HILT CRC

HEAVY INDUSTRY LOW-CARBON TRANSITION COOPERATIVE RESEARCH CENTRE

DE-RISKING DECARBONISATION

OCTOBER 2025

HILTCRC.COM.AU

HILT CRC

OUR PARTNERS

We currently have more than 65 partners representing industry, research and government. Together, we are developing and demonstrating low-carbon technologies that will help accelerate and de-risk the decarbonisation of the steel, iron, alumina and cement industries while growing the economy.

CORE PARTNERS

Australian National University
CSIRO
Curtin University
Fortescue
GRANGE RESOURCES
HANCOCK IRON ORE
Hydro
OneSteel Manufacturing
SOUTH32
SWINBURNE UNIVERSITY OF TECHNOLOGY
THE UNIVERSITY of ADELAIDE

KEY PARTNERS

ADBRI
BHP
BlueScope
calix
EGA EMIRATES GLOBAL ALUMINIUM
FCT COMBUSTION
MAGALDI Dependable technologies
MITSUBISHI HEAVY INDUSTRIES AUSTRALIA
PRIMETALS TECHNOLOGIES
GOVERNMENT OF WESTERN AUSTRALIA
mriwa
SOUTH AUSTRALIA
Government of South Australia Department for Energy and Mining
Tasmanian Government
THE UNIVERSITY OF NEWCASTLE AUSTRALIA
worley

AFFILIATE PARTNERS

14
cba
GLENCORE TECHNOLOGY
GPA
HATCH
Helios
ILUKA
MAGNETITE MINES
picko
Queensland Government
QUEENSLAND TREASURY CORPORATION
QUT
ResourceCo
RioTinto
SysCAD
UNEARTH WHYALLA
ZEN ENERGY

ASSOCIATE PARTNERS

ASU Arizona State University
al AUSTRALIAN ALUMINIUM COUNCIL LTD
AEMO
Australian Renewable Energy Hub
AUSTRALIAN STEEL INSTITUTE
CEMENT INDUSTRY FEDERATION
CORE
DLR Deutsches Zentrum für Luft- und Raumfahrt German Aerospace Center
Energy Exemplar
fpc Forest Products Commission
GARTREE ADVISORY
gda Global Decarbonisation Advisory
IDRIC
INTERNATIONAL ALUMINIUM
KC8
PREDICT Anticipate & Save
Sandia National Laboratories
STANDARDS Australia
Sumitomo SHI FW
SynBio
The Superpower Institute
UC UNIVERSITY OF CANTERBURY
DICAPI
VICTORIA UNIVERSITY OF WELLINGTON TE HERENGA WAKA
wsp

HILT CRC

ABOUT HILT CRC

The Heavy Industry Low-carbon Transition Cooperative Research Centre (HILT CRC) was created to accelerate and de-risk heavy industry's transition to a low-carbon future. Through industry-led research, we develop technologies and strategies for decarbonisation across the iron and steel, alumina, and cement sectors.

Since commencing operations in November 2021, HILT CRC has led groundbreaking research in collaboration with over 65 partners across industry, research organisations and government.

With our partners and world-class researchers, HILT CRC is developing the knowledge and tools global heavy industry needs to navigate the decarbonisation journey.

VISION

A prosperous, net-zero heavy industry sector at the forefront of the low-carbon transition

MISSION

To accelerate and de-risk 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 ENABLED
- FUNDING UNLOCKED
- TRUSTED VOICE
- UPSKILLED WORKFORCE

“WITH OUR PARTNERS, HILT CRC IS ADVANCING PATHWAYS THAT WILL MAKE NET-ZERO HEAVY INDUSTRY ACHIEVABLE.”

JOINT MESSAGE FROM THE CHAIR & CEO

Over the past year, we have been thrilled to see HILT CRC’s momentum grow and our research portfolio continue to meet industry need. We’ve prioritised new projects that de-risk key technologies and pathways – from electric smelting furnaces to low-carbon process heat – and we’ve raised our profile with policymakers to ensure that our research findings have real impact.

Our ecosystem continues to grow, with BHP joining as a Key Partner, Swinburne University of Technology stepping up from Key to Core Partner, and Queensland Treasury Corp, Helios, the Superpower Institute, GDA, Sandia National Laboratories and Gartree Advisory all coming on board. With more applications in the pipeline, we will soon have well over 65 partners.

HILT’s primary purpose is, of course, our research. To mention just a few highlights, we’ve demonstrated:

- that it’s possible to upgrade iron ores via leaching to 67% iron, the threshold required for green iron processes
- relevant areas for policy focus to facilitate green iron industries in Australia
- compelling results for flash reduction, with research-backed findings helping our industry partners secure further funding
- the potential economic viability of thermal energy storage
- that the economics of integrating renewables into high-temperature processing can improve with integrated batteries and flexible demand.

We now have almost 30 postgraduate students working on HILT projects. We provide professional development through short courses and webinars (which have attracted over 3,000 attendees to date), and have kicked off an undergraduate scholarship program.

We’ve also:

- brought people together from all over the world to develop reference scenarios for the AlumiNEXT™ project
- launched projects focused on biomass-derived fuels for green steel (project RP1.017), magnetite-to-green-steel pathways (RP1.018), and biomass/waste-derived syngas for high-temperature heat (RP2.018)
- activated our first two Opportunity Fund projects, on metallothermic ironmaking.

Our 2025 partner review meetings shaped HILT’s strategy for this current financial year and reinforced our commitment to delivering a research portfolio that has impact. The Board’s focus is clear: keep HILT CRC tightly aligned to industry needs, strengthen national coordination and ensure partner value.

We have supported deep engagement with governments (federal and state), ensuring that the results of our research projects inform policy development, regulation and markets. As such, we were thrilled to see Australian Government announcements unlocking billions of dollars of funding for green metals. We were also pleased to see the creation of the Green Metals Innovation Network (GMIN). This initiative, led by CSIRO in partnership with HILT, complements our collaboration model and education platform to accelerate Australia’s green metals capability.

We will continue to maintain a disciplined research portfolio that supports industry to advance pilots and demonstrations. By tapping into our deep cross-sectoral networks, we will keep our focus on real-world challenges, ensuring responsible stewardship of partner funds so every dollar moves industry closer to achieving net-zero emissions while remaining globally competitive.

With our industry, research and government partners, we’re de-risking decarbonisation and accelerating pathways from research to commercialisation.

SUSAN JEANES
CHAIR

JENNY SELWAY
CEO

OUR PEOPLE

BOARD

SUSAN JEANES, CHAIR

TONY WOOD, DEPUTY CHAIR

NEIL GOODMAN

RICHARD HILLIS

RAY MOSTOGL

KYRA REZNIKOV

BILL TE KLOOT

MIKKO HUPA, (SPECIAL RESEARCH ADVISOR)

TEAM

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IAN HARDWICK, CHIEF OPERATING OFFICER

DR JORDAN PARHAM, STRATEGIC INITIATIVES AND PARTNERSHIP DIRECTOR

PROF. GUS NATHAN, RESEARCH DIRECTOR

LOUISE BEAZLEY, ADMINISTRATION MANAGER

TARYN GUYERS, RESEARCH PORTFOLIO MANAGER

DR ALIREZA SALMACHI, EDUCATION AND TRAINING DIRECTOR

ADAM BARCLAY, COMMUNICATIONS AND MARKETING MANAGER

PROGRAM LEADERSHIP

BRIAN MCDONALD, ROY HILL – STEERING COMMITTEE CHAIR

DR ANDREW BEATH, CSIRO – CO-RESEARCH LEAD, PROGRAM 1

ADRIEN GUIRAUD, CSIRO – CO-RESEARCH LEAD, PROGRAM 1

DIAN OLWAGEN, GRANGE RESOURCES – INDUSTRY CHAIR, PROGRAM 1

PROF. PETER ASHMAN, UoA – RESEARCH LEAD, PROGRAM 2, AND DEPUTY RESEARCH DIRECTOR

MITCH BURT, SOUTH32 – INDUSTRY CHAIR, PROGRAM 2

ASSOC PROF. FIONA BECK, ANU – RESEARCH LEAD, PROGRAM 3

SAINDHAV TAMHANE, SA DEPARTMENT FOR ENERGY AND MINING – INDUSTRY CHAIR, PROGRAM 3

DR ALAN MONAGHAN, GLOBAL MISSION COORDINATOR, NZERO INDUSTRIES MISSION

HIGHLIGHTS

TO OCTOBER 2025

RESEARCH WITH IMPACT

28 PROJECTS COMPLETED

$13.2M CASH AND IN-KIND

35 PARTNERS INVOLVED

20 ACTIVE PROJECTS

$54.4M CASH AND IN-KIND

39 PARTNERS INVOLVED

8 AVERAGE PARTNERS PER PROJECT

4 EVALUATION

4 TECHNOLOGY DEVELOPMENT

12 TECHNOLOGY DE-RISKING & DEMONSTRATION

16 PEER-REVIEWED SCIENTIFIC PAPERS

2 PROJECTS EXPANDED BY ARENA FUNDING

Secured Australian Renewable Energy Agency funding of $6.2M to extend and expand existing HILT CRC projects

AVERAGE INDUSTRY CORE PARTNER R&D LEVERAGE OF $10:$1

PROJECT PORTFOLIO DEVELOPED AND APPROVED THROUGH TO 2027

2 PATENT APPLICATIONS FILED

COLLABORATIVE ECOSYSTEM

65+ INDUSTRY, RESEARCH AND GOVERNMENT PARTNERS

↑50% INCREASE SINCE LAUNCH

25+% INTERNATIONAL PARTNERS

New partners in past 12 months: BHP, Queensland Treasury Corp, Helios, the Superpower Institute, GDA, Sandia National Laboratories and Gartree Advisory

