HILT CRC

HEAVY INDUSTRY LOW-CARBON TRANSITION COOPERATIVE RESEARCH CENTRE

DE-RISKING DECARBONISATION

OCTOBER 2024

HILTCRC.COM.AU

HILT CRC

ABOUT HILT CRC

The Heavy Industry Low-carbon Transition Cooperative Research Centre (HILT CRC) was created as a catalyst to propel Australia's heavy industries towards a sustainable future. Through industry-led research, HILT CRC endeavours to mitigate risks and pave the way for effective decarbonisation strategies with a focus on the iron and steel, alumina, and cement and lime sectors.

Since commencing operations in November 2021, HILT CRC has successfully embarked on groundbreaking research in collaboration with over 60 partners across industry, research organisations and government, and currently has 22 active research projects underway.

Heavy industry is a major contributor to the global economy but is also a significant source of emissions. HILT CRC's target sectors contribute around 9% of Australia's total carbon dioxide (CO_2)-equivalent emissions. Furthermore the global downstream processing of Australia's iron ore and bauxite resources contributes three times the emissions of Australia's entire domestic economy.

Given this significant economic and environmental opportunity, HILT CRC is focused on the processes and policies needed to decarbonise the iron/steel, alumina and cement/lime sectors. This has the potential to unlock billions of dollars of annual revenue and investments, safeguard over 100,000 existing jobs and create thousands more, and revolutionise heavy industry – all while reducing CO_2 emissions.

Working with our partners and world-class researchers, HILT CRC is addressing the challenges for global heavy industry to successfully navigate the decarbonisation journey.

VISION

A PROSPEROUS, NET-ZERO HEAVY INDUSTRY SECTOR AT THE FOREFRONT OF THE LOW-CARBON TRANSITION

MISSION

TO DE-RISK AND ACCELERATE DECARBONISATION FOR HEAVY INDUSTRY

WE DO THIS BY

LINKING INDUSTRY, RESEARCH AND GOVERNMENTS ON A LOCAL, NATIONAL AND GLOBAL SCALE

10-YEAR STRATEGIC GOALS TIED TO IMPACT

All HILT CRC projects are conceived, developed and implemented with industry partners from an industry perspective, and underpinned by our impact-driven strategic goals.

- **EMISSIONS REDUCED**
- **INNOVATION ADOPTED**
- **UPSKILLED WORKFORCE**
- **TRUSTED VOICE**
  across industry and government
- **FINANCING UNLOCKED**

HIGHLIGHTS

TO OCTOBER 2024

RESEARCH

21 PROJECTS COMPLETED

$10.4M CASH AND IN-KIND

29 PARTNERS INVOLVED

22 ACTIVE PROJECTS

9 EVALUATION

3 TECHNOLOGY DEVELOPMENT

10 TECHNOLOGY DE-RISKING & DEMONSTRATION

$35.1M CASH AND IN-KIND

34 PARTNERS INVOLVED

7 AVG. PARTNERS PER PROJECT

12 FLAGSHIP PROJECTS

2 ARENA GRANTS WORTH $6.2M

Secured Australian Renewable Energy Agency funding to extend and expand existing HILT CRC projects

AVERAGE INDUSTRY CORE PARTNER R&D LEVERAGE OF $11:$1

PROJECT PORTFOLIO DEVELOPED AND APPROVED THROUGH TO 2027

RD&D FACILITIES PLAN DEVELOPED

38 responses to our research, development and demonstration facilities survey

PARTNER AND STAKEHOLDER ENGAGEMENT

60+ INDUSTRY, RESEARCH AND GOVERNMENT PARTNERS

↑40% INCREASE SINCE LAUNCH

New Core Partner: Hydro | **New Key Partners:** Emirates Global Aluminium, BlueScope, Magaldi

400+ DELEGATES ATTENDED 3 HILT CRC CONFERENCES

2 in Adelaide, 1 in Perth

40 WEBINARS PRESENTED TO >2,500 ATTENDEES

INTERNATIONAL REPRESENTATION INCLUDING COP 28 AND AQW '24 IN DUBAI

Support for Mission Innovation's Net-Zero Industries Mission

12 INDUSTRY FORUMS

Roundtables, workshops, showcases and networking events

HEAVY INDUSTRY WORKFORCE OF THE FUTURE

21 ACTIVE POSTGRADUATE STUDENTS

Targeting 30 by June 2025

11 COURSEWORK GRANTS AWARDED

4 programs completed

2 INDUSTRY SHORT COURSES HELD

> 100 attendees at Adelaide and Perth Green Steel courses

“AT THE CORE OF HILT CRC IS THE ENGAGEMENT BETWEEN OUR OUTSTANDING RESEARCHERS AND INDUSTRY PARTNERS. ACROSS 8 LEADING RESEARCH ORGANISATIONS, WE HAVE OVER 100 RESEARCHERS WORKING ON MORE THAN 20 ACTIVE PROJECTS.”

MESSAGE FROM THE CEO

As HILT CRC enters its fourth year of operation, I am immensely proud of the commitment and support of our industry, research and government partners in shaping a sustainable and prosperous future for heavy industry.

The challenge to abate heavy industry is significant, but I am inspired by the collaboration and enthusiasm from our stakeholders to accelerate decarbonisation in a sector that is critical to the social and economic wellbeing of Australia and globally.

It is fantastic to see that HILT CRC’s efforts are being increasingly recognised: we continue to grow our partnerships and as of October 2024 had more than 60 Partners – a 40% increase since our launch, with an increasing international presence.

This wouldn’t be possible, without the amazing efforts from our head office staff, our Research and Industry Leaders, Steering Committee, Research Advisory Committees and our independent Board.

At the core of HILT CRC is the engagement between our outstanding researchers and industry partners. Across 8 leading research organisations, we have over 100 researchers are working on more than 20 active projects.

We were also successful in securing additional funding to expand and accelerate our efforts in reducing emissions across Australia’s iron and steel supply chain, including A$1.4M from the Australian Renewable Energy Agency (ARENA) and $4.8M secured by The Australian National University (ANU) to extend and expand HILT CRC projects beyond what would have been possible with CRC funding alone.

We engage deeply with our internal and external stakeholders to foster our internal collaborative ecosystem and promote knowledge about our research outcomes. Our 2023 Annual Conference in Perth was a huge success, bringing together 157 delegates and achieving a 100% satisfaction rate from attendees.

Our roundtables, workshops, townhalls and webinars have also been valuable vehicles to disseminate our research and inform our activities. Highlights include HILT CRC’s global leadership at the AQW 2024 Alumina Decarbonisation Workshop, facilitation of Australia’s co-leadership with Austria of Mission Innovation’s Net-Zero Industries Mission, and Australian leadership through our Canberra Research Showcase and national Program 3 roundtable series.

HILT CRC has contributed expertise to policy discussions to better support low-carbon innovations such as green steel and improve cost competitiveness of net-zero iron, steel, alumina and cement products. A highlight on this front was our detailed response to the Department of Industry, Science and Resources (DISR) consultation paper on Green Metals – A Future Made in Australia: Unlocking Australia’s Green Iron, Steel, Alumina and Aluminium Opportunity.

Over the past three years, we have established and expanded education and training programs to upskill the future heavy industry workforce and research knowledge base. We now have 21 PhD students on board and 2 internships completed. The Perth and Adelaide ‘Decarbonisation Routes for Steel’ short courses, led by Professor Geoff Brooks, were a resounding success with high attendance and satisfaction ratings.

As we look forward, innovation and collaboration is more critical than ever if we are to truly grasp the opportunities of a green future-focused heavy industry.

I am confident that, with the continued support of our valued partners and the dedication of our talented teams, we will realise our vision of a sustainable, low-carbon future for heavy industry.

Thank you.

JENNY SELWAY
CEO
HILT CRC

MESSAGE FROM THE CHAIR

As we look ahead over HILT CRC's next seven years, I am encouraged by the progress we have made in de-risking and accelerating heavy industry's decarbonisation pathway.

Now more than ever there is an increasing sense of urgency and opportunity from industry, government and the community for heavy industry to meet net-zero by 2050.

I'm also proud that we have brought together organisations from across the industry, government and research sectors to de-risk the technology pathways critical for this transition.

Following the early phase of our 16 QuickStart projects, we have shifted to longer-term efforts to evaluate the challenges and enablers of decarbonisation and to develop the technologies required to respond.

Importantly, we are investigating both incremental increases in existing approaches and novel or breakthrough technologies. Our Board is very clear – we need to do both, as well as maintaining our international outreach activities, to ensure that our partners stay at the forefront of the global endeavour to decarbonise heavy industry.

Each year brings us closer to our vision of a prosperous, net-zero heavy industry sector that contributes to reducing total emissions by 58 million tonnes by 2040 and 200 million tonnes by 2050.

HILT CRC is working with its partners to enable the realisation of research, development and demonstration facilities at the timelines needed to meet their decarbonisation targets. Over the next few years we will see our research translate into tangible outputs including four demonstration plants and eight new technology platforms adopted by industry.

We continue to foster the workforce of the future. By 2030, we aim to have supported over 55 postgraduate completions and to have trained more than 2,400 industry practitioners, equipping the next generation of industry leaders with the skills they need to champion low-carbon innovation.

As Chair, I am proud of the progress we have made. I am confident that the collective effort of our partners and our dedicated team will build on our success to date. There remain many technical, commercial and policy challenges along the road to decarbonisation but HILT CRC is paving the route forward.

