

WOODSIDE MONASH PARTNERSHIP 2024 ANNUAL REPORT

monash.edu/woodside

A partnership between:



FutureLab



**IN THE DYNAMIC LANDSCAPE
OF THE WOODSIDE MONASH
PARTNERSHIP, WE HAVE
WITNESSED CONTINUED
EVOLUTION AND ADAPTATION.**

WOODSIDE MONASH PARTNERSHIP LEADERSHIP

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CRICOS provider: Monash University 00008C

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INTRODUCTION

The innovative endeavours and the collaborative spirit of our teams have propelled us to new heights, resulting in breakthroughs that are reshaping industries and advancing sustainable solutions.

We invite you to discover the challenges we've tackled and the innovative solutions we've crafted.

FOREWORD FROM LEADERSHIP

We are pleased to present the ninth annual report of the Woodside Monash Partnership, which encompasses the FutureLab and the Energy Partnership.

2024 marks a year full of innovative outcomes, where the Partnership successfully demonstrates its value, adaptability and strategic nature.

We celebrated an outstanding period of progress characterised by significant research advancements, valuable industry collaborations and impact. In doing this, it is important to highlight and recognise the dedication, expertise, and innovative spirit of all the staff at Monash University and Woodside Energy, as well as the students and external collaborators, who contribute to the Partnership. It is their passion, commitment and excellence that makes this Partnership so successful. Special recognition goes to Neil Kavanagh, Voula Terzoudi and Dr Claudia De Los Rios Perez for their constant support and guidance throughout 2024.

Over the past year, our partnership has continued to excel and grow—not only in the scope of our research but also in the strength of our community. Our teams made exciting strides, including the official offshore deployment of cold spray technology for aluminium coating repair, the full integration of the additive manufacturing (AM) monoflange into the procurement system, the deployment of the hydrogen/ammonia facility network optimisation system, the completion of Pluto's crew rostering system, the development of an AI bird counting system for the Trinidad and Tobago's platforms, and the global recognition of our work on the importance of cleanliness in feedstock powders

which addresses a key quality assurance challenge in metal powder additive manufacturing. In addition, we were delighted to launch Monsol, the first spin-out from the partnership that aspires to significantly contribute to the renewable energy sector with a novel ultra-low cost solar technology, and we were thrilled for one of our teams to be granted AUD 2,300,000 in funding from the Australian Renewable Energy Agency to advance renewable hydrogen production technology.

As we enter 2025, we do so eager to ensure the Woodside Monash Partnership – the largest single industry-academia partnership in Australia and one where collocation, co-development and collaboration around a shared vision is key – continues to deliver outstanding solutions and to lead in energy innovation.

We hope you find this annual report as inspiring and fascinating as the challenges the partnership tackled, the solutions it devised and the people who created them.

Professor Maria Garcia de la Banda, Woodside FutureLab at Monash Co-Chair, Information Technology, Monash University

Professor Christopher Hutchinson, Woodside FutureLab at Monash Co-Chair, Engineering, Monash University

Professor Paul Webley, Energy Partnership Director, Monash University

WOODSIDE MONASH PARTNERSHIP

INNOVATING FOR A SUSTAINABLE FUTURE

At the forefront of the ever-evolving Woodside Monash Partnership, we are driving continuous innovation and progress across our core pillars: the Woodside FutureLab at Monash and the Woodside Monash Energy Partnership.

Woodside Energy and Monash are united by a shared dedication to pioneering innovative solutions for real-world challenges, recognising that charting a sustainable course toward a lower-carbon economy is among the most pressing issues of our time.

Collaborating with some of the brightest minds at esteemed institutions like Monash University, Woodside Energy aspires to employ evidence-based, innovative approaches to disrupt conventional thinking.