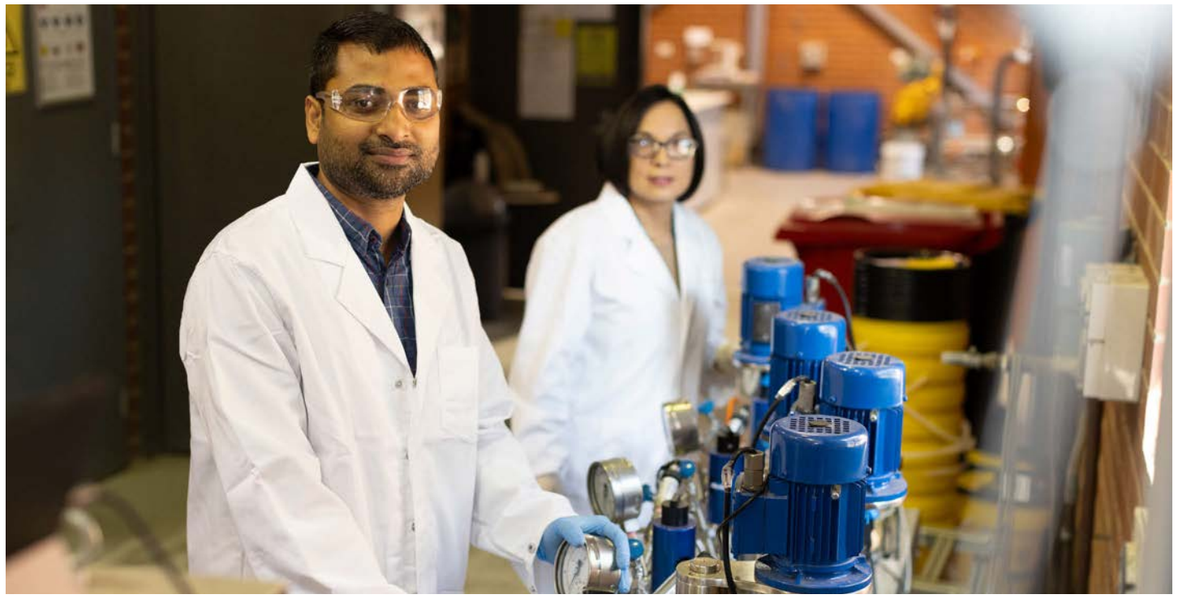
600+ DELEGATES AT 4 HILT CRC CONFERENCES
2 in Adelaide, 2 in Perth

>50 WEBINARS PRESENTED TO >3,000 ATTENDEES

20+ INDUSTRY FORUMS

Roundtables, workshops, showcases and networking events

INTERNATIONAL TRADING PARTNER TIER LAUNCHED IN 2025



TRUSTED VOICE

CO-MANAGEMENT OF GMIN TO ACCELERATE GREEN METALS IN AUSTRALIA

HILT will co-manage the Green Metals Innovation Network with CSIRO, with funding of $10M over 4 years

9 GOVERNMENT SUBMISSIONS

Including Green Metals: Consultation; Carbon Leakage review; AEMO Inputs, Assumptions and Scenarios Report

INTERNATIONAL LEADERSHIP OF NET-ZERO INDUSTRIES MISSION

Facilitation of Australia's co-leadership with Austria, through Mission

INTERNATIONAL REPRESENTATION

Including COP 28 and AQW '24 (Dubai); SEAISI 2025 (Jakarta); Expo 2025 (Osaka)

UPSKILLED WORKFORCE

28 ACTIVE POSTGRADUATE STUDENTS
Targeting 41 by June 2026

10 COURSEWORK GRANTS AWARDED
5 programs completed

INAUGURAL HILT AWARDS PRESENTED

4 INDUSTRY SHORT COURSES HELD

> 150 attendees at Green Steel and Alumina courses

5 UNDERGRADUATE ENGINEERING SCHOLARSHIPS AWARDED

HILT CRC STRATEGIC OUTCOME 1

RESEARCH WITH IMPACT

DELIVERING WORLD-CLASS RESEARCH, DEVELOPMENT AND DEMONSTRATION OUTCOMES AND SUPPORT FOR UPTAKE PATHWAYS FOR INDUSTRY.

Project status as of October 2025.

COMPLETED PROJECTS

RP1.001 Materials behaviour in iron ore direct reduction

RP1.002 Decarbonising steam for alumina

RP1.003 Alternative construction materials using by-products

RP1.004 Technoeconomic analysis of ironmaking using Australian ores

RP1.005 Evaluation of Australian iron ores for H_2DRI

RP1.006 Thermal beneficiation

RP1.007 Low-carbon calcination for alumina

RP1.008 Green pyromet/ hydromet beneficiation pathways

RP1.009 Iron ore testing in flash reduction process

RP1.010 Hydrogen and plasma iron ore reduction

RP1.011 Upgrading iron ore using leaching

RP2.001 Green hydrogen supply for industry

RP2.002 Carbon utilisation and recycling

RP2.003 Green heat for industry

RP2.004 CCUS roadmap for cement and lime

RP2.005 Hydrogen risks and impact

RP2.006 Hub options for competitive hydrogen supply

RP2.008 Lost production and variability

RP2.009 Thermal energy storage

RP2.010 Utilisation of refuse-derived fuels

RP2.011 High-temperature heat pumps

RP2.012 Bioenergy opportunities in heavy industry

RP2.014 Low-cost reliable green electricity supply

RP3.001 Regional hubs for net zero heavy industry

RP3.002 Lifecycle analysis of heavy industry

RP3.003 Review of trade and regulatory implications

RP3.004 Green iron and steel export analysis

RP3.005 Green iron and steel market & cost factors

P1 Process Technologies

P2 Cross-Cutting Technologies

P3 Facilitating Transformation

ACTIVE PROJECTS

RP1.011-ARENA Upgrading iron ore using leaching

RP1.012-ARENA Prevention of sticking in H_2DRI production

RP1.013 Alumina Refineries' Next Generation (AluminEXT™)

RP1.014 De-risking electric smelting furnace

RP1.015 Hydrogen direct flash reduction

RP1.016 Thermal beneficiation

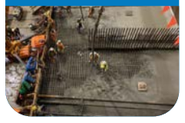
RP1.017 Biomass for green steel production

RP1.018 Green steel from magnetite

OFP 001 Metallothermic processing of Australian iron ores

OFP 002 Metallothermic processing of Australian iron ores

RP2.007 Hydrogen burners for cement and iron



RP2.013 Mineral carbonation for CCUS

RP2.015 Hydrogen impact on materials and infrastructure

RP2.016 Thermophysical properties of ores

RP2.017 Thermal energy storage

RP2.018 Syngas from biomass

RP3.006 Green certification & verification

RP3.007 Energy infrastructure investment

RP3.008 Policy roadmap

RP3.009 Australian green iron ore exports

PROGRAM 1 PROCESS TECHNOLOGIES

Develops and tests technologies that cut emissions and support production of green iron/steel, green alumina, and lower-carbon lime and cement.

PROGRAM 2 CROSS-CUTTING TECHNOLOGIES

Creates cross-sector solutions for low-carbon energy integration, low-carbon heat/fuels, CCUS, and circular-economy options.

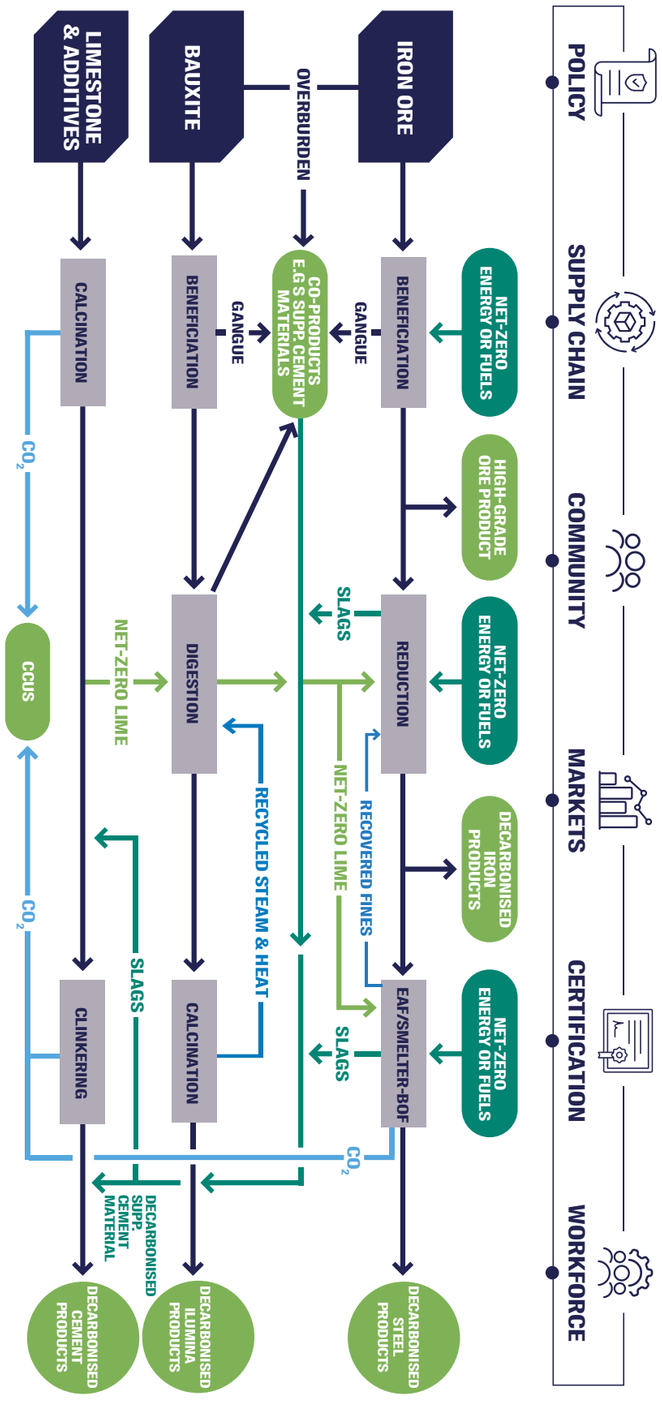
PROGRAM 3 FACILITATING TRANSFORMATION

Identifies the policy, market and infrastructure enablers needed to scale and adopt low-carbon technologies.

HILT CRC

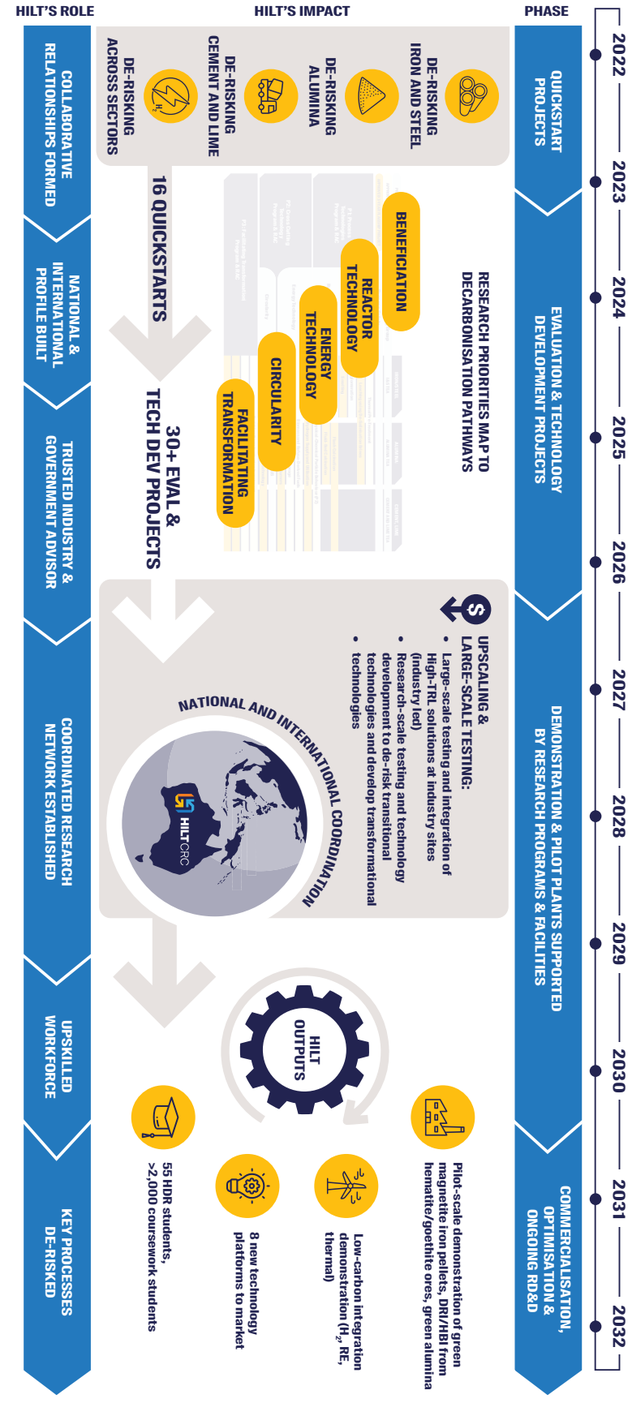
PATHWAYS TO DECARBONISE HEAVY INDUSTRY

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



RESEARCH DIRECTION

HILT's 10-year research plan (as shown in the figure below) has four main phases. In the first phase (years 1 and 2), Quickstart Projects were completed to develop a coordinated set of follow-on research projects, which are now underway. We are now turning our attention to upscaling and demonstrating the technologies that are being developed through these projects.