Finally, I would like to thank all our partners and all external stakeholders for their ongoing support, which is vital as we embark together on our next phase.

SUSAN JEANES
Chair
HILT CRC

HILT CRC

OUR RESEARCH

Since HILT CRC's launch in 2021, our teams of researchers have worked closely with industry to focus projects on the practical challenges that companies face to de-risk the technology pathways needed to decarbonise their heavy industrial processes.

Our 16 completed QuickStart projects were largely scoping in nature with durations ranging from 6-12 months, providing results that have led to new longer duration projects.

We have now implemented the next, more strategic phase of our research agenda. This reflects a transition from HILT CRC's establishment phase to a coordinated set of 3-year projects designed to de-risk the technologies that are best aligned with the heavy industry sector's priorities and therefore best placed to accelerate decarbonisation.

HILT CRC considers the complete industrial process from raw materials to end product, including waste and by-products, together with new linkages between industries. Understanding and optimising these linkages is crucial to lowering the cost of decarbonisation.

INDUSTRY-LED RESEARCH PROGRAMS

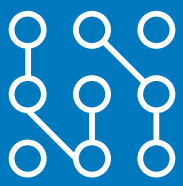
PROGRAM 1
PROCESS TECHNOLOGIES

Producing green iron products from magnetite

Producing green iron products from hematite/goethite ores

Green alumina calcination

Low-carbon construction materials



PROGRAM 2
CROSS-CUTTING TECHNOLOGIES

Integrating variable renewable energy sources into industrial processes

New energy sources: electrification, hydrogen, solar thermal and biomass/waste

Hybrid technology for multiple energy sources

Integrated capture and re-use of CO_2 in industrial processes

PROGRAM 3
FACILITATING TRANSFORMATION

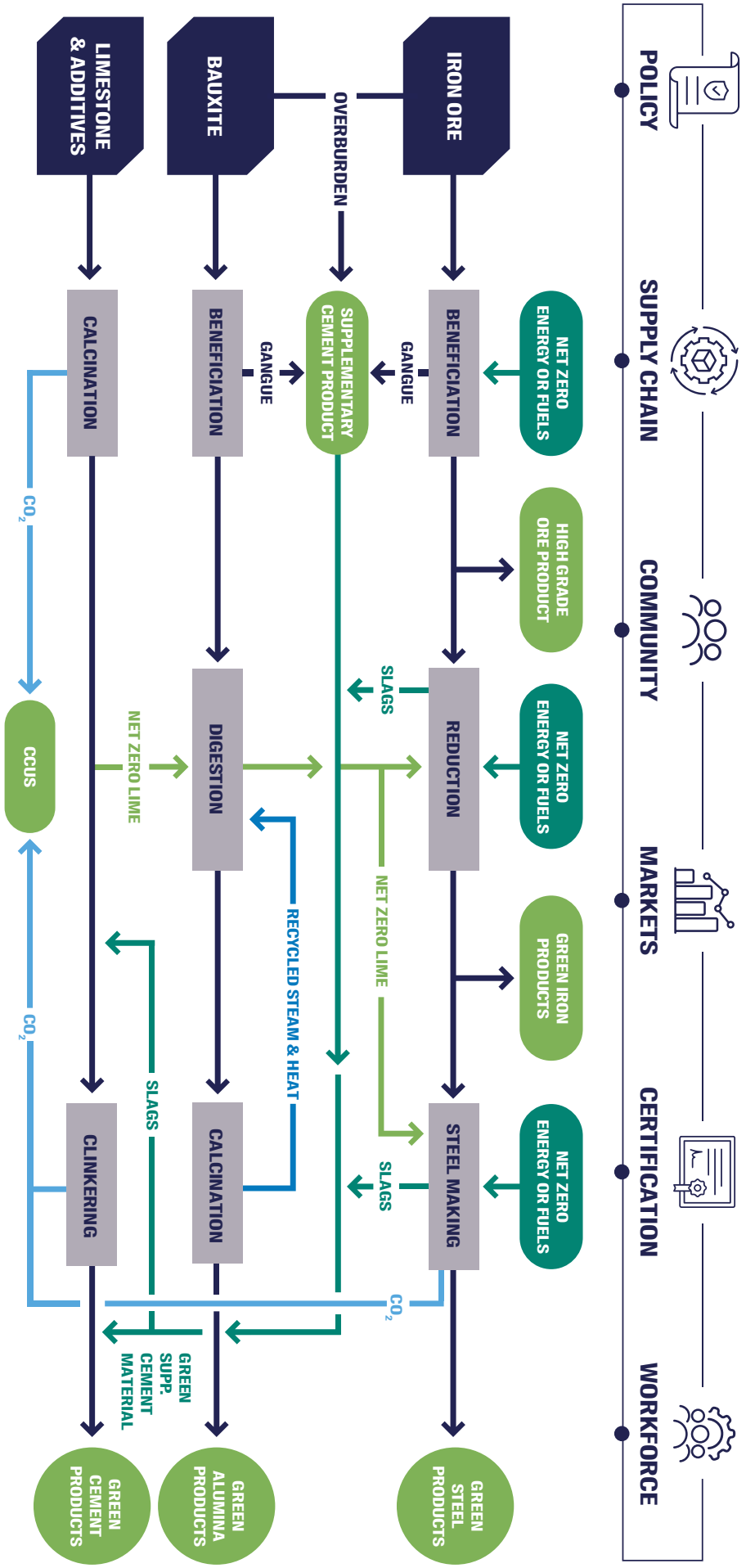
Developing supporting frameworks for emerging low-carbon technologies

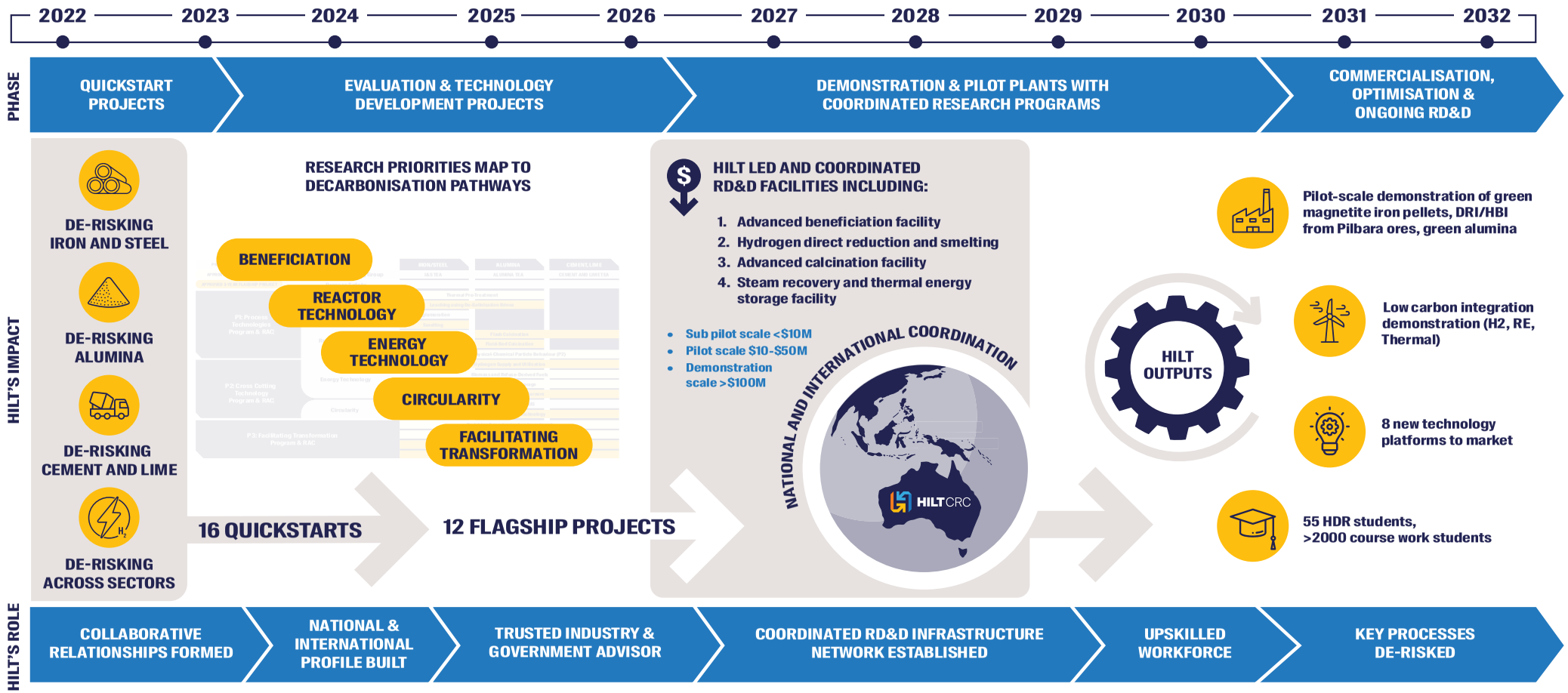
Assessing barriers and policy enablers for the production and trade of low-carbon products and commodities

Enabling facilities and infrastructure

PATHWAYS TO DECARBONISE HEAVY INDUSTRY

HILT CRC has mapped decarbonisation pathways and areas where technology can be deployed and have a significant impact on decarbonisation as shown in the figure left. The figure shows individual technologies and pathways for the decarbonisation of HILT CRC's sectors, as well as the linkages between them.





