HILT CRC

Australian Government
Department of Industry, Science and Resources

Cooperative Research Centres Program

HDR PROJECT SUMMARY

DE-RISKING FLUIDISED BED HYDROGEN IRONMAKING: EXPERIMENTAL STUDIES, REDUCTION KINETICS, AND TECHNO-ECONOMIC EVALUATION

SUPERVISOR

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PROJECT PARTNER

The Australian National University (ANU)

PROJECT TYPE

PhD

DATE ADVERTISED

August 2025

HDR PROJECT DESCRIPTION AND MOTIVATION

As the global steel industry moves toward low-emission production pathways, hydrogen-based reduction technologies have emerged as promising alternatives to traditional carbon-intensive processes. Among these, fluidised bed hydrogen direct reduction ironmaking (FBH_2DRI) offers the potential for continuous, scalable, and flexible operation using fine iron ore particles without the need for agglomeration, making it well-suited to Australian ore types.

Recent preliminary techno-economic analyses suggest that that even low-grade Pilbara ores could yield cost-competitive green steel when processed via FBH_2DRI coupled with a two-step smelter-basic oxygen furnace (BOF) route. This innovative combination could overcome limitations typically associated with low-grade ores, offering a viable pathway for large-scale green steel production in Australia. While the overall concept of FBH_2DRI is understood in theory, commercial deployment depends on several technological and operational uncertainties. These include the precise behaviour of various ore types under hydrogen-rich atmospheres, fluidisation dynamics, reactor performance under realistic process conditions, and the impact of process parameters on product quality and sticking behaviour. Furthermore, the economics of integrating FBH_2DRI into green steelmaking supply chains—especially for unconventional ores—remain underexplored

This project investigates FBH_2DRI using Pilbara iron ores. This includes experimental work on reactor design and chemical kinetics, as well as system-level techno-economic assessments of integrated steelmaking flowsheets, taking into account Australian ore characteristics, renewable energy inputs, and process flexibility. The PhD activities will complement the on-going activities in two projects including the HILT project RP1.012 Prevention of sticking in H_2 fluidised bed direct reduced iron production and ARENA project De-risking large-scale Australian fine-ore hydrogen ironmaking. Together, these efforts support the broader objective of establishing Australia as a global leader in green iron and steel production. The scholarship will be jointly supported by HILT CRC and the ARENA project, with each organisation contributing to the funding.

PROJECT OBJECTIVES

The project will address three key objectives, as detailed below:

Hydrogen fluidised bed hydrogen reduction experiments

- Prepare and characterise iron ore samples (e.g., hematite, magnetite, or alternative ores) with controlled particle size distribution.
- Conduct hydrogen reduction experiments using lab-scale fluidised bed reactor.
- Evaluate the effect of process variables – ore composition, particle size, temperature, and gas composition – on the reduction behaviour of iron ores.
- Comprehensive material characterisation of the reduced products.

Extract kinetics from low-temperature fluidised bed experiments

- Fit experimental data to kinetic models (e.g. shrinking core, nucleation and growth, or Avrami models) to extract reaction rate constants.
- Determine activation energy and other kinetic parameters through temperature-dependent fluidised bed experiments.
- Compare kinetic behaviour across ore types, focusing on differences due to mineralogy, porosity, and particle size.
- Validate kinetic models using additional experiments and/or simulations.

Techno-economic evaluation of fluidised bed hydrogen reduction for alternative Ores

- Develop process flow diagrams for fluidised bed reduction integrated with green steelmaking routes.
- Perform mass and energy balances for different ore types and process conditions.
- Incorporate kinetics data from experimental results into process simulation tools.
- Estimate the levelised cost of green iron/steel, and conduct scenario/sensitivity analysis.

QUALIFICATIONS AND EXPERIENCE

The ideal candidate will have a strong academic background in chemical, mechanical, and process engineering with demonstrated interest in ironmaking, reactor design, or hydrogen-based processes. Experience in one or more of the following areas will be advantageous:

- Experimental research involving fluidised beds, gas–solid reactions, or high-temperature reactors.
- Process modelling and simulation, including mass and energy balances, kinetics, or CFD.
- Techno-economic assessment and systems analysis of industrial processes.
- Handling and characterisation of ores and metallic powders.

To determine your eligibility for studying at ANU, visit study.anu.edu.au/apply/postgraduate-research.

Further enquiries: Dr Alireza Rahbari, alireza.rahbari@anu.edu.au.

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HILT CRC POSTGRADUATE PROGRAM

Are you interested in receiving training from world-leading researchers, whilst working with industry partners on real-world problems?

Join the HILT CRC postgraduate program for a research career in de-risking decarbonisation for heavy industry.

Through engagement with industry and universities we are committed to training the heavy industry workforce of the future through practical, demand driven research projects with world-leading teams and facilities.

We offer Higher Degrees by Research (HDR) through a PhD or Masters qualification for up to 3.5 years duration, providing you with the opportunity to acquire world-leading training in a field of growing demand to take your engineering career further.

By joining our postgraduate research program, you will work on real industry problems and challenges with the potential for immediate high-impact practical results to decarbonise heavy industry.

When undertaking a research degree with us, you will also gain:

Expert knowledge – designed specifically for the heavy industry sector and draws on your foundation of engineering knowledge by developing further skills tailored to transitioning the steel, iron, alumina and cement industries to reduce heavy industry's carbon emissions.

Invaluable networking opportunities and professional development – benefit from opportunities to collaborate and network with multiple industries and research experts and teams via participating in the HILT CRC specialised webinars, yearly conferences, and master classes.

Career outcomes – linked with industry and government, you will gain hands on industry experience to help you develop the skills required to operate in a new low-carbon economy, become an expert in your field, and enhance your employability.

A platform for communicating your findings – your research findings may be presented at industry conferences, published, commercialised and in turn, create a positive impact on society.

Financial Support and Scholarships

We can provide full, co-funded or top-up scholarships to eligible postgraduate students (Higher Degree by Research students at both Master and PhD levels) across our three research programs at our partner universities. The distribution of funding is at the discretion of the principal (main) supervisor of the project and may be used for student stipend, costs associated with the research project or other expenditure related to the project.

Any student interested in undertaking a postgraduate scholarship is encouraged to review the Scholarship Guidelines and complete the HDR Scholarships Application Form. Details for how to apply for postgraduate scholarships are included in the guidelines.

How to Apply

All HILT CRC prospective postgraduate students are required to enrol in their degree through their host institution as per the normal university application process. Therefore, students need to meet the requirements stipulated by the host university to enrol (e.g. appropriate Honours or Masters degree).

Further Information

For more details about the postgraduate research opportunities and projects, and financial support with HILT CRC, contact us at hdr@hiltcrc.com.au