Members of the RP1.011-ARENA team undertaking research in Dr Hockaday's lab.

PROJECT UPDATE

RP1.011-ARENA: UPGRADING IRON ORE FOR DIRECT REDUCED IRON USING PRODUCTS FROM SEAWATER REVERSE OSMOSIS BRINES (THE BALIO PROCESS)

Project leaders:	Professor Jacques Eksteen and Dr Lina Hockaday, Curtin University
Project partners:	Curtin University, Australian Renewable Energy Agency (ARENA), The University of Adelaide, Fortescue, Hancock Iron Ore, Minerals Research Institute of WA, Agilitus, Proxa Australia
Industries:	Iron and steel
Commenced:	March 2024
Total project value:	$5,113,167 (cash and in kind)

This project received funding from the Australian Renewable Energy Agency (ARENA) as part of ARENA's Advancing Renewables Program.

THE CHALLENGE

Australia has abundant lower-grade hematite/goethite ores that, unprocessed, struggle to meet specifications for current green steel pathways, which require higher-grade iron content. This project is developing a process that uses the salty brine left over from seawater desalination to make the chemicals needed to 'wash' impurities out of the iron ore – known as Brine-derived Alkaline Leaching of Iron Ores, or the BALIO process. The goal is to demonstrate that the process can technically and commercially upgrade these ores to the grades suitable for direct reduced iron (DRI) / electric arc furnace (EAF) green steel processes.

PROJECT APPROACH

The project combines laboratory experiments on key operations – such as caustic leaching, brine treatment, salt splitting and thermal pretreatment – with process modelling and technoeconomic analysis. Key elements include:

- testing heat treatment and simple chemical attack to increase iron content and remove problem impurities (e.g. silica, alumina and phosphorus)
- treating seawater brine to make the acids and alkalis the process needs, after removing the minerals that cause scaling
- using the output from one step to feed the next, so the process is consistent with that anticipated in a real plant
- building a practical cost model alongside the experiments to understand what drives costs, what plant size makes sense, and which design choices matter most
- turning process by-products into useful materials (e.g. zeolites for water treatment), creating potential extra revenue and reducing waste.

"THIS COLLABORATION HAS REFLECTED A STRONG COMMITMENT TO ADDRESSING COMPLEX TECHNICAL CHALLENGES THROUGH RIGOROUS RESEARCH AND OPEN DIALOGUE."

– Stephan Kruger, Technical Engineer, Metals Technology Development, Fortescue

OUTCOMES AND INDUSTRY IMPACT

The research team has successfully upgraded multiple ore samples from ~55–60% iron to above 67% (calcined basis), which is in the range needed for green steel pathways.

Laboratory testing has confirmed that thermal pretreatment increases the removal of phosphorus from the samples during chemical attack.

Pilot nanofiltration removed over 75% of calcium, magnesium and sulphate from seawater brines (cutting scaling risk), and salt-splitting produced acid and alkali at the concentrations needed to run the circuit. Thermal pretreatment improved leachability and phosphorus removal, informing design choices for scale-up.

The team has also produced zeolites suitable for water treatment and calcium–aluminium–silicate hydrate (C-A-S-H) materials. These materials are potential cement clinker substitutes, with potential to be used in the cement industry, opening additional revenue streams and reducing waste.

Technoeconomic modelling confirms electricity for salt splitting, evaporation and thermal pretreatment is the dominant operating cost driver. Commercial viability of the process is therefore sensitive to electricity prices and process energy demand.

The project outcomes to date have allowed HILT CRC to file an international patent application, 'Hydrometallurgical iron ore beneficiation process', a key step on the path towards commercialisation.

The project is currently focusing on demonstrating partial integration between process steps by undertaking testing that uses outputs from some steps as inputs to others, making the test environment more representative of real-world operation.

RECOGNITION

The project was recognised with two awards in 2025:

- The Cooperative Research Australia Award for Excellence in Innovation (Research Institution Leadership in Industry-Research Collaboration)
- Curtin University Science and Engineering Pro Vice-Chancellor Staff Excellence Award (Research Team Award for Industry Engagement and Impact).

Dr Hockaday accepting the Cooperative Research Australia Award for Excellence in Innovation in Melbourne, May 2025.

FUTURE STEPS

Detailed technoeconomic calculations as well as pilot-plant design and costing are also being advanced to develop a robust upscaling and commercialisation of the BALIO process for iron producers and steelmakers.

WATCH DR HOCKADAY EXPLAINING THE PROJECT:

All project partners came to Adelaide in May 2025 for a face-to-face meeting to establish plans and priorities.

PROJECT UPDATE

RP1.013: ALUMINA REFINERIES' NEXT-GENERATION TRANSITION (ALUMINEXT™) PROJECT

Project leader:	Associate Professor Woei Saw, The University of Adelaide
Project partners:	The University of Adelaide, CSIRO, The Australian National University, South32, Hydro, Emirates Global Aluminium, Worley, Calix, Minerals Research Institute of WA, Rio Tinto, SysCAD, Energy Exemplar, 1414 Degrees
Industry:	Alumina
Commenced:	January 2025
Total project value:	$5,170,934 (cash and in kind)

Keep an eye on the AlumiNEXT™ webpage for our upcoming animated explainer video:

THE CHALLENGE

The RP1.013 AlumiNEXT™ project is working with industry to lower emissions in alumina refining – without loss of reliability or product quality – by retrofitting options in current assets and developing pathways to next-generation, net-zero refineries.

The focus is the two major emissions sources in alumina production: the Bayer process (in which the bauxite is converted to aluminium hydroxide), responsible for 60% of energy requirements; and calcination (the high-temperature step that turns aluminium hydroxide into alumina), which accounts for 30%.

PROJECT APPROACH

AlumiNEXT™ is designed to inform industry's decarbonisation decisions through comparative cost-benefit analyses, novel concepts development, case studies and performance models examining:

- development of optimised process configurations for low-carbon steam generation and recovery
- evaluation of partial electrification and thermal energy storage integration into existing refineries
- design and evaluation of innovative calciner configurations
- integration and technoeconomic evaluation of innovative, next-generation calcination and steam recovery designs.

OUTCOMES AND INDUSTRY IMPACT

The first priority for the team has been developing baseline models and parameters for low- and high-temperature refinery cases, giving producers comparable starting points to evaluate decarbonisation technologies and process designs. The research team is working with SysCAD on the reference refinery process models – a simulation tool co-designed with partners to test decarbonisation options and understand plant-wide impacts. Model outcomes will be combined with cost databases for both conventional and novel equipment to inform technoeconomic modelling.

A key milestone was the AlumiNEXT™ face-to-face meeting in Adelaide in May 2025. All research and industry partners came together to agree on priorities and identify complementary research initiatives. As Project Leader Dr Woei Saw noted, building the relationships and shared understanding is essential to move from models to industry adoption.

"AT THE END OF THE DAY, OUR COMPANIES FACE THE SAME DECARBONISATION CHALLENGES... BY WORKING COLLABORATIVELY, THROUGH ALUMINEXT, WE CAN OPTIMISE A LOT OF DEVELOPMENT AND SPEED UP THE PROCESS."

– Emilio Pai, Emirates Global Aluminium

FUTURE STEPS

The project team is focused on finishing the reference refinery models, delivering costed transition scenarios across multiple geographies and advancing laboratory-scale designs for low-carbon calciners and steam-recovery integrations that are ready to scale.

The program will continue to align with energy infrastructure work through project RP3.007 and thermal energy storage work through RP2.017 so that technology choices and energy supply decisions progress together.

Project Leader Dr Woei Saw.

Yarwun Alumina Refinery in Gladstone, Queensland.

The ZESTY pilot plant at Calix in Bacchus Marsh, Victoria.

CASE STUDY

ZESTY: FAST-TRACKING GREEN IRON FROM AUSTRALIAN ORES

RP1.009: TESTING OF AUSTRALIAN IRON ORES IN A HYDROGEN DIRECT FLASH SMELTING PROCESS

RP1.015: DE-RISKING FLASH REDUCTION OF AUSTRALIAN IRON ORES

Project leaders:	Professor Geoff Brooks, Swinburne University of Technology (RP1.009) Dr Shabnam Sabah, Swinburne University of Technology (RP1.015)
Project partners:	Swinburne University of Technology, Calix, The University of Adelaide, Grange Resources, Hancock Iron Ore, OneSteel Manufacturing (both projects); Fortescue Metals Group (RP1.009)
Industries:	Iron and steel
Timeline:	RP1.009: June 2023 – August 2024 RP1.015: commenced February 2025
Total project value:	RP1.009: $574,693 (cash and in kind) RP1.015: $1,118,814 (cash and in kind)

THE CHALLENGE

Hydrogen direct reduced iron (H_2-DRI) is emerging as a leading alternative to decarbonise steel production and hence meet net-zero goals. But integrating Australian ores – which are often rich in silica – into H_2-DRI technologies presents unique hurdles, from ore compatibility to cost-effective processing.

FLASH REDUCTION OF IRON ORES

Calix's Zero Emissions Steel Technology (ZESTY) is a novel flash reduction process built on Calix's patented electric flash calciner platform.

In ZESTY, fine iron ore particles fall through a vertical reactor heated indirectly by renewable electricity. Hydrogen is introduced in a counter-flow, acting as a reductant rather than fuel. The hydrogen reacts with the oxygen, reducing ore to metallic iron at lower temperatures than a blast furnace.