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RESEARCH DIRECTION

HILT CRC'S 10-YEAR RESEARCH PLAN

FUTURE PLANS

Following on from our first phase of QuickStart projects in years one and two, we have developed a coordinated set of follow-on research projects, which map to the decarbonisation pathways for our three industry sectors.

Our research focus areas, detailed in the figure below, fall into five focus areas:

- Beneficiation to improve ores and make them more suitable for decarbonised processes.
- Reactor technology needed to progress decarbonised processes.
- Energy technology – recognising the criticality of supply and integration of low-carbon energy and fuels for heavy industry decarbonisation.
- Circularity, including carbon capture, utilisation and storage (CCUS).
- Facilitating transformation to address the non-technical barriers to decarbonisation.

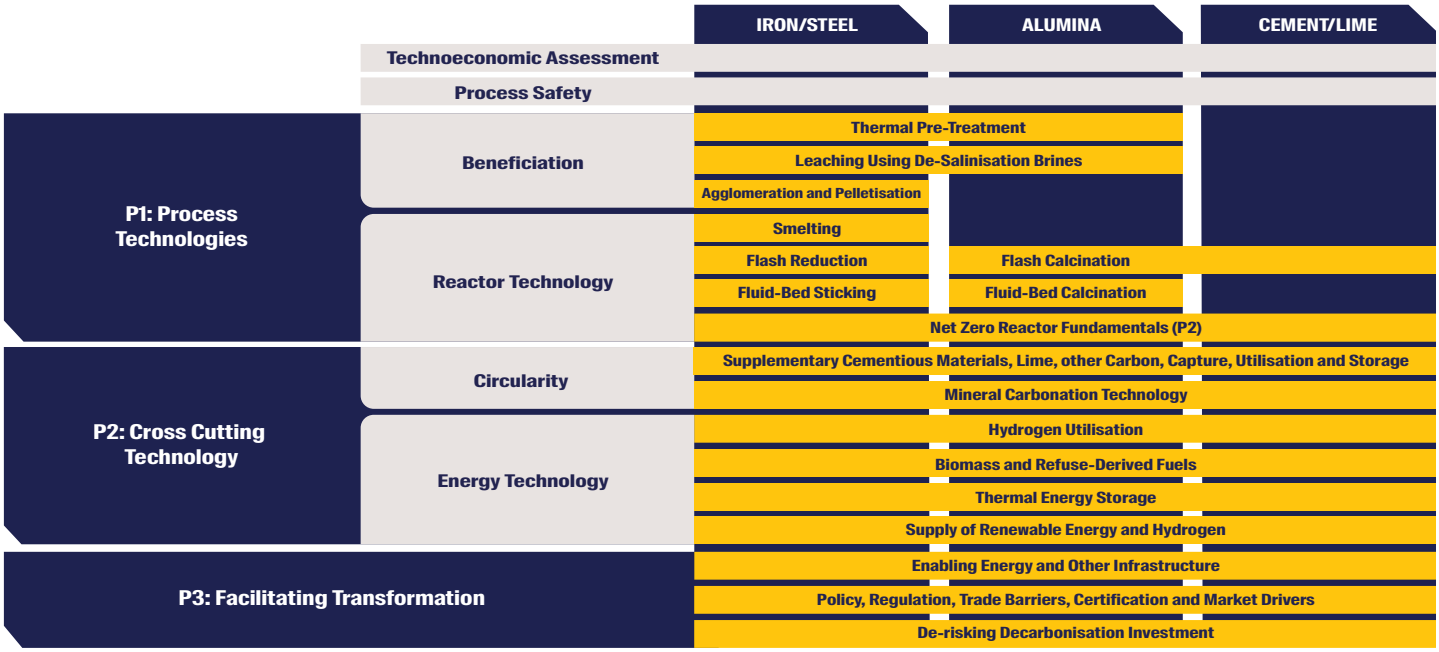
The potential safety impacts of our research are considered across all focus areas.

For HILT CRC's research strategy beyond 2027, we are designing more specific plans for upscaling and demonstrating the technologies that are being developed through our flagship projects.

Our Research, Development and Demonstration (RD&D) Facilities Plan aims to ensure that suitable facilities at laboratory, pilot and demonstration scales are available at the timelines needed to meet industry's decarbonisation targets. HILT CRC proposes that the fastest, least costly and least risky way to developing RD&D facilities is via a nationally (and internationally) coordinated approach that includes a mix of large, medium and small scale facilities working together, and involves industry, research and government working collaboratively, particularly on knowledge sharing.

While beyond the scope of our research strategy, in the longer-term we see the need for ongoing heavy industry decarbonisation research beyond the current 10-year funding of HILT CRC. A constant pipeline of research – from evaluation and development to demonstration and de-risking – is crucial.

HILT CRC RESEARCH FOCUS AREAS 2023 TO 2027



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COMPLETED PROJECTS

Defining framework for Outcome/ Deliverables for HILT CRC Projects

RP1.001
Materials Behavior During and After Direct Reduction in Shaft and Fluidised bed processes
Tom Honeyands, UoN

RP1.002
Decarbonising Steam for Alumina Production
Andrew Beath, CSIRO

RP1.003
Alternative Construction Materials for the Cement Industry
Woei Saw, UoA

RP1.004
Impact of Hydrogen DRI on Melting in an Electric Furnace
Geoff Brooks, SUT

RP1.005
Hydrogen Ironmaking: Fluidised Bed H_2DRI with Australian Focus
John Pye, ANU

RP1.006
Thermal Pre-treatment of Low-grade Iron Ore for Enhanced Beneficiation
Alfonso Chinnici, UoA

RP1.007
Preliminary TEA of Alumina Calcination Options
Woei Saw, UoA

RP1.008
Green Pyromet /Hydromet Beneficiation Pathways
Alfonso Chinnici, UoA

RP1.009
Testing of Australian Iron Ores in a Hydrogen Direct Flash Smelting Process
Geoff Brooks, SUT

RP1.011
The Upgrading of Iron Ore for DRI Production Using Products from Seawater RO Brines
Jacques Eksteen, Lina Hockaday, CU

RP2.001
Green Hydrogen Supply Modelling
Joe Coventry, ANU

RP2.002
Carbon Utilisation and Recycling
Greg Metha, UoA

RP2.003
Green Heat for Industry
John Pye, ANU

RP2.004
A CCUS Roadmap for the Australian Cement and Lime Sector
Hai Yu, CSIRO

RP2.005
Hydrogen Utilisation in Industrial Processes
Liezl Schoeman, CSIRO

RP2.006
Hydrogen Supply within HILT Regional Hubs– H_2 Cost and Synergistic Opportunities
Tara Hosseini, CSIRO

RP2.009
Advancing the Viability of High Temperature Thermal Energy Storage for Industrial Applications
Joe Coventry, ANU

RP3.001
Review of Regional Hydrogen Production Hubs
Liam Wagner, CU

RP3.002
Carbon Mapping of Heavy Industry
Michele John, CU

RP3.003
Review of Trade and Regulatory Implications
Peter Draper, UoA

ANU: The Australian National University
CSIRO: Commonwealth Scientific and Industrial Research Organisation
CU: Curtin University
SUT: Swinburne University of Technology
UoA: University of Adelaide
UoN: University of Newcastle

P1 Process Technologies
P2 Cross-Cutting Technologies
P3 Facilitating Transformation

ACTIVE PROJECTS

RP1.010
Hybrid Hydrogen Direct and Plasma Reduction of Iron Ore
Alireza Rahbari, ANU

RP1.011-EXTENSION
The Upgrading of Iron Ore for DRI Production Using Products from Seawater RO Brines (ARENA)
Jacques Eksteen, Lina Hockaday, CU

RP1.012
Prevention of Sticking in H_2 Fluidised DRI Production (ARENA)
Tom Honeyands, UoN

RP1.013
Alumina Refineries' Next Generation Transition (AlumiNEXT™)
Woei Saw, UoA

RP1.014
De-Risking of Electric Furnace Smelting Furnace for Australian Ores
Geoff Brooks, SUT

RP1.015
De-risking flash reduction of Australian iron ore
Shabnam Sabah, SUT

RP1.016
Upscaling of novel green thermally assisted beneficiation pathways and impact of beneficiation on DRI and pellet production
Alfonso Chinnici, UoA

RP2.007
Feasibility Combustion Study ... for Hydrogen into Iron and Cement Sectors
Alfonso Chinnici, UoA

RP2.008
Lost Production and Variability
John Pye, ANU

RP2.010
Utilisation of RDF: Understanding the Value Proposition, Risks and Supply Chains
Woei Saw, UoA

RP2.011
Thermal Energy Recovery using High-Temperature Heat Pumps
Maziar Arjomandi, UoA

RP2.012
Opportunities for Bioenergy in Australian Heavy Industry
San Shwe Hla, CSIRO

RP2.013
Mineral Carbonation
Alfonso Chinnici, UoA

RP2.014
Low-Cost Reliable Green Electricity Supply for Low-Carbon Heavy Industry
Bin Lu, ANU

RP2.015
Hydrogen Utilisation: Evaluation of Impact on Materials and Infrastructure
Liezl Schoeman, CSIRO

RP2.016
Thermo-Physio Chemical Particle Behaviour
Zhiwei Sun, UoA

RP2.017
Advancing the viability of high-temp thermal energy storage for industrial applications – Phase 2
Joe Coventry, ANU

RP3.004
Intermediate Product Exports for Australia-China Green Steel
Jorrit Gosens, ANU