**SCAN TO WATCH
THE WOODSIDE
TESTIMONIAL VIDEO**

WOODSIDE FUTURELAB AT MONASH

Established in 2016, the Woodside FutureLab remains steadfast in its mission to unlock the potential of additive manufacturing, materials engineering, and data science to tackle contemporary challenges. Our materials engineering endeavours address global issues such as corrosion through pioneering technologies and advanced materials. Simultaneously, our advanced manufacturing and design initiatives revolve around additive manufacturing (AM) as a game-changing technology. In parallel, the data science pillar employs cutting-edge machine learning, optimisation, and visualisation techniques to empower sophisticated decision-making, particularly in realms like crew allocation and energy network optimisation.

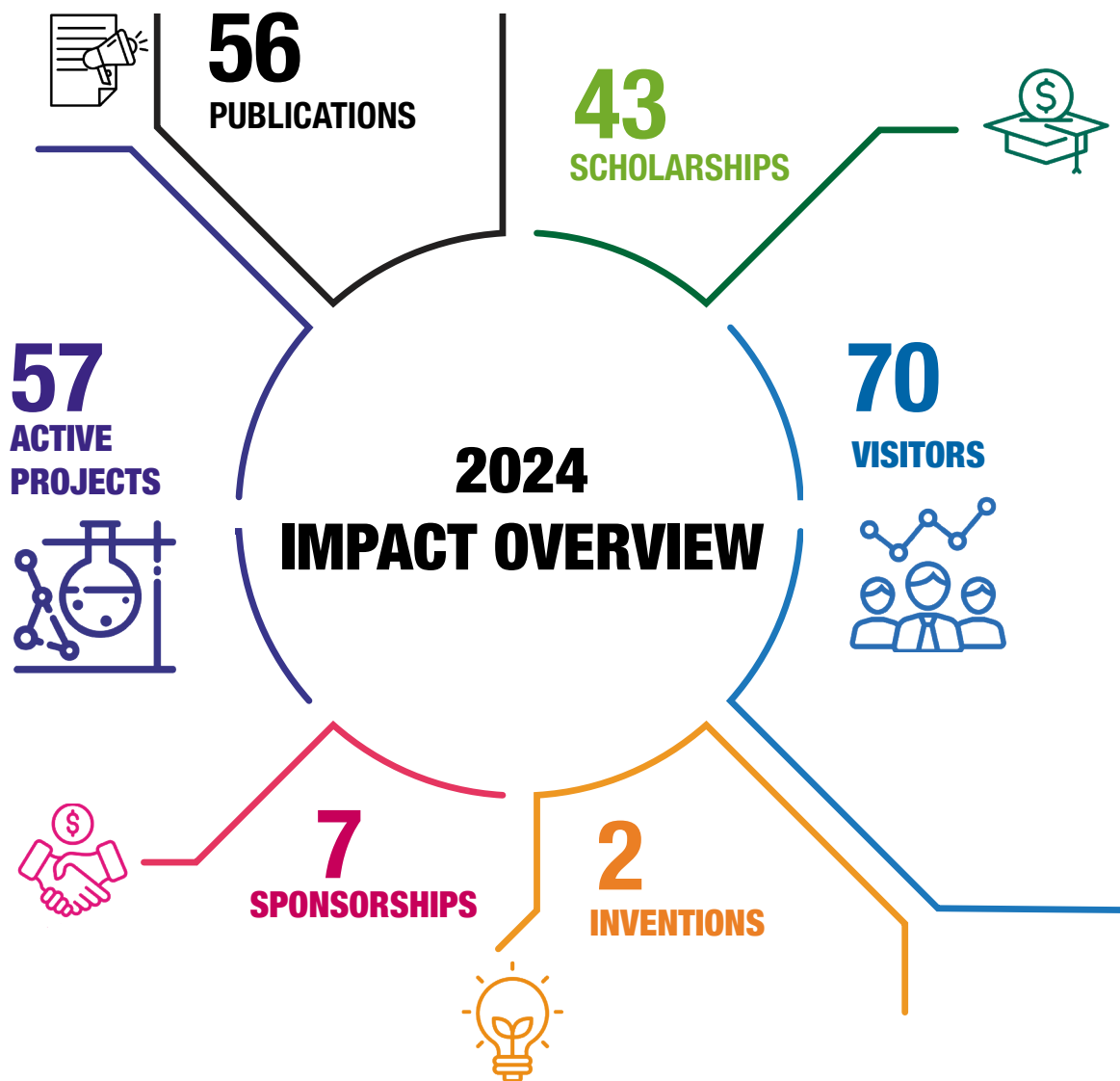
The Woodside FutureLab at Monash University focuses on researching opportunities for industry-wide technological innovation by assembling world-class, cross-disciplinary teams to explore disruptive, breakthrough technologies.