ZESTY's flexible operation enables it to take advantage of renewable energy when it is cheapest and avoids the need for expensive pelletisation, which is often unsuited to Pilbara ores.

"THE R&D WORK UNDERTAKEN TO DATE HAS BEEN INVALUABLE FOR THE ZESTY TECHNOLOGY. WE LOOK FORWARD TO CONTINUING TO WORK WITH OUR PARTNERS ACROSS THE IRON AND STEEL VALUE CHAIN AS WE TAKE THE TECHNOLOGY TO DEMONSTRATION SCALE."

– Chris Ormston, Calix Limited

PROJECT APPROACH AND OUTCOMES SO FAR

HILT CRC has been working with Calix to develop and de-risk ZESTY for Australian ores.

Project RP1.009 tested Australian iron ores in Calix's fully electric pilot plant at Bacchus Marsh, Victoria, which was modified to enable flash hydrogen direct reduction. The project team reduced a range of hematite-goethite and magnetite ores under varying conditions, measuring metallisation, throughput, energy use and product quality.

The RP1.009 trials demonstrated up to 95% metallisation for hematite-goethite ores in the ZESTY reactor, validating the process's potential. Small particles (under 200 µm) demonstrated the highest metallisation.

Testing of silica-rich ores yielded valuable insights into the complex interactions between iron and gangue phases and their effect on metallisation. These findings are being further investigated in RP1.015. Magnetite required further treatment, pointing to pre-oxidation as a possible solution.

Economic analysis has illustrated the commercial promise of ZESTY, showing that estimated costs are potentially competitive with other DRI methods, with further opportunities to reduce costs through reactor optimisation and productivity improvements.

RP1.015 is taking the next step, de-risking the ZESTY technology by addressing challenges identified in RP1.009. The project is:

- investigating the complex reaction pathway, including side reactions with gangue impurities in low-grade ores, and testing strategies to maximise metallisation
- exploring options to improve magnetite performance, with pre-oxidation as one potential pathway
- examining how hematite and goethite respond to different hydrogen concentrations and residence times, refining understanding of reduction kinetics
- applying particle tracking and advanced modelling to improve reactor design and efficiency.

INDUSTRY IMPACT

These projects have directly supported Calix's commercialisation pathway. The Front-End Engineering and Design study for a demonstration plant was informed by the outcomes of RP1.009. Subsequently, in July 2025, the Australian Renewable Energy Agency (ARENA) awarded $44.9M to Calix to build a 30,000-tonne-per-annum ZESTY demonstration plant. Providing up to 50% of the project budget, the grant is subject to matched contributions and key project milestones being achieved.

"IT TOOK CENTURIES TO OPTIMISE THE BLAST FURNACE. THROUGH THESE PROJECTS, WE CAN DE-RISK ZESTY IN YEARS, NOT DECADES."

– Prof Geoff Brooks, Swinburne University of Technology

The new facility will produce low-carbon DRI and hot briquetted iron and test flexible operation matched to renewable energy supply. It will be a highly significant step in demonstrating the performance and viability of the ZESTY technology for upgrading Pilbara ores in the emerging global green steel market.

RP1.009 melting experiment.

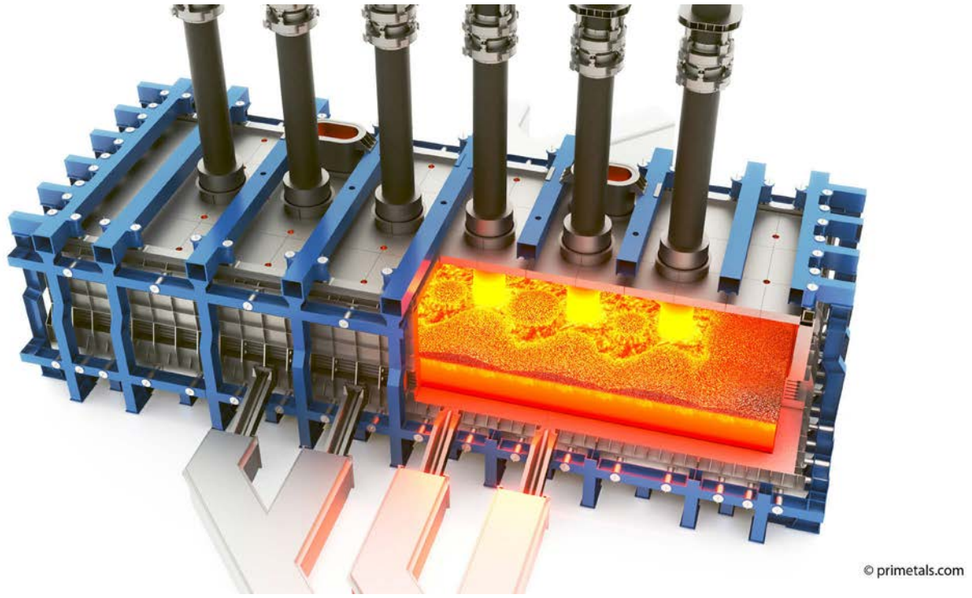
Dr Sabah receiving a HILT Award for RP1.009 from Research Director Prof. Gus Nathan and CEO Jenny Selway.

FUTURE STEPS

RP1.015 will help inform iron ore producers and steelmakers of the benefits and risks of the ZESTY technology. It will complement and inform Calix's demonstration plant by:

- extending ore assessments to evaluate ZESTY compatibility and performance, with an emphasis on low-grade, high-gangue-containing ores
- building flash reduction-kinetics models for hematite/goethite
- optimising magnetite performance
- determining residence-time requirements
- validating particle behaviour for plant design.

In parallel, Calix will be progressing their plans to build the ZESTY demonstration plant, including finalising the location for the facility and the associated service and utilities.



CASE STUDY

AUSTRALIAN ORES IN ELECTRIC SMELTING FURNACES

RP1.014: DE-RISKING ELECTRIC SMELTING FURNACES FOR AUSTRALIAN ORES

Project leader:	Professor Geoff Brooks, Swinburne University of Technology
Project partners:	Swinburne University of Technology, CSIRO, Grange Resources, Fortescue, Hancock Iron Ore, OneSteel Manufacturing, Calix, Minerals Research Institute of WA, Primetals Technologies
Industries:	Iron and steel
Commenced:	September 2024
Total project value:	$1,583,426 (cash and in kind)

THE CHALLENGE

Two of HILT's completed projects, RP1.004 and RP1.005, demonstrated that for many low-quality Pilbara ores, dealing with impurities in an electric smelting furnace (ESF) is potentially a more economic pathway to green iron and steel than alternative technologies. However, these projects recommended that further research was needed to validate the performance, energy usage and slag characteristics of Australian ores in ESFs. Project RP1.014 will inform these requirements.

PROJECT APPROACH

This project uses a combination of modelling, laboratory testing and pilot-scale trials to de-risk the use of Australian ores in ESFs through:

- thermodynamic modelling to predict energy use and metal and slag chemistry across a wide range of ore qualities
- heat transfer and smelting models to assess how different direct reduced iron (DRI) forms (fines, briquettes, pellets) behave under ESF conditions
- high-temperature experiments to validate models, examining productivity, slag chemistry and energy needs
- using pilot and full-scale ESF data from partners to refine the models
- technoeconomic analysis that expands earlier models to deliver cost and risk assessments specific to Australian ores.

PRIMETALS TECHNOLOGIES IS COMMITTED TO DEVELOPING AND INDUSTRIALISING THIS BREAKTHROUGH TECHNOLOGY, AND THROUGH OUR JOINT FUNDAMENTAL R&D EFFORTS IN THIS PROJECT, WE ARE ESTABLISHING A SOLID FOUNDATION FOR FUTURE FULL-SCALE PLANT DEPLOYMENT AND OPTIMISATION."

– Gerald Wimmer, Vice President Converter Steelmaking, Primetals Technologies

OUTCOMES AND INDUSTRY IMPACT

The project has already delivered important knowledge. Thermodynamic modelling has clarified how ore chemistry, gangue content and operating conditions affect both hot metal quality and slag properties, pointing to operating windows that maximise efficiency and yield.

Heat-transfer modelling is giving industry new insight into how brush arc dynamics influence productivity, scale-up potential and energy efficiency. The early results suggest that the properties of the slag are crucial to the productivity of the process. Small-scale high temperature experiments (at 1500°C) have commenced using commercially available DRI products to validate the heat transfer models being developed.

By producing this kind of fundamental data and system-level insights, this project will reduce uncertainty around Australian ores in ESFs and provide companies with credible evidence to inform their activities.

"WITH A COMBINATION OF MATHEMATICAL MODELLING, LABORATORY AND LARGER-SCALE TESTING, WE'RE HOPING TO DE-RISK ELECTRIC SMELTING FOR THE AUSTRALIAN IRON-ORE INDUSTRY."

– Professor Geoff Brooks, Swinburne University of Technology

Project Leader Prof. Geoff Brooks.

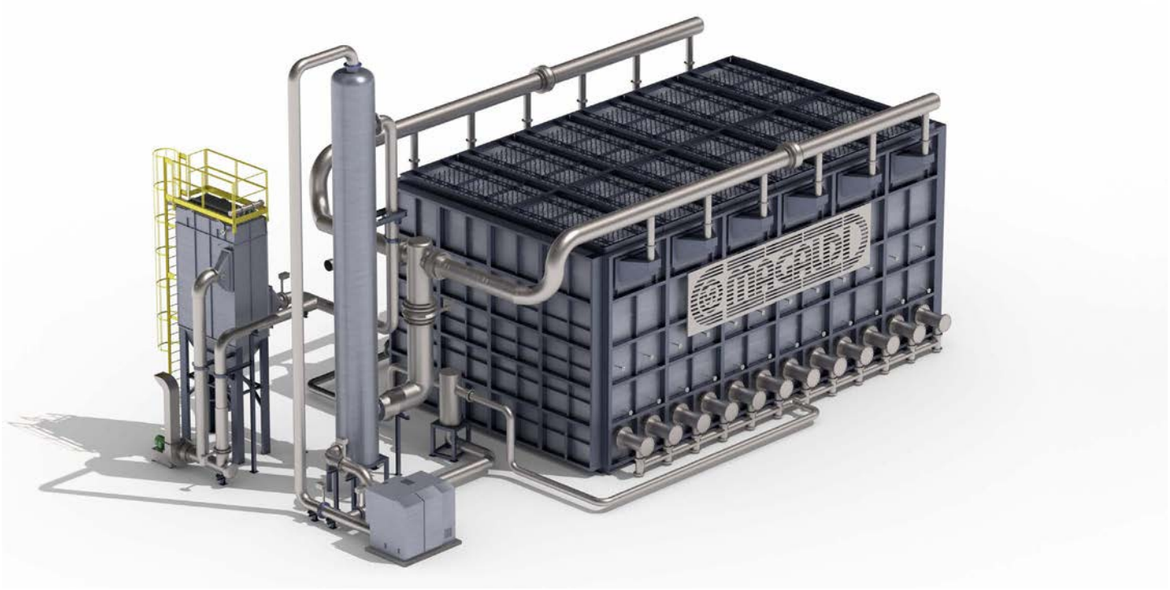
FUTURE STEPS

The project plan will continue with further thermodynamic and heat transfer modelling, high-temperature laboratory trials to test productivity and slag quality, and technoeconomic calculations tailored to Australian ores.