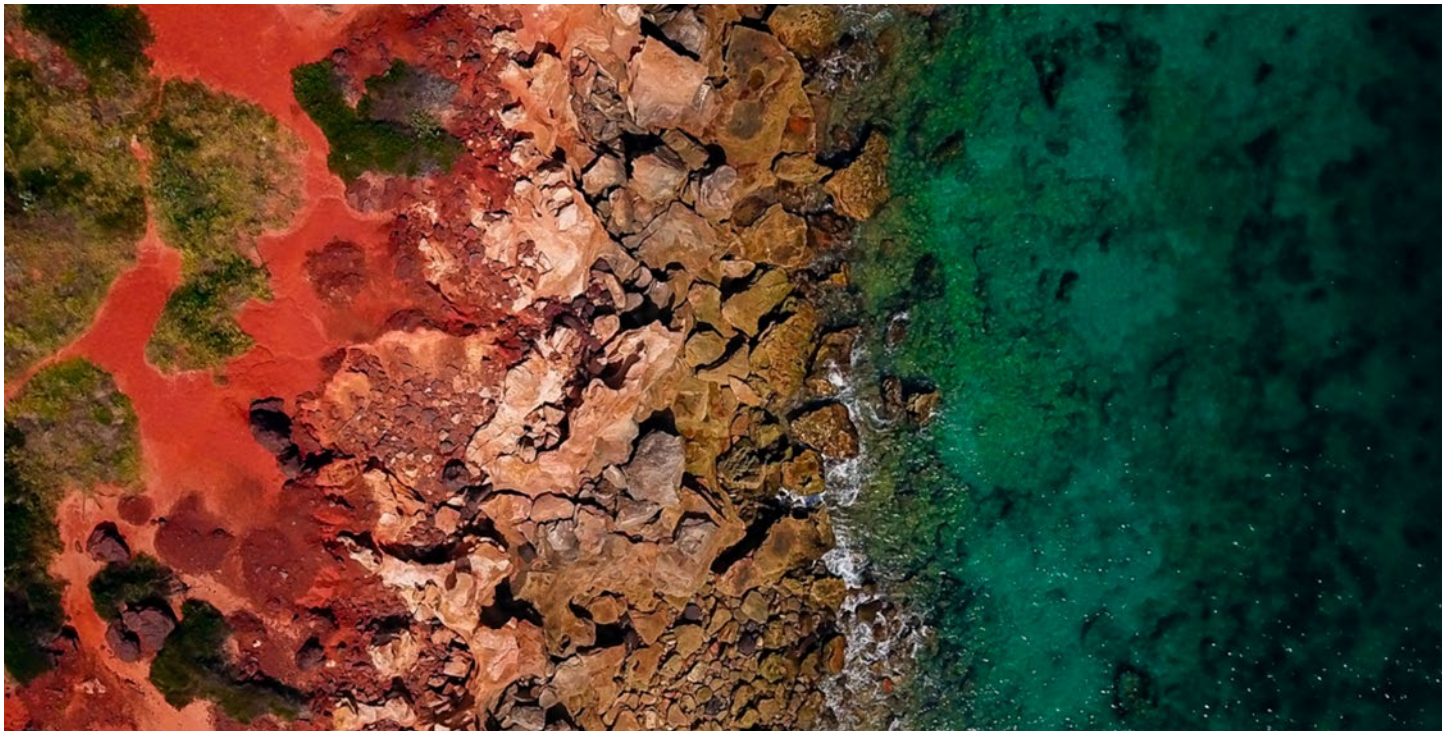
RP3.005
Analysis of Market, Cost and Locational Factors for Green Iron and Steel in Australia
Frank Jotzo, ANU

RP3.006
Certification and Verification to Enable a Successful LCT for Heavy Industry
Emma Aisbett, ANU

RP3.007
Energy Infrastructure Investment
Tara Hosseini, CSIRO

RP3.008
Policy Roadmap for HI Low Carbon Transition
Anthony Kosturjak, Jim Hancock, UoA

Flagship Project



PROJECT CASE STUDY – PROGRAM 1

RP1.011: Upgrading iron ore for direct reduced iron production using products from seawater reverse osmosis brines

Project Leaders:	Professor Jacques Eksteen and Dr Lina Hockaday, Curtin University
HILT CRC partners:	Curtin University, The University of Adelaide, Fortescue, Roy Hill, Minerals Research Institute of Western Australia (MRIWA)
Project partners:	ARENA, BG&E Resources, PROXA Australia
Industries:	Iron and steel
Commenced:	01 June 2023
Total project value:	Stage 1 – Core research: $3.9 million (cash and in kind) Stage 2 – Research commercialisation: $2 million (cash and in kind)

Complementary HILT CRC projects:

RP1.008 Green pyromet/hydromet beneficiation pathways

This project explores how byproducts from seawater desalination – specifically, the salty brine left over after removing fresh water – can be used to improve low-grade iron ore quality. The goal is to upgrade low-grade iron ores and tailings for direct reduced iron (DRI) production, which is particularly relevant for hematite and goethite ores from the Pilbara region in Western Australia.

THE CHALLENGE

Beneficiation is the process of improving the quality of ores by separating valuable minerals from waste material. Traditional beneficiation uses physical methods such as crushing and magnetic separation. However, these methods can create large amounts of waste (tailings), which can constitute 40-70% of input material, be costly to manage, and contain some of the iron ore itself.

The project aims to improve beneficiation using seawater brines left behind when reverse osmosis filters fresh water from seawater.

Rather than release the brine into the ocean, which can be economically and environmentally costly, the team is using it to produce sodium hydroxide (NaOH) through a process called salt splitting. This can then be used leach the ore, or "wash it with soap", as Project Co-Leader Dr Lina Hockaday describes it, to remove impurities such as silica, alumina and phosphorus.

"This chemical upgrading process has been studied for decades, but it's never been commercialised because the reagents were too expensive," she says.

“IN THE BEGINNING, THIS SOUNDED LIKE A WILD IDEA – WE ARE NOW CONFIDENT THAT IT’S NOT, THAT IT HAS POTENTIAL TO BE A REALISTIC SOLUTION.”

– Dr Lina Hockaday, Curtin University

Project Co-Leader Dr Lina Hockaday in her lab at Curtin University.

INDUSTRY AND ENVIRONMENTAL IMPACTS

By improving ore quality in a commercially and environmentally beneficial way, the project offers significant potential to boost both the sustainability and value of iron ore exports.

Furthermore, a PhD project has confirmed that the process can produce valuable byproducts, such as zeolites (used in water purification). Future work will investigate also producing geopolymers (which can replace cement in the manufacture of green concrete).

By upgrading the ore closer to where it is mined, the project also reduces the need for long-distance shipping of waste materials and lowers carbon emissions.

In addition to improving the quality of iron ore, the project could also help solve the problem of brine disposal from desalination plants.

“We’re taking two waste streams – iron ore tailings and desalination brine – and turning them into something valuable,” she says.

The initial evaluation phase of the project has been expanded with additional funding support from ARENA, MRIWA, Curtin University and additional project partners coming on board.

Another potential benefit is that for every tonne of iron ore processed, around six kilolitres of fresh water are produced as a byproduct.

“This water could be used for drinking, agriculture, or even in the production of hydrogen for green steel,” says Dr Hockaday.

FUTURE STEPS

The project’s first year confirmed the feasibility of the technique and developed a detailed business case. It will now focus on testing and refining the process to ensure it is both economically viable and scalable by:

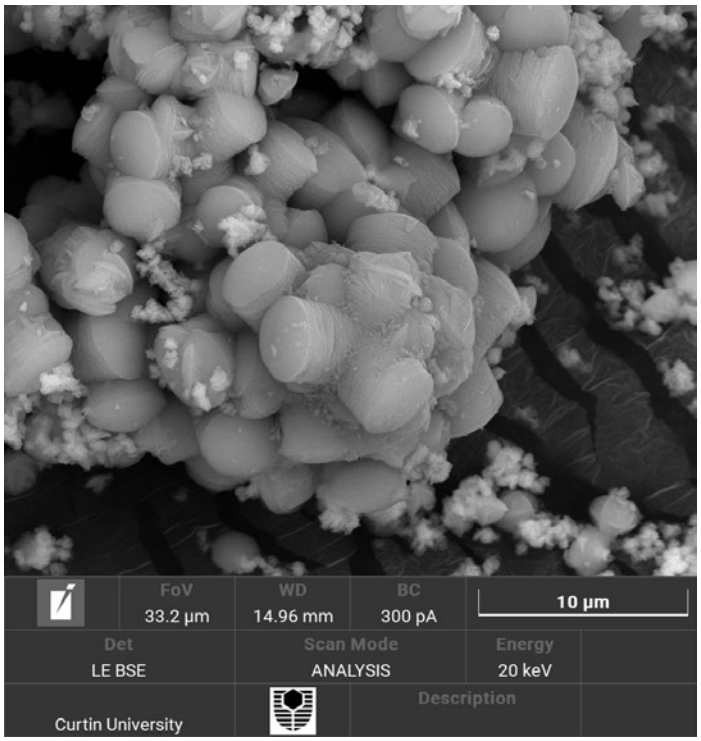
1. Conducting laboratory and mini-plant experiments to integrate the process steps

2. Developing a detailed techno-economic analysis to identify risks and determine the critical research required to develop the technology

3. Costing and designing a pilot plant for the process. This pilot plant will be crucial in demonstrating the scalability if the process in future.

Dr Hockaday emphasises that collaboration with industry partners, such as iron ore producers Fortescue and Roy Hill, is critical.