WOODSIDE MONASH ENERGY PARTNERSHIP

Woodside Energy and Monash have forged a robust, long-term research partnership to craft inventive solutions for real-world challenges. The Woodside Monash Energy Partnership is dedicated to building a sustainable path toward a lower-carbon economy.

Established in 2019, the Woodside Monash Energy Partnership remains at the forefront of the transition toward a more sustainable, lower-carbon future. Our approach revolves around three core pillars: affordable, bulk clean energy; carbon abatement; and thought leadership. These pillars align seamlessly with our fundamental themes: New Energy Technologies, Carbon Capture, Conversion, Utilisation, and Energy Leadership. Our initiatives are centred on hydrogen production and carbon abatement to deliver energy solutions that are cost-competitive in today's markets, scalable for bulk energy transportation, and value-added through the creation of carbon products.

As we stride boldly into the future, our unwavering commitment to innovation, sustainability, and leadership propels us to new heights, enabling us to make a positive and enduring impact on a rapidly changing world.



FROM MONASH, WE ARE VERY PROUD TO REPORT THAT DURING 2024 WE PRODUCED:

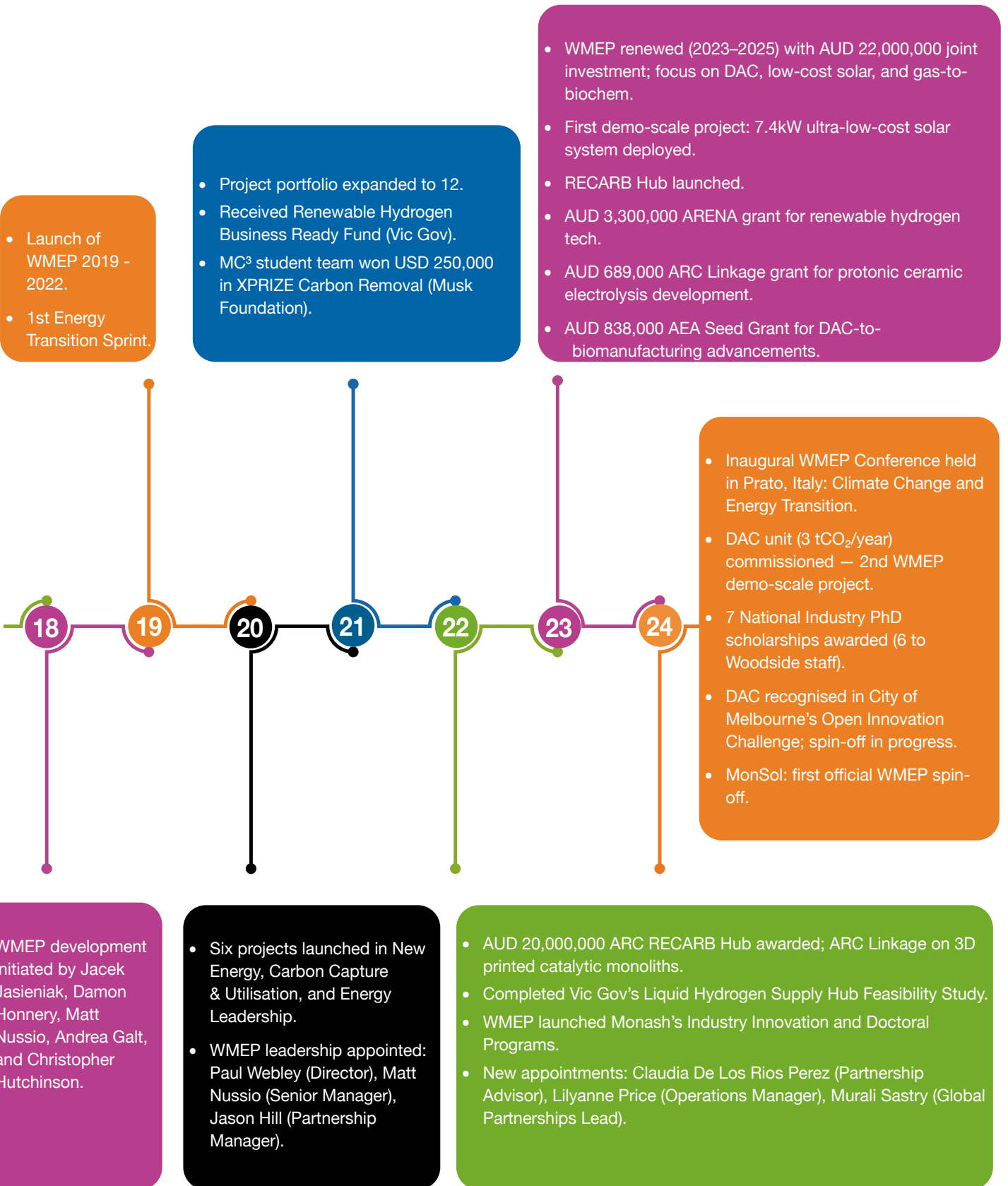
- **57 active projects.**
- **56 publications** - journal articles, conference posters and presentations, and media (Magazine articles, web page articles, YouTube videos, and Newsletter articles).
- **2 invention** disclosures.
- **70 visitors** explored the FutureLab, WMEP, and Monash labs and facilities through the Woodside Monash Partnership.
- **43 scholarships**
 - » 30 PhDs.
 - » 1 Masters.
 - » 12 Undergraduates.
- **7 sponsorships.**
 - » SMUCE (Society of Monash University Chemical Engineers) Victorian Chemical Engineering Students Industry Night.
 - » Monash Energy Club Industry sponsor.
 - » Australian and New Zealand National Design Project Award sponsor.
 - » Woodside Monash Energy Partnership Conference sponsor.
 - » 4th Engineering Postgraduate Conference.
 - » Best student in Corrosion studies award.
 - » Monash Carbon Capture and Conversion.