"Many people think ESFs are going to replace the blast furnace in the transition to green steelmaking," Prof. Brooks says. "It is crucial to Australia's iron ore industry that we can help them show their ores work in this technology."

By the project's completion, industry will have:

- validated models predicting how Australian ores perform in ESFs
- clarity on productivity, energy use and slag applications
- a technoeconomic basis for ESF decisions.



CASE STUDY

THERMAL ENERGY STORAGE FOR HEAVY INDUSTRY

RP2.009 & RP2.017: ADVANCING THE VIABILITY OF HIGH-TEMPERATURE THERMAL ENERGY STORAGE FOR INDUSTRIAL APPLICATIONS, PHASES 1 & 2

Project leader:	Professor Joe Coventry, Australian National University (ANU)
Project partners:	ANU, CSIRO, The University of Adelaide, QUT, Hancock Iron Ore, Hydro, OneSteel Manufacturing, South32, Emirates Global Aluminium, Magaldi, 1414 Degrees, Primetals Technologies
Industries:	Alumina and aluminium Cement and lime Iron and steel
Timeline:	Phase 1 (RP2.009): July 2023 to June 2024 Phase 2 (RP2.017): commenced October 2024
Total project value:	Phase 1: $924,324 (cash and in kind) Phase 2: $1,615,343 (cash and in kind)

THE CHALLENGE

Heavy industry is one of the largest users of heat. Thermal energy storage (TES) combined with clean electricity from renewable energy sources offers a promising solution for reliable, low-cost, high-temperature heat. The challenge is to de-risk TES systems for integration into existing plants by showing they can operate at the conditions and scale heavy industry requires in technically robust and commercially viable ways.

PROJECT APPROACH

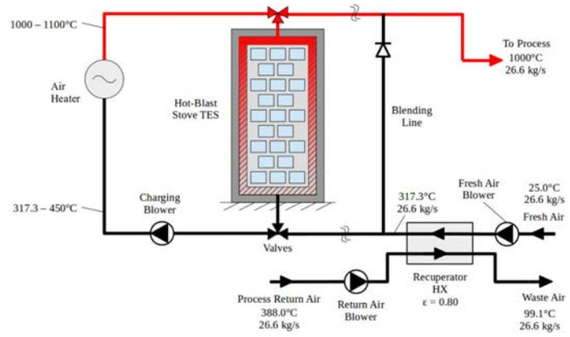
HILT CRC's TES program has taken a two-phase approach:

- RP2.009 conducted a scoping study of TES options and mapped them against industrial needs. The team reviewed a wide range of storage options, tested candidate materials in the lab and modelled how TES might integrate into real industrial processes. Case studies looked at alumina calcination and hydrogen-based direct reduced iron (H_2-DRI), two processes where energy use is both large and costly.
- RP2.017 is expanding the work from RP2.009 to medium- and high-temperature use cases (up to ~1200°C), developing detailed process models, laboratory and pilot-scale testing, and technoeconomic assessments for alumina, steel and cement.

Phase 1 surveyed TES options – molten salts, packed beds and particle-based systems – and built the first hot blast stove (HBS) storage model, validating it against operational data. It also ran lab tests on high-temperature behaviour and materials handling.

"WE THINK THE POTENTIAL FOR INTEGRATING THERMAL ENERGY STORAGE INTO BOTH EXISTING AND NEXT-GENERATION ALUMINA REFINERIES IS VERY HIGH."

– Professor Joe Coventry, ANU



Flow sheet showing how a hot blast stove TES system supplies 1000°C hot air to an alumina calcination process (Coventry et al.*, 2024).*

Phase 2 is deepening the HBS adaptation (e.g. real brick geometries, insulation design, airflow/pressure-drop limits) and adding cycling/durability testing of checker bricks – heat-resistant ceramic blocks stacked in a lattice inside HBS units that store heat during firing and release it to air during blowing – while extending the modelling to annual simulations and technoeconomic assessments of cost, reliability and integration with variable renewable power.

What sets this project apart is its scope: from fundamental material behaviour under thermal cycling, through to full supply chain economics, the project is building the evidence industry needs to decide whether TES can be part of their decarbonisation toolkit.

OUTCOMES AND INDUSTRY IMPACT

The research shows that TES can be both technically and commercially credible for heavy industry:

Technical feasibility

Laboratory and modelling work has confirmed that candidate TES materials can withstand repeated cycling, with sticking and flowability limits mapped. In steelmaking, HBS models were validated against full-scale operational data; in alumina, retrofit options were benchmarked against partner refinery conditions. These results give confidence that TES can work in practice, not just in theory.

Process integration

Integration studies in RP2.009 mapped out specific options, from TES supplying pre-heated ore and hydrogen in H_2-DRI, to retrofit configurations in alumina calcination and steam generation. Work in RP2.017 has refined these concepts, showing how design choices influence efficiency and practicality.

Commercial opportunity

Calculations undertaken in both projects have demonstrated that although heat from electricity combined with TES is not yet cheaper than natural gas under current Australian conditions, it does reduce fossil fuel use, cut emissions and provide flexibility for round-the-clock renewable heat. This provides opportunities to mitigate future exposure to price fluctuations in gas markets and policy shifts.

Collaboration

The TES projects depend on deep collaboration between industry and research. "There's a sense among industry partners that the decarbonisation of the alumina sector is not something that can be tackled by one company alone; it has to be done in partnership," says Professor Coventry. "There's great collaboration and sharing of information and there's no question that researchers can't ask."

Together, the validated HBS component model, annual system simulations and partner-benchmarked alumina retrofit scenarios support progress towards a TES demonstration plant.

FUTURE STEPS

RP2.017 will continue adapting HBS for long-duration TES with detailed modelling using real checker-brick geometries, insulation design and airflow/pressure-drop limits to keep operation within materials constraints. Annual system simulations will be used to quantify performance and costs under industrial conditions. It will also refine alumina retrofit assessments benchmarked to partner conditions, quantifying CO_2 abatement and integration trade-offs across retrofit options.

Ultimately, the project aims to support future pilot-scale deployment of TES in high-temperature industrial uses relevant to HILT partners.

Project Leader Prof. Joe Coventry.

CASE STUDY

POWERING HEAVY INDUSTRY WITH LOW-COST, 24/7 GREEN ELECTRICITY

RP2.014: LOW-COST RELIABLE GREEN ELECTRICITY SUPPLY FOR LOW-CARBON HEAVY INDUSTRY

Project leader:	Dr Bin Lu, Australian National University (ANU)
Project partners:	ANU, Hancock Iron Ore, South32
Industries:	Alumina and aluminium Cement and lime Iron and steel
Commenced:	March 2024
Total project value:	$174,430 (cash and in kind)

"TOGETHER WITH FLEXIBLE DEMAND AND GRID INTERACTION, 24/7 RENEWABLE ELECTRICITY CAN ACCELERATE THE LOW-CARBON TRANSFORMATION OF HEAVY INDUSTRY AND PROVIDE A COST ADVANTAGE FOR GREEN POWER."

– Dr Bin Lu, ANU

THE CHALLENGE

While solar and wind costs have fallen dramatically, their variability makes continuous supply costly. Adding storage such as batteries can smooth variability, but can more than double the price of electricity. For industries where energy can account for half or more of the production costs, that equation is unsustainable.

"For many heavy industry processes, you can't just stop when the sun sets or the wind drops," Project Leader Dr Bin Lu explains. "Interrupting production will lead to economic loss."

PROJECT APPROACH

This project developed a modelling framework to assess how heavy industry could integrate variable renewable electricity.

Unlike typical models that examine a single year or a narrow set of assumptions, this framework simulates energy supply-demand balance on an hourly basis over a typical project lifetime (25 years). It co-optimises generation, transmission and storage producing a realistic long-term view of cost dynamics.

The project combined:

- high-resolution energy modelling, including solar, batteries, grid connectivity and load flexibility
- geographic information system (GIS) analysis across Western Australia's Pilbara, Mid West and South-West regions to map renewable resources
- scenario testing of baseline vs optimised cases, balancing local generation with grid interactions
- demand-response mechanisms, showing how flexible industrial loads can further cut costs.

By modelling these systems under multiple scenarios, the project provides a comprehensive costed roadmap for green electricity supply tailored to heavy industry.

OUTCOMES AND INDUSTRY IMPACT

The modelling shows that heavy industry can achieve cost savings with integrated renewable electricity systems.

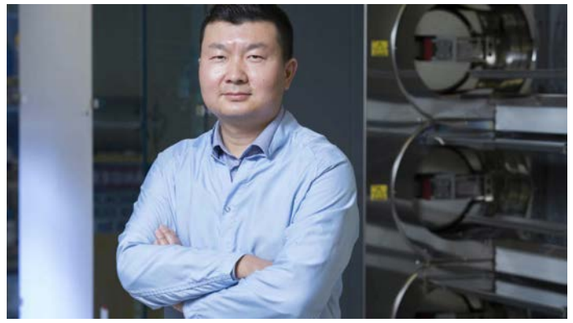
The project's key findings include:

- On-site solar photovoltaics (PV) and lithium-ion batteries can support continuous operations while delivering significant emission reductions.
- When the cost of emissions ($80–$420/t CO_2-e over time) suggested by the Australian Energy Market Commission (AEMC) are added to the cost of natural gas-fired power, solar and battery electricity systems offer a more cost-effective green alternative.
- Connecting to the grid and optimising load profiles can further lower electricity costs and enhance system reliability, supporting practical zero-emission transitions in heavy industry.

According to the model, adding grid interaction strategies is predicted to reduce costs by a further 23-42%. Incorporating flexible load management – adjusting demand to align with renewable availability – was calculated to deliver the greatest benefits, cutting cost to less than one-third of gas-fired power.

From an emissions perspective, PV and battery integration alone can cut emissions by 21-88% compared with gas-fired power. When grid interaction and demand flexibility are included, renewable penetration can rise to 100%, eliminating emissions entirely.

The algorithms, cost models and GIS data from this project will be made publicly available, allowing industry partners to use the modelling framework to test their own assumptions and scenarios.



Project Leader Dr Bin Lu.

SPOTLIGHT ON ENERGY

RP3.007: UNLOCKING INVESTMENT IN ENERGY INFRASTRUCTURE FOR NET-ZERO INDUSTRIAL HUBS

Project leader:	Dr Tara Hosseini, CSIRO

Affordable, reliable low-carbon energy at scale is a critical requirement for heavy industry decarbonisation. HILT is integrating findings from across our energy-related research in Programs 1, 2 and 3 to help address this.