“Every time we report results, they give us feedback on how it would affect their operations,” she says. “We get that understanding of the value chain, and the value proposition for industry.”



Scanning electron microscope (SEM) image of zeolite crystals (image courtesy of Curtin University with thanks to John de Laeter Centre for the use their SEM equipment).

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PROJECT CASE STUDY – PROGRAM 1

RP1.013: Alumina refineries' next-generation transition (AlumiNEXT™) project

Project Leaders:	Dr Woei Saw, University of Adelaide
HILT CRC partners:	South 32, Hydro, Emirates Global Aluminium, Worley, Calix, SysCAD, Energy Exemplar, 1414 Degrees, The University of Adelaide, CSIRO, The Australian National University, Rio Tinto, MRIWA, KWA Kenwalt
Industries:	Alumina and aluminium
Commenced:	01 July 2024
Total project value:	$4.2 million (cash and in kind)

Complementary HILT CRC projects:

RP1.002: Evaluation of thermal storage and mechanical vapour recompression use to allow variable renewable input for steam in alumina production

RP1.007: Preliminary assessment of technical and economic feasibility of key options for low-carbon alumina calcination

RP2.009: Advancing the viability of high-temperature thermal energy storage for industrial applications

RP2.011: Thermal energy recovery using high-temperature heat pumps

RP2.017: Advancing the viability of high-temperature thermal energy storage for industrial applications – Phase 2

RP3.007: Unlocking investment in energy infrastructure for net-zero industrial hubs

The alumina industry plays a crucial role in the global economy but, as one of the most energy-intensive heavy industry sectors, it faces significant challenges in transitioning to low-carbon operations.

HILT CRC's AlumiNEXT™ project will address this challenge by de-risking and developing innovative low-carbon solutions for alumina refineries in two focus areas:

- steam generation and recovery in the Bayer process
- low-carbon calcination methods and designs.

THE CHALLENGE

Alumina refineries face multiple obstacles to decarbonisation:

- The steam generation required for the Bayer process and the high temperatures required for calcination are primarily derived from fossil fuels.
- Developing and implementing low-carbon technologies for high-temperature processes like calcination presents significant technical challenges.
- Transitioning to low-carbon technologies while maintaining product quality and operational efficiency is a complex undertaking.
- Low-carbon alumina production must be economically competitive.

According to Project Leader Dr Woei Saw, calcination and the Bayer process offer enormous potential for innovation but they also present major technical hurdles.

"Low-carbon steam offers significant potential benefit with less risk for implementation," he says.

"Electrification could revolutionise alumina calcination but we need to ensure any new designs can be integrated at scale while maintaining production and performance."

PROJECT APPROACH

AlumiNEXT™ is divided into two work packages:

1. Low-carbon steam generation and recovery:
    - Evaluate the potential for low-emission technologies – including thermal energy storage (TES), heat pumps and alternative heat transfer media – to replace or complement traditional gas-powered steam generation.
    - Optimise waste heat recovery systems to further reduce energy consumption.
    - Explore alternative heat transfer media to steam in the Bayer process.
2. Low-carbon calcination processes:

- Investigate a two-stage calcination process that allows for greater flexibility in integrating renewable energy sources.
- Investigate how to transition the calcination process by using low-emission heating methods, particularly electrification, such as microwave, induction and plasma heating, or hybrid systems that combine TES with hydrogen or gas.
- Design a low-carbon calciner at lab-scale and develop an understanding of how to scale this to pilot or commercial scale.
- Conduct kinetic studies of steam calcination to inform reactor design and performance.
- Develop techniques for removal of alumina fines prior to the direct steam recovery system.

OUTCOMES AND INDUSTRY IMPACT

The project is designed to de-risk the transition to low-carbon emissions, providing a clear pathway for industry to adopt the new technologies.

The work aims to deliver solutions that can be applied across alumina refineries, with configurations tailored for different plants.

Cost-benefit and comparative analyses of different technologies will give refineries the data they need to make informed decisions about transitioning to low-carbon operations.

“We’re looking at a future where alumina refineries can operate with zero emissions, using advanced technologies that don’t just reduce carbon but improve efficiency across the board,” says Dr Saw. “We want to co-optimise these systems to balance efficiency, cost and sustainability.”

“OUR GOAL IS NOT JUST TO DECARBONISE, BUT TO DO SO IN A WAY THAT MAINTAINS OR EVEN ENHANCES THE ECONOMIC VIABILITY OF ALUMINA PRODUCTION.”

– Dr Woei Saw, University of Adelaide

PROJECT CASE STUDY – PROGRAM 2

RP2.006: Hydrogen supply within HILT regional hubs – H_2 cost and synergistic opportunities

Project Leaders:	Dr Tara Hosseini, Commonwealth Scientific and Industrial Research Organisation (CSIRO)
HILT CRC partners:	CSIRO, The University of Adelaide, ANU, Grange Resources, Fortescue, LIBERTY Steel, Hatch
Industries:	Alumina and aluminium Cement and lime Iron and steel
Commenced:	01 June 2023
Total project value:	$617,000 (cash and in kind)

Complementary HILT CRC projects:

RP2.001: Green hydrogen supply modelling for industry

RP2.014: Low-cost reliable green electricity supply for low-carbon heavy industry

RP3.007: Unlocking investment in energy infrastructure for net-zero industrial hubs

Hydrogen, especially green hydrogen produced from renewable energy sources like wind and solar, is considered an essential element of the transition to a low-carbon economy. However, there are major challenges to commercially sustainable, reliable hydrogen production and delivery, such as cost uncertainties and the intermittency of renewable energy sources. Furthermore, hydrogen production, storage and transportation costs vary significantly based on location and method.

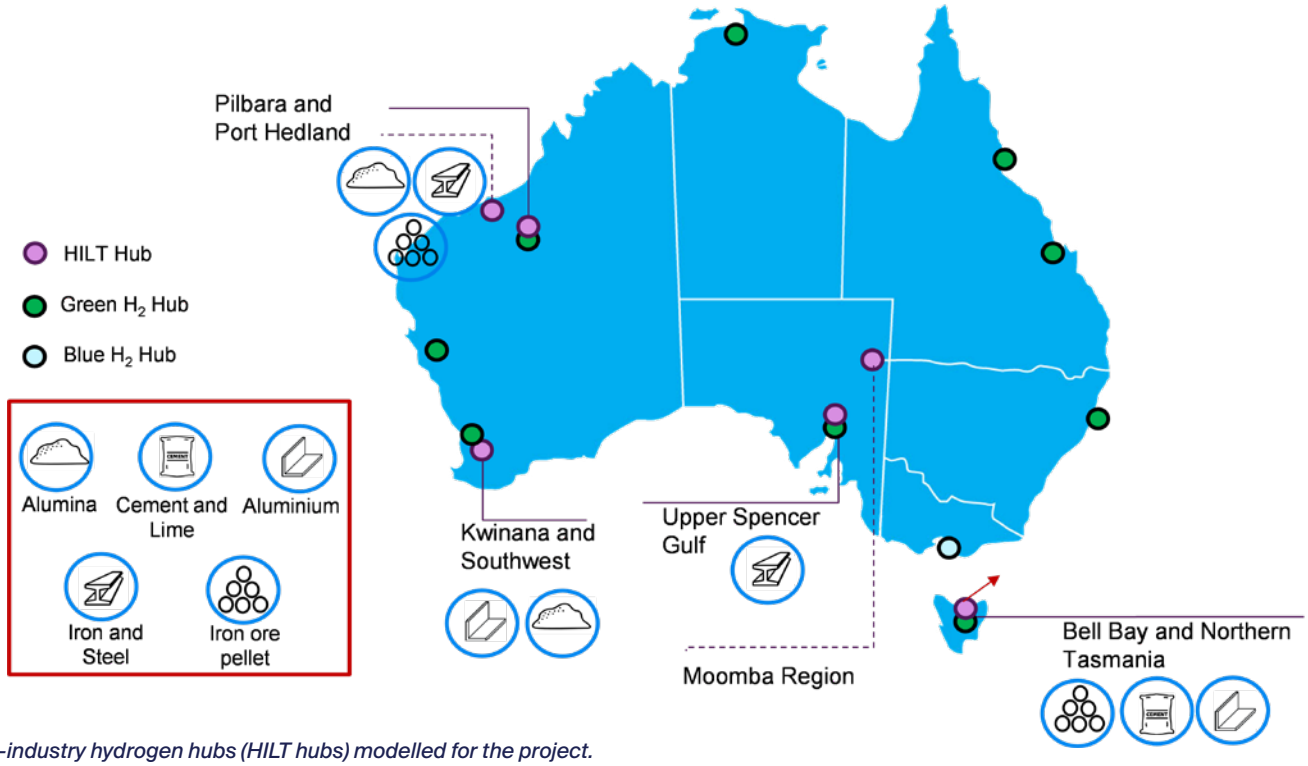
Regional hydrogen hubs have the potential to bring together hydrogen producers and users in a single location, reducing costs through shared infrastructure and economies of scale. The project aimed to:

- Accelerate the decarbonisation of heavy industries through strategic hydrogen deployment.
- Provide industries and policymakers with a clear framework for understanding the cost dynamics of hydrogen supply within different Australian regions.

