-removal-wins-fresh-investment-round/

The Cement Sector Has The Technology to Clean Up Its Emissions
https://www.bloomberg.com/news/articles/2021-09-14/australian-clean-cement-technology-gets-serious-about-scaling-up

Calix begins to reap low carbon cement dividend
https://www.aumanufacturing.com.au/calix-begins-to-reap-low-carbon-cement-dividend

Manufacturing news briefs – Stories you might have missed
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Calix partnering in $39m Australian government low carbon research
https://busycontinent.com/calix-partnering-in-39m-low-carbon-research/

Pioneering technology offers a cleaner future for cement
https://ec.europa.eu/research-and-innovation/en/projects/success-stories/all/pioneering-technology-offers-cleaner-future-cement

Calix partnering in government-funded low-carbon research
https://www.processonline.com.au/content/business/news/calix-partnering-in-government-funded-low-carbon-research-333991926

The Global Status of CCS Report 2021
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LEILAC Project, Cutting-edge Technology to Efficiently Capture CO_2
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Canberra meets Calix; the company cashing-in on low carbon future for Australia's industrials
https://www.ausbiz.com.au/media/canberra-meets-calix-the-company-cashingin-on-low-carbon-future-for-australias-industrials?videoId=11797

Using carbon capture to innovatively reduce cement industry emissions: a virtual 'visit' to LEILAC, Belgium
https://www.theclimategroup.org/our-work/news/LEILAC_site_visit

Pioneering technology offers a cleaner future for cement.
https://ec.europa.eu/research-and-innovation/en/projects/success-stories/all/pioneering-technology-offers-cleaner-future-cement

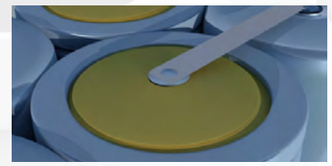
Sustainable processing

Saving through smarter energy use – Calix revolutionising industrial energy use

https://www.aumanufacturing.com.au/saving-through-smarter-energy-use-calix-revolutionising-industrial-energy-use

Battery

Monash chemists find novel salt solution for lithium-ion battery fires



https://www.pv-magazine-australia.com/2021/08/18/monash-chemists-find-novel-salt-solution-for-lithium-ion-battery-fires/

Biotech

Effects of Magnesium Oxide and Magnesium Hydroxide Microparticle Foliar Treatment on Tomato PR Gene Expression and Leaf Microbiome
https://www.mdpi.com/2076-2607/9/6/1217

calix

At Calix, we take Corporate Social Responsibility (CSR) seriously.
The pandemic has proven that people and businesses can overcome adversity and give back to their community even in the toughest of times. At Calix, we believe we can help create lasting social change that benefits the whole of society, while continuing to grow.

Calix is proud to announce it has become an Official Supporter of the Ocean Impact Organisation, supporting innovation for a healthy ocean.

The Ocean Impact Organisation's (OIO) purpose is to transform ocean health through inspiration, innovation, and good business. Our partnership with the OIO reflects our commitment to a more sustainable future for our oceans, in alignment with our research and development activities in marine coatings, aquaculture and shipping decarbonisation.

Calix is a proud Official Supporter of the Ocean Impact Organisation, supporting innovation for a healthy ocean.

Find out more, watch the discussion between our CEO Phil Hodgson and Nich Chiarelli, OIO's founder and CEO.

https://youtu.be/pPXkyPrG8vQ

To learn more about Calix technology, products, applications and services:
www.calix.global

Or call 1300 0 CALIX

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