RP3.007 will assess opportunities and optimal pathways for staged investments in electricity and gas infrastructure to support low-carbon energy at scale in key regional locations by 2050.

The work integrates bottom-up heavy industry demand modelling with energy supply options and storage, then evaluates policy settings and public–private co-investment options that can unlock de-risked projects.

Project outputs for industry partners include hub-specific energy demand projections, integrated system models, and investment pathways that support long-term contracting, infrastructure sequencing and competitiveness. The project will also assist government partners by estimating the level and timing of co-investment based on jobs, regional growth and emissions benefits – evidence to inform enabling policy and market design.

Interest in RP3.007 is exceptionally strong – it is one of HILT's largest collaborative projects, with 12 partners: CSIRO, Curtin University, Swinburne University of Technology, The Australian National University, Australian Energy Market Operator, The University of Adelaide, Grange Resources, Fortescue, South32, OneSteel Manufacturing, BlueScope and Energy Exemplar.

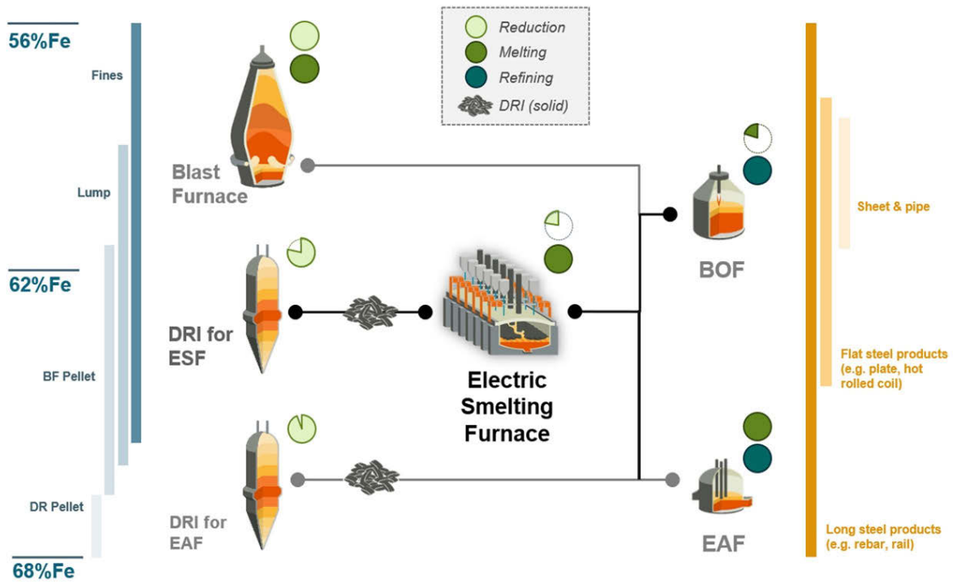


Illustration of blast furnace and direct reduction-based steel production routes (adapted from Gadd et al.*, 2023).*

CASE STUDY

POSITIONING AUSTRALIA FOR CHINA'S GREEN STEEL TRANSITION

RP3.004: INTERMEDIATE PRODUCT EXPORTS FOR AUSTRALIA–CHINA GREEN STEEL

Project leader:	Dr Jorrit Gosens, Australian National University (ANU)
Project partners:	ANU, Curtin University, Fortescue, Grange Resources, Hancock Iron Ore, OneSteel Manufacturing, Minerals Research Institute of WA
Industries:	Iron and steel
Commenced:	June 2023
Total project value:	$487,489 (cash and in kind)

THE CHALLENGE

China produces more than half of the world's steel and consumes over 80% of Australia's iron ore exports. This trade underpins Australia's resource economy. But as China starts using more scrap and transitions towards net-zero by 2060, its steel sector is expected to demand less ore and shift to hydrogen-based green steelmaking.

China's shift in ore demand raises fundamental questions:

- Will Australian ore – much of it low-grade hematite – remain competitive in green steel pathways?
- Should Australia continue exporting iron ore, or shift to value-added intermediate products such as pellets, ore-based metallics like hot briquetted iron (HBI), or smelted iron?
- How do hydrogen prices, technological developments, and policy settings alter the equation?

For industry and policymakers alike, it is crucial to identify Australia's best position in decarbonised steel supply chains.

"AS CHINA'S STEEL INDUSTRY DECARBONISES, AUSTRALIA'S EDGE SHIFTS FROM VOLUME TO VALUE. OUTCOMES OF THIS PROJECT SHOW HOW WE CAN CUT EMISSIONS AND GROW EXPORT REVENUES AT THE SAME TIME BY CHOOSING THE RIGHT INTERMEDIATE PRODUCTS AND THE RIGHT PLACES TO MAKE THEM."

– Richard Carcenac, Head of Green Metal Technology, Fortescue

PROJECT APPROACH

RP3.004 developed a technoeconomic optimisation model combining:

- process modelling to examine how ore composition affects energy use, flux demand, iron losses and emissions across different green steel routes
- global iron ore composition and production capacity, and iron ore, iron and steel production costs data
- sensitivity analysis to test how shifts in demand levels for green steel, relative hydrogen production cost, and production capacities of electric smelting furnaces (ESFs), alter competitiveness of different iron ore, green iron and steelmaking value locations.

Separately, the project assessed impacts on lifecycle greenhouse gas emissions across 14 supply chain scenarios.

In effect, the model helped examine a simple but critical question: What is the least-cost way to meet Chinese steel demand under different decarbonisation scenarios?

OUTCOMES AND INDUSTRY IMPACT

The results were clear: the relative cost of hydrogen production between Australia and China is a critical factor in determining the location of green iron production, and the development of ESF technology is decisive for the use of Australian low-grade iron ores.

The model predicted that if Australia can produce green hydrogen A$0.50/kg cheaper than China, green iron could be competitively produced in Australia, rather than in China.

The model also showed that the ESF is likely to be a pivotal technology for Australian Pilbara hematite-goethite ores. The model predicts that increasing global ESF capacity will increase the demand for Australian ore. ESFs enable the use of a wider variety of ores and hence, for green steelmaking, support the use of Pilbara hematite ores with higher gangue content – as demonstrated by HILT projects RP1.004 and RP1.005. This underscores the importance of project RP1.014's goal of de-risking ESFs for Australian ores (see the case study in this brochure).

Exporting intermediate products such as HBI or smelted iron could provide a transition pathway for Australian iron ores. By value-adding in Australia and reducing technical risk for Chinese buyers, intermediate exports could keep Australian ores competitive while China ramps up its own green steel capacity.

Project Leader Dr Jorrit Gosens.

"FOR PILBARA ORES TO BE COMPETITIVE IN CHINA GREEN STEEL VALUE CHAINS, OUR MODELLING HIGHLIGHTS THE IMPORTANCE OF A COMPETITIVE HYDROGEN PRICE RELATIVE TO CHINA, AND THE IMPORTANCE OF ESF TECHNOLOGY – THESE AREAS ARE WHERE POLICY NEEDS TO INTERACT."

– Dr Jorrit Gosens, ANU

The project also released a policy brief, 'Economic and emissions analysis of Australia-China green steelmaking value chains'.

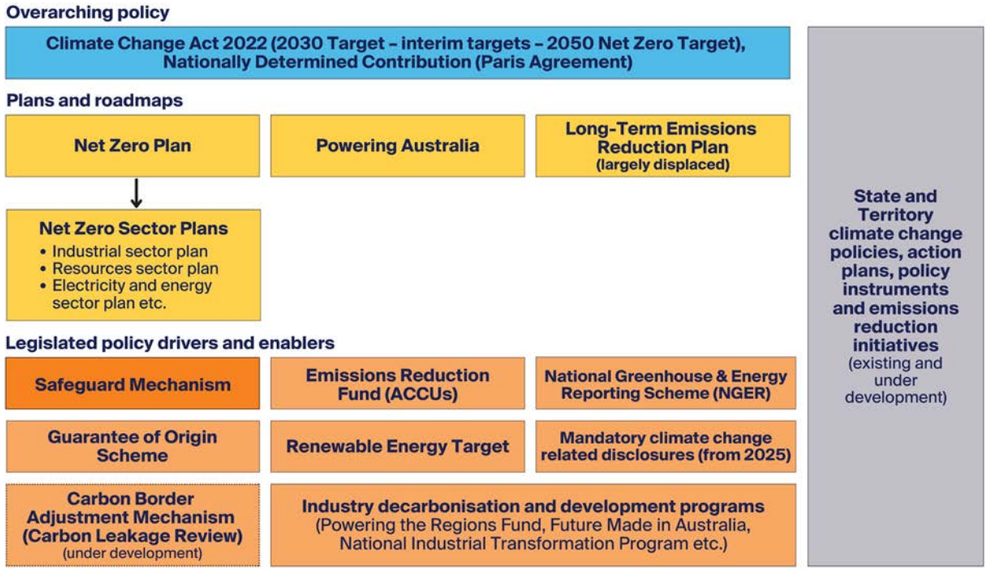
The insights generated by RP3.004 will help government identify policy levers – from hydrogen incentives to ESF demonstration support – that could help secure Australia's place in China's future green steel supply chains.

FUTURE STEPS

Work will continue in a follow-on project, RP3.009 Australian green iron exports: modelling global markets in a decarbonised steelmaking industry. This will expand analysis beyond China to key demand markets in Japan, Korea, India and the European Union, and key competitor regions in green iron supply in Latin America, the Middle East and North Africa.

The new project will also look at other Australian iron ore producing regions – such as Mid-West Western Australia, South Australia and Tasmania – to examine how local iron ore grades and renewable energy costs change the end-to-end processing cost to produce steel.

By integrating results from HILT CRC projects on beneficiation, smelting and hydrogen supply, RP3.009 is set to deliver the most comprehensive picture yet of Australia's future global competitiveness in iron ore and green iron.



Australia's climate change policy framework fundamentals (Kosturjak & Hancock, 2025).

CASE STUDY

NAVIGATING AUSTRALIAN POLICY PATHWAYS FOR INDUSTRIAL DECARBONISATION

RP3.008: A POLICY ROADMAP FOR AUSTRALIA'S HEAVY INDUSTRY LOW-CARBON TRANSITION

Project leaders:	Jim Hancock and Anthony Kosturjak, The University of Adelaide
Project partners:	The University of Adelaide, Australian National University, Queensland University of Technology, Fortescue, Hancock Iron Ore, OneSteel Manufacturing, South32, BlueScope Steel, Cement Industry Federation
Industries:	Alumina and aluminium Cement and lime Iron and steel
Commenced:	July 2024
Total project value:	$738,878 (cash and in kind)

THE CHALLENGE

Without stable and supportive policies for heavy industry decarbonisation, investment risks increase, projects may be delayed or abandoned, and carbon leakage risks (when production shifts to jurisdictions with weaker emissions reduction policies) intensify.