THE CHALLENGE

There are several critical challenges to developing hydrogen hubs in Australia:

- **Cost uncertainty:** Fluctuating hydrogen costs, driven by factors such as the price of renewable energy and the cost of transportation and storage, can complicate or delay decisions by heavy industry to invest in decarbonisation.
- **Intermittency of renewable energy:** Mismatches between hydrogen production and demand, caused by intermittency, require effective storage solutions, which in turn increase costs.
- **Supply chain costs:** From energy generation to end use, each step contributes to overall costs.
- **Regional constraints:** Factors like land availability and labour costs vary widely between regions.



Heavy-industry hydrogen hubs (HILT hubs) modelled for the project.

PROJECT APPROACH

The project created a detailed cost estimation framework for hydrogen supply across six key industrial hubs aligned to HILT's Core industry partners: Northern Tasmania; Upper Spencer Gulf and Moomba, South Australia; Port Hedland, Kwinana, and the Pilbara, Western Australia. This framework factors in regional differences in renewable energy availability, hydrogen production costs, storage and transportation infrastructure.

Project Leader Dr Tara Hosseini notes that the project was premised on aggregating hydrogen users within specific regions to reduce costs through shared infrastructure.

"Our goal is to create hydrogen hubs that take advantage of co-location benefits," she says. "By clustering producers and users together, we can reduce the costs of transportation and storage, making hydrogen more cost-competitive for heavy industries."

OUTCOMES AND INDUSTRY IMPACT

Across the six hubs analysed, the project identified optimal hydrogen delivery costs for various demand levels.

"Green hydrogen costs varied significantly across regions due to geographic factors, such as labour costs, the distance between hydrogen production sites and end users, and renewable resource availability," Dr Hosseini says. "The cost of delivered hydrogen ranged from US$3.50/kg to US$8/kg."

Demand had minimal impact on green hydrogen costs, but for blue hydrogen (produced from natural gas), costs were significantly influenced by production scale and location-specific factors.

The project has developed a cost estimation tool that will allow industries and policymakers to assess the relative costs of hydrogen production at different scales and under various operational conditions. The tool will help industries make informed decisions about their decarbonisation strategies.

INDUSTRIAL EFFICIENCY AND ECONOMICS

Dr Hosseini notes that the project's outcomes provide valuable insights for both industry and government.

"Industries can use the results to make informed decisions about their decarbonisation plans," she says. "They will also inform the development of effective policies based on unlocking regional economic and environmental potential."

A new HILT CRC project, *Unlocking investment in energy infrastructure for net-zero industrial hubs*, will build on this project by also considering electricity and natural gas and different regionally specific scenarios for transitioning energy supply and heavy industry demand. This will enable cost-optimised evaluations of energy infrastructure needed to reach net-zero carbon emissions by 2050.

"THESE INSIGHTS WILL BE INVALUABLE FOR INDUSTRIES LOOKING TO DECARBONISE – BY PROVIDING CLEAR, DATA-DRIVEN ESTIMATES OF HYDROGEN COSTS, WE CAN HELP BUSINESSES PLAN FOR A SUSTAINABLE FUTURE."

– Dr Tara Hosseini, CSIRO

HILT CRC

PROJECT CASE STUDY – PROGRAM 3

RP3.005: Market, cost and locational factors for green iron and steel in Australia

Project Leaders:	Professor Frank Jotzo, ANU
Participants:	ANU, Swinburne University of Technology, Queensland University of Technology, The University of Adelaide, LIBERTY Steel, Fortescue, MRIWA
Industries:	Iron ore and steel
Commenced:	01 June 2023
Total project value:	$525,000 (cash and in kind)

Complementary HILT CRC projects:

RP3.004: Intermediate product exports for Australia-China green steel

RP3.006: Certification and verification to enable a successful low-carbon transition for heavy industry

RP3.008: A policy roadmap for Australia's heavy industry low-carbon transition

THE CHALLENGE

As the world's largest exporter of iron ore, Australia is ideally placed to use its abundant resources, renewable energy potential, vast land mass, and strategic port access to become a leading supplier of green iron and steel.

However, there are significant challenges to realising this vision. Technological hurdles include the processing of Australia's dominant type of iron ore – hematite – into green iron.

Project Leader Professor Frank Jotzo notes that Australia faces competition from countries with well-established assistance for green commodities development.

"Federal and state governments are supportive, but there's uncertainty over how to best go about this," he says. "It's not a matter of just copy/pasting from other countries, which have settings geared towards domestic markets, whereas Australia's green iron industry would be heavily export oriented."

PROJECT APPROACH

The project is employing a multi-faceted approach to build a comprehensive understanding of Australia's green iron and steel opportunity, including:

1. Expert elicitation: Interviewing key players in Australia's iron and steel sector to gather insights on industry enablers and obstacles.

2. Scenario modelling: Developing illustrated scenarios of how the green iron and steel industry might evolve, mapping out potential futures to 2050 and beyond.

3. Policy analysis: Examining effective policy mechanisms to create favourable conditions for industry development, tailored to Australia's export-oriented market.

Future scenarios consider factors such as global decarbonisation trajectories, supply-demand relationships and Australia's ability to compete in the international green iron and steel market.

"The modelling is providing deeply illustrated scenarios of how the green iron and steel industry might evolve," Professor Jotzo says. "What's the demand, where does the supply come from, what is Australia's role under different conditions?"

The analysis is exploring how green iron and steel production could align with the expected decline of Australia's coal and gas exports, creating a more environmentally and commercially sustainable industrial future.

OUTCOMES AND INDUSTRY IMPACT

According to Professor Jotzo, the research is revealing nuanced industry perspectives.

"We're developing a shared baseline understanding in the Australian iron and steel community regarding the future potential for a green commodity industry," he says.

Views vary widely among experts on the likelihood of success for a green iron and steel industry in Australia.

Some question the global willingness to pay premium prices for green steel products and are concerned about competition from other locations, while others see enormous potential, especially given Australia's established trade links with major steel producers in East Asia.

IMPLICATIONS FOR POLICY AND INDUSTRY

The outcomes will also provide essential insights for policymakers, helping to bridge existing knowledge gaps and inform government strategies – such as the Future Made in Australia agenda – for developing the sector, providing a clearer understanding of how to optimise the conditions required for an Australian green iron and steel industry.

For industry, the project offers valuable insights into strategy development and investment decisions in the evolving green steel market.

As the global push towards net-zero emissions intensifies, this project provides a crucial waypoint in Australia's push to become a large green commodity exporter, underscoring the need for collaboration among industry, government and research institutions as they navigate the complex transition to a low-carbon heavy industry future.

"THE PRIZE IS SO LARGE THAT MOST PEOPLE IN INDUSTRY ARE VERY EXCITED ABOUT THE POTENTIAL, EVEN IF THE PROBABILITY THEY ASCRIBE TO ACHIEVING THAT DIFFERS."

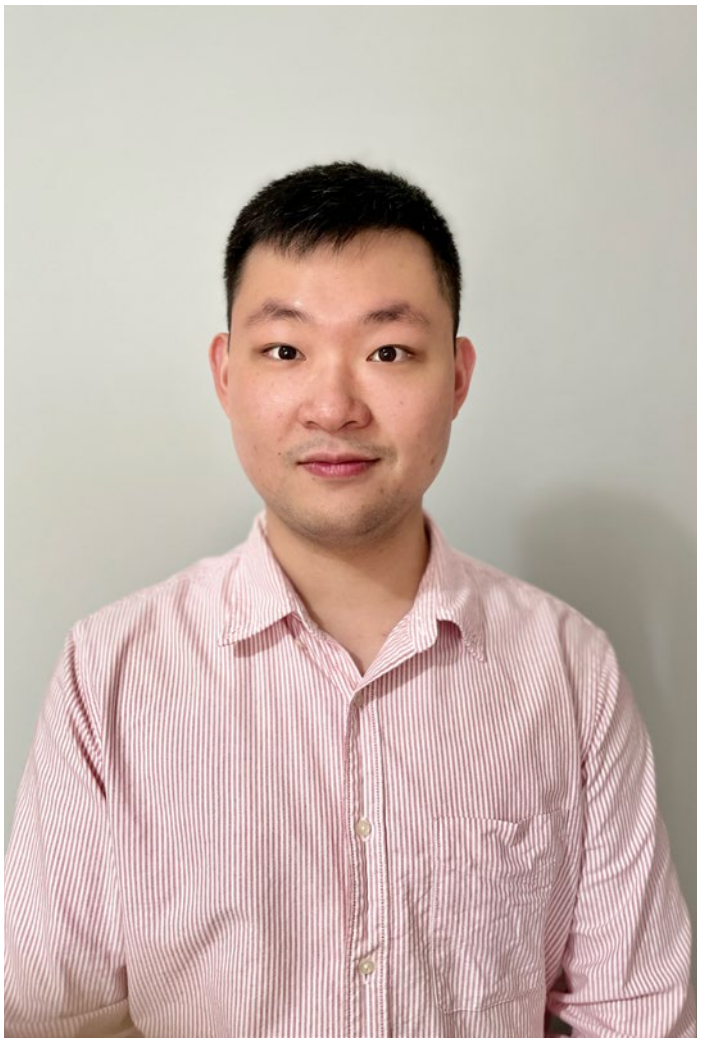
– Professor Frank Jotzo, ANU

HILT CRC

INTERNSHIP CASE STUDY

Enhancing combustion efficiency in alumina production

HILT CRC partner:	Emirates Global Aluminium (EGA)
Internship supervisor:	Emilio Pai, EGA
PhD student:	Daniel Ang
PhD supervisor:	Dr Woei Saw, University of Adelaide
PhD project:	Assessment of hydrogen-driven alumina calcination process
Industries:	Alumina and aluminium
Internship period:	May to September 2024



OVERVIEW

Daniel Ang undertook a research internship with Emirates Global Aluminium (EGA) from May to September 2024. Supervised by Emilio Pai, Senior Manager – Process Engineering at EGA, the internship focused on improving combustion efficiency and reducing volatile organic compound (VOC) emissions in EGA's alumina calcination process.