At the same time, international competitors are moving quickly. If Australia's policy frameworks do not provide sufficient clarity or incentives, Australian heavy industry risks losing competitiveness or seeing investment flow overseas.

PROJECT APPROACH

RP3.008 set out to provide industry with a clearer picture of the current and future policy landscape and options for policy reform.

The project team is:

- mapping federal, state and territory policies covering emissions reduction, industry development and energy. This includes the reformed Safeguard Mechanism, which directly regulates emissions from large industrial facilities, tightens emissions allowances over time, enables carbon credit trading and establishes a domestic carbon price for industry
- reviewing international approaches – e.g. the European Union's Carbon Border Adjustment Mechanism (CBAM) and the US Inflation Reduction Act – to highlight lessons for Australia
- identifying frictions and overlaps, such as Safeguard Mechanism policy settings with unintended consequences, competing emissions targets and approval bottlenecks
- identifying key barriers to heavy industry decarbonisation, including the limited commercial maturity of net-zero technologies and insufficient market willingness to pay a green premium for low-emissions industrial products
- engaging directly with stakeholders through workshops and consultations to test assumptions and co-design options
- developing policy reform pathways.

This approach ensures that the work is both rigorous and grounded in the practical realities faced by industry.

OUTCOMES AND INDUSTRY IMPACT

To date the project has delivered two working papers that map domestic and international policy landscapes and a synthesis report combining analysis and stakeholder insights.

One of the key themes to emerge is that Australia's policy environment is complex. Federal, state and territory governments have rolled out a mix of climate, energy and industry measures, but overlaps and inconsistencies create uncertainty and risk for companies considering long-term investment decisions.

In some areas, such as approvals processes and social licence for new energy projects, policy bottlenecks are slowing the pace of industrial transformation. In others, such as demand-side incentives, gaps remain. For example, there are few measures to encourage buyers to pay more for low-carbon products, leaving producers with limited signals that markets will reward decarbonisation.

The project's comparative analysis adds a global dimension. While Australia has made progress – tightening the Safeguard Mechanism and establishing the Powering the Regions Fund and Future Made in Australia initiative – international competitors may be moving faster. The European Union's Clean Industrial Deal and CBAM, Canada's investment tax credits, and Japan and Korea's targeted industrial decarbonisation programs are creating both incentives and markets.

Industry will be able to use the project's analyses to anticipate regulatory requirements and identify policy risks that could affect competitiveness. For policymakers, the work highlights priority options to encourage green metals production. These levers are not just about cutting emissions; they are about protecting Australia's competitive position in the global shift to green materials.

The broader message is that policy design will play a key role in determining Australia's competitiveness in a decarbonising global economy.

Collaboration

Collaboration is at the heart of the project. For example, a workshop in Canberra in August 2025 brought together more than 30 government and industry stakeholders. The workshop explored Australia's current policy settings, international comparisons and preliminary reform options, with feedback shaping the project's options paper.

This process demonstrates HILT CRC's unique role in convening diverse stakeholders and ensuring research outputs are not just analytical but also practical and actionable.

FUTURE STEPS

Professor Frank Jotzo (ANU) is developing a new work package within the project, which will quantify the economic impacts of policy instruments to support green commodity exports. These outputs will help industry navigate the policy environment and support governments in designing reforms that foster competitiveness while accelerating decarbonisation. The project will also deliver an options paper outlining reform pathways.

Project Co-Leader Jim Hancock.

Project Co-Leader Anthony Kosturjak.

"THIS PROJECT WILL HELP INDUSTRY PARTNERS GAIN A BETTER IDEA OF THE POLICY ENVIRONMENT AND IDEAS FOR HOW IT COULD BE IMPROVED, AND GIVE GOVERNMENTS RESOURCES TO DEVELOP GOOD POLICY THAT CAN BALANCE AT TIMES CONFLICTING DEMANDS AND OBJECTIVES."

– Jim Hancock, The University of Adelaide

COLLABORATIVE ECOSYSTEM

FORGING PRODUCTIVE AND ENDURING RELATIONSHIPS AND NETWORKS

HILT CRC works to forge collaboration among our industry, research and government partners to support the decarbonisation transition of the steel, iron, alumina and cement industries. We enable this by providing multiple opportunities for collaboration, including forums and roundtables, project workshops and meetings, webinars on industry and research updates, informal networking events and our annual conference.

HILT CRC Conference, Adelaide, October 2024.

"HILT'S INDUSTRY PARTNERS ARE EXTREMELY HELPFUL IN DEFINING THE NUANCE OF POLICY ISSUES THAT CONCERN THEM, AND WHICH RESEARCHERS ALONE MIGHT NOT SEE."

– Jim Hancock, The University of Adelaide and Co-Leader, project RP3.008

65+	**INDUSTRY, RESEARCH AND GOVERNMENT PARTNERS**
↑50%	**INCREASE SINCE LAUNCH**
25+%	**INTERNATIONAL PARTNERS**

"THE GROWTH OF HILT MEMBERS IS TESTAMENT TO THE POSITIVE COLLABORATIVE ENVIRONMENT."

– Alumina sector industry partner

THE HILT CRC ANNUAL CONFERENCE

HILT CRC's 3rd Annual Conference brought together research, industry and government partners in Adelaide to connect and discuss our activities and progress in helping heavy industry's transition to a low-carbon future.

Highlights included:

- more than 150 delegates, 100% satisfied to extremely satisfied
- presentation of HILT CRC's inaugural award winners in 3 categories
- confirmation of HILT CRC's research focus on fundamentals to de-risk transitional technologies and develop transformational technologies to support and accelerate deployment by HILT's industry partners.

HILT CRC Conference, Adelaide, October 2024.

VIEW THE 2024 CONFERENCE VIDEO:

HILT CRC Conference, Adelaide, October 2024.

Bioenergy project (RP2.012) team members visit Grange Resources in Tasmania.

CEO Jenny Selway with HILT CRC project leaders Dr Shabnam Sabah (Swinburne, left) and Dr Tara Hosseini (CSIRO), and PhD student Dian Fellicia (Swinburne, right).

HILT Research Director Prof. Gus Nathan (centre) at Hydro in Brazil with Refinery General Manager Sergio Ferreira (right) and research engineer Lia Lima (left).

HILT CRC AWARDS

Presented at our annual conference, the HILT CRC Awards recognise and celebrate the significant achievements of our researchers, including postgraduate students.

The 2024 winners were:

- Best contribution to industry-research collaboration: Swinburne University for Project RP1.009
- Best contribution to de-risking and accelerating decarbonisation: Dr Tara Hosseini, CSIRO for Project RP2.006
- Best contribution to research quality: The University of Adelaide, Curtin University and ANU for Projects RP1.008 and RP1.011.

Drs Alfonso Chinnici (RP1.008) and Lina Hockaday (RP1.011) receiving their joint HILT Award from Gus Nathan and Jenny Selway.

Chris Cooper from ANU receiving the award for best PhD presentation at the 2024 HILT conference.

TRUSTED VOICE

USING RESEARCH-BACKED FINDINGS TO INFORM STAKEHOLDERS AND FACILITATE TRANSFORMATION

HILT CRC strives to be a trusted voice to inform government, combining evidence-based research with broad stakeholder engagement.

We regularly lodge formal submissions to key Australian federal and state government consultations and run a coordinated program of briefings with government agencies to inform them of our project outputs. We have provided advice on topics such as Future Made in Australia, the Green Iron Investment Fund, the Industrial Net-Zero Plan, and the Australia/China Policy Dialogue on Steel Decarbonisation.

We also undertake and translate research to inform government and other key stakeholders through public webinars, reports and events. HILT's trusted voice is a key element of our Program 3: Facilitating Transformation, which identifies the policy, market and infrastructure enablers needed to scale and adopt low-carbon technologies.

HILT is also collaborating with CSIRO to oversee the $10-million Green Metals Innovation Network, which was launched in 2025.

CSIRO Chief Executive Dr Doug Hilton, Minister for Industry and Innovation Tim Ayres and CEO Jenny Selway at CSIRO's Waite campus for the GMIN launch in June 2025.

CEO Jenny Selway joined Prime Minister Anthony Albanese MP and then Minister for Industry and Science Ed Husic MP at Curtin University in March 2025 for the announcement of $750 million in Future Made in Australia funding to advance innovation in green metals.

HILT researcher Dr Hina Aslam (ANU) leads discussions at a green iron workshop hosted by the World Economic Forum and Greenhouse in Adelaide in August 2025.

HILT staff and researchers are regularly invited to present at major research and industry events, in Australia and overseas. Recent events with HILT representation include United Nations Climate Change Conferences (COP 28 & 29); the Australian Green Iron & Steel Forum; The Minerals, Metals & Materials Society (TMS) Annual Meeting & Exhibition (USA); International Alumina Quality Workshops (UAE); High Temperature Minerals Processing (HiTeMP) Forums; The South East Asia Iron and Steel Institute (SEAISI) Conference & Exhibition (Indonesia); and green metals discussions at the Osaka 2025 World Expo (Japan).

NET-ZERO INDUSTRIES MISSION

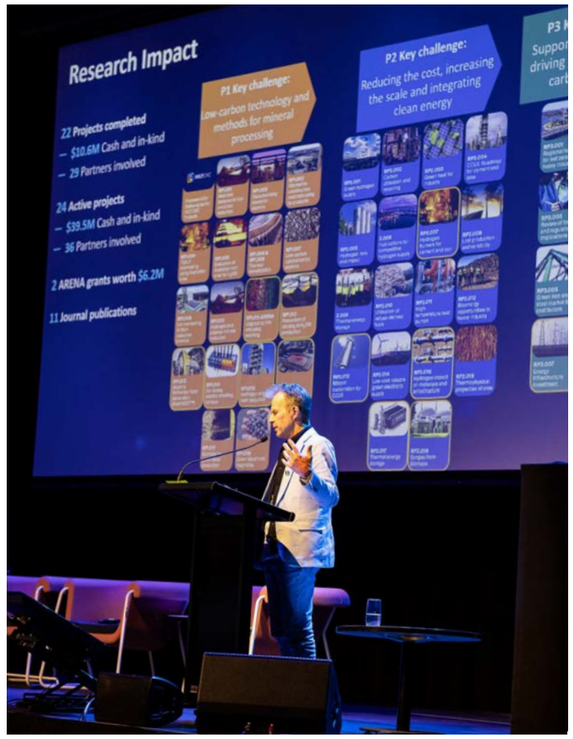
Since July 2022, HILT CRC has facilitated Australia's co-leadership of the Net-Zero Industries Mission with Austria, funded through Department of Climate Change, Energy, the Environment and Water.

One of NIM's primary functions is to foster global knowledge sharing and relationship building. NIM has published detailed information for over 20 technology demonstration projects and negotiated partnerships with:

- over 15 international organisations including the International Renewable Energy Agency, International Energy Agency, United Nations Industrial Development Organization, Worldsteel, World Economic Forum and Global Cement and Concrete Association
- 7 countries – Australia, Austria, Canada, China, Finland, Germany, South Korea and the UK – and the European Union.

NIM has published five white papers to date, with the most recent outlining how artificial intelligence (AI) can support the development and use of technology databases that accelerate decarbonisation in heavy industry.

SA Minister for Energy and Mining Tom Koutsantonis MP at the 2024 HILT Conference in Adelaide.



HILT Research Director Prof. Gus Nathan delivering a keynote address at the State of Energy Research Conference 2025 in Sydney, July 2025.

"I LIKE THE DIRECTION THAT HILT HAS TAKEN IN LISTENING TO THE INDUSTRY VOICES ABOUT WHAT THE REQUIREMENTS ARE TO DECARBONISE, INCLUDING THE RENEWED ENERGY AND FOCUS ON PROGRAM 3."

– Iron/steel sector industry partner

GOVERNMENT SUBMISSIONS

HILT has contributed 9 government submissions to date, including:

- Green metals: Unlocking Australia's green iron, steel, alumina and aluminium opportunity
- Australia's Carbon Leakage review
- AEMO Draft 2025 Inputs, Assumptions and Scenarios Report

UPSKILLING THE WORKFORCE

TRAINING PROGRAMS TO SUPPORT A LOW-CARBON HEAVY INDUSTRY

HILT's postgraduate student cohort at the inaugural student retreat in Hahndorf, SA, October 2024.

HILT CRC's Education & Training Program aims to be a major catalyst for equipping Australia's future workforce with the skills required to adapt to low-carbon technologies, processes and markets. We provide opportunities to both retain expertise in industry and attract new entrants. We do this by:

- providing postgraduate support and industry internships
- providing funding for relevant academic coursework for masters and undergraduate students, and undergraduate scholarships
- providing professional development to HILT partners
- disseminating research results through webinars and conferences.

The program takes advantage of our highly innovative environment, building capacity for innovation and leadership. To date, HILT CRC has:

- appointed 28 active postgraduate students
- brokered 3 industry internships
- awarded 10 coursework grants, with 5 programs completed
- delivered more than 50 webinars on relevant research, technology and policy.

"I LEFT ENRICHED WITH KNOWLEDGE AND INSPIRED TO TRANSLATE THAT KNOWLEDGE INTO ACTION WITHIN MY ROLE AT CSIRO."

– Participant from HILT CRC's Decarbonisation Routes for Steel short course (Adelaide, 26-27 August 2024)

"THE PHD STUDENT INTERNSHIP PROGRAM HAS BEEN HIGHLY SUCCESSFUL, PROVIDING INVALUABLE INFORMATION WHILE FOSTERING TALENT DEVELOPMENT."

– HILT industry partner

Prof. Geoff Brooks presented HILT CRC's Decarbonisation Routes for Steel short course to SA Government personnel in Adelaide, August 2025.

28 **ACTIVE POSTGRADUATE STUDENTS**

10 **COURSEWORK GRANTS AWARDED**
Five programs completed

4 **GREEN METALS SHORT COURSES HELD**
3 x steel; 1 x alumina; >150 attendees

3 **INDUSTRY INTERNSHIPS COMPLETED**

INDUSTRY SHORT COURSES

HILT CRC has delivered short courses on Decarbonisation Routes for Steel and Low-Carbon Alumina Production to provide industry and government professionals with the latest knowledge and practical tools for decarbonisation.

The green steel course, led by Professor Geoff Brooks (Swinburne University of Technology) has been held in Adelaide (twice) and Perth. Geoff's outstanding communication skills kept the diverse group of attendees highly engaged and garnered unanimously positive feedback.

The low-carbon alumina course, delivered by Gus Nathan and Woei Saw (The University of Adelaide) and David Cochrane (formerly South32) has been held in Perth and is scheduled for December 2025 in Brisbane.

Prof. Gus Nathan presenting at the Perth alumina short course.

"EXTREMELY USEFUL FOR INDUSTRY, ACADEMIC AND TECHNOLOGY COMPANY REPRESENTATIVES ALIKE."

"MOST RELEVANT FOR OUR BUSINESS AND TECHNOLOGY."

– Participants from HILT CRC's Low-Carbon Alumina Production short course (Perth, 8-9 September 2025)

CEO Jenny Selway presenting at the 2024 HILT student retreat.

COURSEWORK DEVELOPMENT GRANTS

HILT CRC provides financial support for the development of coursework materials for VET, undergraduate and postgraduate levels through the HILT CRC Coursework Grant Program.

Courses developed or supported through the program include:

- Masters in Renewable Energy, Renewable Energy Systems Major – Queensland University of Technology
- Decarbonisation of Metallurgical Processes – The University of Adelaide
- Carbon Capture and Storage in Geological Formations – The University of Adelaide
- Decarbonisation Case Study, 3D Scan and Learning materials for incorporation into Apprenticeship programs for Electricians, Instrumentation & Control Technicians, Mechanical Fitter – TAFE SA
- Decarbonisation in Process Engineering – Queensland University of Technology
- Systems Engineering and Industry Practice (SEIP); Renewable Power Technology (RPT); and Business Management Systems (BMS) – The University of Adelaide.

HILT CRC COURSEWORK DEVELOPMENT GRANT CASE STUDY

TEACHING MATERIALS FOR NET ZERO: SWINBURNE'S HEAVY-INDUSTRY VIDEO SERIES

SWINBURNE UNIVERSITY OF TECHNOLOGY

LEAD COURSEWORK DEVELOPER: DR SHANTI KRISHNAN

"DESIGNED FOR DIVERSE AUDIENCES, INCLUDING STUDENTS, INDUSTRY PROFESSIONALS AND EDUCATORS, THESE VIDEOS INTEGRATE INNOVATIVE, REAL-WORLD RESEARCH TO MOTIVATE AND EMPOWER STUDENTS, SUPPORTING BOTH TRADITIONAL CLASSROOM LEARNING AND INDUSTRY UPSKILLING INITIATIVES."

– Dr Shanti Krishnan

Supported by a HILT CRC Coursework Development Grant, Swinburne University of Technology has developed a series of four 30–40-minute video modules on key decarbonisation themes – green steel, green construction, mineral recycling and digitalisation in net-zero engineering – delivered by leading experts including Professors Geoff Brooks, Akbar Rhamdhani and Jay Sanjayan, and Dr Shanti Krishnan.

Designed to engage mechanical and civil engineering students, the videos – produced by Media, Film and TV students from Swinburne – combine expert commentary, storytelling, lab visits and real-world challenges to illustrate sustainable engineering approaches. The content has also been shared publicly to broaden its reach and impact.

"This grant has been essential for producing high-quality professional videos and bringing together leading academics, researchers and industry experts to develop cutting-edge educational content," Dr Krishnan said.

"The HILT CRC-Swinburne partnership facilitated access to world-class expertise, advanced facilities and in-house resources, empowering our talented Film and TV HDR students to produce these videos under expert supervision."

The course materials will reach an estimated 300 students per year. By ensuring that the learning experience is highly industry-relevant, the project supports HILT CRC's mission to develop a future workforce ready to lead the low-carbon transition.

VIEW THE COURSE VIDEOS:

CURTIN UNIVERSITY–HILT CRC ENGINEERING SCHOLARSHIPS

In 2025, HILT CRC established scholarships with Curtin University to support engineering students with an interest in green metals and decarbonisation of heavy industry, and to develop a cohort of decarbonisation leaders for Australia's future workforce.

The scholarships are open to domestic students in eligible engineering disciplines including mining, metallurgical, chemical, energy, mechanical and electrical engineering.

Initially, up to four scholarships were to be made available, each valued at $3,750 per semester for up to two years (maximum $15,000). However, after receiving more than 60 applications, HILT and Curtin awarded five students: Jiun Wei Cheong, Kai Dunne, Nikita Ghorpade, Caitlin Oh and Fransiskus (Rio) Widjaja.

PUBLICATIONS

JOURNAL PAPERS

2024

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.

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

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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).

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Wang R, Purohit S, Paymooni K, Honeyands T. 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.

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Lewis E, Wetzler Z, Li G, Saw W, Nathan G, Kennedy E, Stockenhuber M, Oliver T, Chinnici A. Thermal treatment of lizardite for mineral carbonation using high flux radiation, Fuel, Volume 386, 2025, 134187.

Lin Y, Lee L, Lewis E, Cook N, Saw W, Nathan GJ, Chinnici A. Thermally Assisted Beneficiation of Low-Grade Iron Ore Powder: Influence of Heating Rate on Upgrade, Microstructure, and Mineralogy. Metall Mater Trans B (2025).

Mokhtarani B, Jafarian M, Sabah S, Dufty T, Brooks G, Saw W, Chinnici A, Graham NJ. New Insights Into Hydrogen Reduction of Hematite in an Indirectly Heated Flash Reactor from Measurements and First-Order Modeling. Metall Mater Trans B (2025).

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Purohit S, Pownceby MI, Guiraud A. Sticking and Swelling of Iron Ore Pellets: Mechanisms and Controlling Factors. J. Sustain. Metall. 11, 67–87 (2025).

Rahbari A, Shahabuddin M, Sabah S, Brooks G, Pye J. Production of green steel from low-grade ores: An end-to-end techno-economic assessment. Cell Reports Sustainability. 2025; Volume 2, Issue 1.

INDUSTRY BRIEFS

RP3.006

What are embedded emissions accounting frameworks (EEFS)? (August 2024)

The Australian Government's Guarantee of Origin (GO) Scheme (August 2024)

RESEARCH REPORTS

RP3.006

Policies and regulatory drivers of embedded emissions accounting for Australian heavy industry low-carbon transition: The case of the iron and steel sector

Mapping embedded emissions accounting frameworks for heavy industry low-carbon transition: The case of iron and steel

Policies and regulatory drivers of embedded emissions accounting for aluminium and cement's low-carbon transition

Mapping embedded emissions accounting frameworks for aluminium and cement's low-carbon transition

GOVERNMENT SUBMISSIONS (PUBLIC)

Australian Energy Market Operator (AEMO) Draft 2025 Inputs, Assumptions and Scenarios Report (Stage 2 – March 2025)

Australian Energy Market Operator (AEMO) Draft 2025 Inputs, Assumptions and Scenarios Report (Stage 1 – February 2025)

Senate Economics Legislation Committee – Future Made in Australia (Production Tax Credits and Other Measures) Bill 2024 (January 2025)

Australian Government's 2nd consultation on Australia's Carbon Leakage Review (December 2024)

Tasmanian Government's Emissions Reduction and Resilience Plan for Tasmania's Industrial Processes and Product Use Sector (October 2024)

Australian Government's Consultation Paper on 'Green Metals – A Future Made in Australia: Unlocking Australia's Green Iron, Steel, Alumina and Aluminium Opportunity' (July 2024)

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

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