The calciner, a critical part of the alumina production process, burns natural gas for high-temperature processing of aluminium hydroxide derived from bauxite. Daniel's work employed computational fluid dynamics (CFD) modelling to assess combustion performance and explore improvements, including the potential for using hydrogen as a cleaner fuel.

CHALLENGES

The internship arose from EGA's need to improve combustion efficiency.

"Our calciner uses fluidised bed recirculation, and we noticed some incomplete combustion, meaning that some natural gas was bypassing the furnace," Emilio says. "The challenge was to improve the mixing of natural gas with air in the furnace to enhance efficiency without compromising alumina quality."

The project also explored the potential for hydrogen fuel in alumina calcination.

"Daniel's PhD focuses on understanding hydrogen combustion through CFD modelling," Emilio says. "This internship provided an excellent opportunity for him to develop his knowledge by studying the current process using natural gas."

"HILT CRC GIVES EARLY-CAREER RESEARCHERS LIKE ME A PLATFORM TO CONNECT WITH INDUSTRY. IF I WAS AN INDEPENDENT PHD STUDENT, IT WOULD BE ALMOST IMPOSSIBLE TO SECURE AN INTERNSHIP LIKE THIS."

– Daniel Ang, University of Adelaide

INTERNSHIP APPROACH

After an initial two weeks on site in the United Arab Emirates, Daniel worked from Australia, meeting weekly with EGA's team to refine his approach and update them on his findings.

His CFD modelling simulated modifications to the calciner's geometry and operating conditions, including repositioning gas lances (used to inject gas into the combustion chamber) and heating air supplied to enhance combustion.

Key elements of Daniel's work included:

- Detailed analysis of gas mixing and combustion in the calciner
- Simulation of various modifications to improve efficiency
- Comparison of methane and hydrogen combustion for future decarbonisation options.

"We tested two methods to change operating conditions – modifying the calciner's geometry and implementing an electric air heater," Daniel explains. "The goal was not just to cut emissions, but also to ensure the quality of the alumina wasn't compromised."

The internship allowed Daniel to apply theoretical knowledge in a real-world industrial setting.

"It was rewarding to see how fundamental techniques could be applied to solve practical problems," he says. "It was also a great way to learn about the potentially major variations between small-scale experiments and large-scale industrial settings."

OUTCOMES AND IMPACT

Daniel's findings have supported EGA's approach to addressing the calciner issues.

"The modifications Daniel suggested are relatively simple and much less costly than other solutions proposed," Emilio says. "Even if an approach doesn't work perfectly, the trial-and-error process using CFD modelling is invaluable because the costs of testing these modifications are low."

The study's insights will also support future decarbonisation efforts at EGA, particularly as the company considers transitioning to hydrogen fuel.

"Collaborating with students like Daniel can help us explore innovative solutions and accelerate our progress towards decarbonisation," Emilio says.

For Daniel, the internship affirmed his passion for industrial research and development.

"It opened my eyes to the importance of industry collaboration in solving real-world problems," he says.

Daniel's work demonstrates the power of collaboration between industry and research, advancing the goal of decarbonisation while providing real-world experience for emerging researchers.

As Emilio notes, "Internships like these are crucial for exploring new technologies and driving progress in sustainability."

Left to right: Emilio Pai, Dr Woei Saw, Daniel Ang and Siyun Ning, another HILT CRC PhD student, at EGA headquarters in Dubai.

PARTNERSHIPS AND ENGAGEMENT

PARTNERSHIPS

HILT CRC works collaboratively between our industry, research and government partners to develop and demonstrate the technologies needed to transition the steel, iron, alumina and cement industries by reducing their CO_2 emissions.

Our governance structure is designed to foster collaboration and ensure HILT CRC activities are aligned with industry's needs.

We greatly appreciate the support of our industry collaborators, particularly Core Partners Fortescue, Grange Resources, Hydro, Liberty/GFG, Roy Hill and South32. Together with our research Core Partners – ANU, CSIRO, Curtin University and The University of Adelaide – these organisations form our Steering Committee. Our 10 Core Partners plus 12 Key Partners make up our three Research Advisory Committees to oversee project development and progress.

HILT's partners continue to grow. We now have over 60 partners, a net increase of 40% since our launch. Core and Key Partners joining us after our establishment include Hydro, BlueScope Steel, Emirates Global Aluminium and Magaldi Power.

FUNDING

HILT CRC has also been actively seeking additional funding to leverage its current funding and expand and accelerate its research activities. Highlights to date include:

- A$1.4M in funding from ARENA, with additional support from MRIWA and Curtin University, to extend project RP1.011: Upgrading iron ore for direct reduced iron production using products from seawater reverse osmosis brines.
- An additional A$4.8M was secured by The Australian National University (ANU) to expand RP1.012: Prevention of sticking in H_2 fluidised bed direct reduced iron production.

TRUSTED VOICE

HILT CRC organises and participates in a wide variety of stakeholder engagement to build its internal collaborative ecosystem, foster networks and promote knowledge about the outcomes of its activities.

Highlights include:

The HILT CRC Annual Conference

This event brings together our research, industry and government partners to connect and discuss research pathways. Our second conference, in Perth in 2023, featured:

- 157 delegates across 3 days
- 100% very satisfied or above according to conference survey responses
- Strong endorsement for the importance of HILT CRC's role in fostering collaboration and knowledge sharing.

Chair Susan Jeanes opens the 2023 HILT CRC Conference in Perth.

Roundtables and workshops

These bring industry, research and government together around focused topics in action-orientated formats, including:

- **AQW 2024 Alumina Decarbonisation Workshop** in Dubai and subsequent report.
- **Roundtable on Common User Pilot Facility & Green Iron and Steel Initiatives** in Perth, in conjunction with CSIRO and MRIWA.
- **Upper Spencer Gulf Industry Roundtables** on collaborative initiatives to foster heavy industry transition in South Australia.
- **Program 3** Roundtables held across Australia to formulate next stages in Program 3 projects.

Saindhav Tamhane, SA Department for Energy and Mining, speaks at a 2023 Program 3 roundtable in Canberra

Speaking at conferences and events

- **2023 United Nations Climate Change Conference (COP28):** CEO Jenny Selway represented HILT CRC, speaking at the Breakthrough Agenda Steel and Cement roundtables and the Leadership Group for Industry Transition (Leadit) Summit, and sitting as a jury member in the inaugural Net-Zero Industries Mission Industrial Decarbonisation Awards.
- CRC staff and researchers regularly present at national and international events. Highlights in 2024 included the 12th International Alumina Quality Workshop and Conference in Dubai; the 8th Annual Energy and Mines Summit in Perth; and the World Hydrogen Summit in Rotterdam.

Dr Alan Monaghan, Net-Zero Industries Mission (left) and Jenny Selway (right) present the Net-Zero Industries Award for Young Talents to Dr Suneeti Purohit, CSIRO, at COP28 in Dubai, United Arab Emirates.

Government engagement

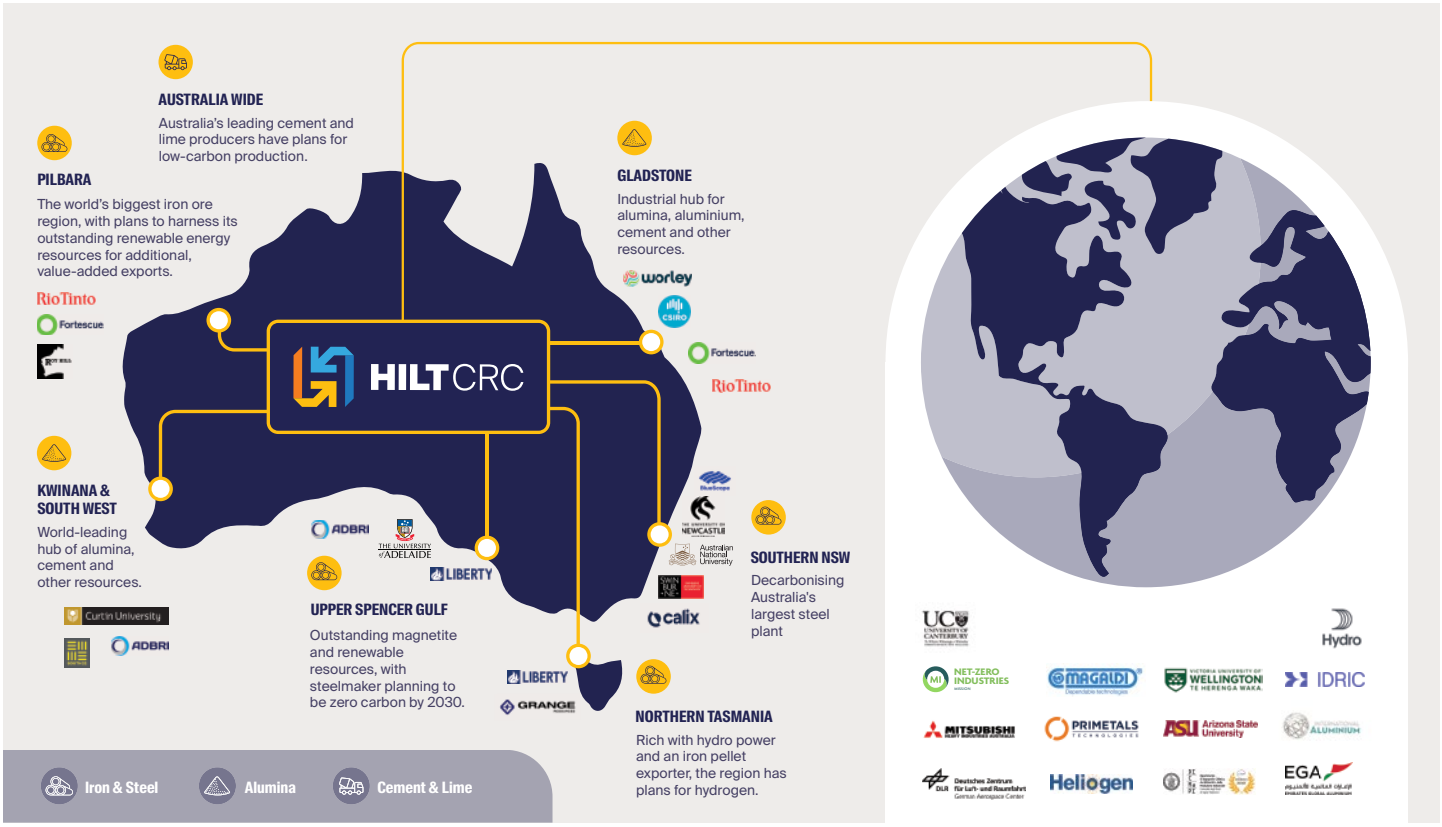
HILT CRC engages closely with government, not only through our partner organisations, but also by contributing to government processes. We have made submissions to several consultations, including:

- DISR's Green Metals – *A Future Made in Australia: Unlocking Australia's Green Iron, Steel, Alumina and Aluminium Opportunity* consultation paper.
- DISR and the Climate Change Authority's Heavy Industry Sectorial Plan consultation.
- The Tasmanian Government's *Draft Emissions Reduction and Resilience Plan for Tasmania's Industrial Processes and Product Use Sector*.

Other recent highlights include:

- a Canberra Research Showcase for policymakers working on decarbonisation
- CEO Jenny Selway's appointment to the Industrial Decarbonisation and Green Metals Advisory Panel, a commitment under the Future Made in Australia agenda to support investment in green metals and help heavy industry decarbonise.

LINKING INDUSTRY, RESEARCH AND GOVERNMENTS



EDUCATION AND TRAINING

We are upskilling and training heavy industry's workforce, enabling skilled personnel to transition to a low-carbon sector.

Our Education and Training Program takes advantage of HILT CRC's highly innovative environment, building capacity for innovation and leadership.

As with our research programs, our education and training are end-user driven, with a focus on:

- professional development based on micro-credentials and short courses
- a suite of postgraduate research, education and training activities
- support for course development in industry-relevant undergraduate and vocational education and training programs.

To date, HILT CRC has:

- appointed 21 active postgraduate students
- brokered 2 industry internships
- awarded 11 coursework grants, with 4 programs completed
- delivered more than 30 webinars on relevant research, technology and policy.

The postgraduate student cohort at the HILT CRC 2023 Annual Conference.

GREEN STEEL SHORT COURSE

Our short course on 'Decarbonisation Routes for Steel' was held in April 2024 in Perth and August 2024 in Adelaide in collaboration with Swinburne University of Technology.

Led by Professor Geoff Brooks, the course covered the basic chemistry of hydrogen production and combustion and reduction of oxides; considered the different ways hydrogen could be used to replace carbon in iron and steel production; and examined non-hydrogen options.

The course was a resounding success with a full house of around 60 people at each event and 90% of participants extremely satisfied.

Professor Geoff Brooks, Swinburne University of Technology, presents the inaugural 'Decarbonisation Routes for Steel' short course in Perth in April 2024.

HILT CRC COURSEWORK DEVELOPMENT GRANT CASE STUDY: TAFE SA

In 2023, the Strategic Industry Partnerships team (SIP) at TAFE SA submitted Coursework Development Grant for Decarbonisation Case Study, 3D Scan and Learning materials for incorporation into Apprenticeship programs for Electricians, Instrumentation & Control Technicians and Mechanical Fitters.

The CRC awarded TAFE SA $30,000 to help develop case study and support learning objectives derived from Calix's Low Emissions Intensity Lime and Cement (LEILAC) calciner technology.

The content developed with the support of the grant will be incorporated into three Certificate III qualifications, identified for their relevance to heavy industry decarbonisation activities.

PUBLICATIONS

JOURNAL PAPERS

Meybodi MA, Beath AC. Decarbonizing Industrial Steam Generation Using Solar and Wind Power in a Constrained Electricity Network. *Solar.* 2024; 4(3):471-490

Lee L, Ingenhoven P, Saw WL, Nathan GJ. The techno-economics of transmitting heat at high temperatures in insulated pipes over large distances. *Applied Energy.* 2024; Vol. 358, 122634.

Li L, Yu H, Puxty G, Zhou S, Conway W, Feron P. Integrated CO_2 Capture and Mineralization Based on Monoethanolamine and Lime Kiln Dust. *Industrial & Engineering Chemistry Research.* 2024 63 (36), 16019-16028

Sabah S, Shahabuddin M, Rahbari A, Brooks G, Pye J, Rhamdhani MA. Effect of gangue on CO_2 emission for different decarbonisation pathways. *Ironmaking & Steelmaking.* 2024;51(4):356-368.

Satritama B, Cooper C, Fellicia D Pownceby MI, Palanisamy S, Ang A, Mukhlis RZ, Pye J, Rahbari A, Brooks GA, Rhamdhani MA. Hydrogen Plasma for Low-Carbon Extractive Metallurgy: Oxides Reduction, Metals Refining, and Wastes Processing. *J. Sustain. Metall.* 2024.

Shahabuddin M, Rahbari A, Sabah S, Brooks G, Pye J, Rhamdhani MA. Process modelling for the production of hydrogen-based direct reduced iron in shaft furnaces using different ore grades. *Ironmaking & Steelmaking.* 2024;0(0).

Shahabuddin M, Rahbari A, Sabah S, Brooks G, Pye J, Rhamdhani MA. The performance and charge behaviour in melter/smelter for the production of hot metal in hydrogen DRI-based steelmaking. *Ironmaking & Steelmaking.* 2024;0(0).

Wang R, Purohit S, Paymooni K, Honeyands T. 2024. Sticking in Shaft Furnace and Fluidized Bed Ironmaking Processes: A Comprehensive Review Focusing on the Effect of Coating Materials. *Metall Mater Trans* B. 2024; 55, 2977–3006.

CONFERENCE PROCEEDINGS

Ning S, Nathan G, Ashman P, Saw, W. Assessment of Multi-Stage Mechanical Vapour Recompression Process for Decarbonizing Steam Generation in an Alumina Refinery. Proceedings of the 12th *International AQW Conference and Exhibition – Alumina 2024.* 2024.

Ning S, Nathan G, Ashman P, Saw, W. Technical Assessment of Steam Recovery from Calciners in Alumina Refinery. Proceedings of the *12th International AQW Conference and Exhibition – Alumina 2024.* 2024.

GOVERNMENT SUBMISSIONS (PUBLIC)

Response to the Tasmanian Government *Draft Emissions Reduction and Resilience Plan for Tasmania's Industrial Processes and Product Use Sector*. October 2024.

Response to the DISR consultation paper: *A Future Made in Australia: Unlocking Australia's Green Iron, Steel, Alumina and Aluminium Opportunity.* July 2024.

Response to the Joint Standing Committee on Trade and Investment Growth *Inquiry into Australia's transition to a green energy superpower.* November 2022.

CRCS DELIVERING TOWARDS NET ZERO

ACIL Allen. *Mapping and quantification of CRCs' work on decarbonisation*. 2024. (This independent study, commissioned by Cooperative Research Australia, highlights the contribution of CRCs that are directly or indirectly supporting Australia's decarbonisation goals.)

HILT CRC CEO Jenny Selway with the leaders of other decarbonisation-focused CRCs at the 2024 Canberra launch of the 'Mapping and quantification of CRCs' work on decarbonisation' report.

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DR ALAN MONAGHAN, GLOBAL MISSION COORDINATOR, NET-ZERO INDUSTRIES MISSION

OUR PARTNERS

We currently have more than 60 partners representing industry, research and government. Together, we are developing and demonstrating low-carbon technologies that will help de-risk and accelerate the decarbonisation of the steel, iron, alumina and cement industries and grow Australia's economy.

CORE PARTNERS

Australian National University
CSIRO
Curtin University
Fortescue
GRANGE RESOURCES
Hydro
LIBERTY
SOUTH32
ROY HILL
THE UNIVERSITY of ADELAIDE

KEY PARTNERS

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wsp

HILT CRC

hiltcrc.com.au

General enquiries
enquiries@hiltcrc.com.au

To learn more about HILT CRC, partnership opportunities or how you can further engage with us, get in touch via **hiltcrc.com.au/connect**

Acknowledgement of Country

HILT CRC would like to respectfully acknowledge the Traditional Owners of the ancestral lands throughout Australia and their continuing connection to the land, waters and culture and pay our respects to them, their cultures and to their Elders past, present and emerging.

Australian Government
Department of Industry, Science and Resources

Cooperative Research Centres Program