- FutureLab officially opens at Monash as a five year philanthropic partnership; Nick Birbills appointed Chair.
- Key researcher links established: Christopher Hutchinson (Additive Manufacturing – Metals Sebastian Thomas (Corrosion) Maria Garcia de la Banda (Data Science).
- Demonstrated on-demand 3D-printed spare parts (metals and polymers); part flown to Karratha via helicopter in under one week.

- Christopher Hutchinson and Maria Garcia de la Banda appointed acting co-chairs.
- Development of the Woodside Monash Energy Partnership (WMEP) initiated.

- Developed interactive decision support tool for H₂ supply/demand networks; later extended to NH₃ and improved cost modeling.
- Launched decommissioning research in image-assisted flowline separation and pyrolysis.



2024 HIGHLIGHTS

INDUSTRY IMPACT

- Cold spray was deployed offshore for coating repair of crane booms, within approximately 12 months from technology identification in the market. Technical report produced by FutureLab shared with further oil and gas companies as part of technology sharing agreement.
- Woodside Energy is now world leading in the implementation of additive manufacturing (AM) components in service. The Galperti Monoflange is, as of 2024, fully embedded in the procurement system with all approvals achieved, as the preferred equipment. The International Association of Oil and Gas Producers (IOGP) meeting concerning the harmonisation of AM documentation into the wider industry kicked-off with Dr Lee Djumas leading as co-chair. The associated digital inventory scope has been started in Gulf of Mexico warehouse.
- Research on the effect of nano-oxides in AM components has been picked up by further industries, identifying the cause of and providing a solution for the performance of thousands of AM components globally. The findings have been incorporated directly into the proposed IOGP Material Datasheet for LPBF IN625.
- Decommissioned subsea flowlines arrived at Monash for polymeric characterisation and analysis for identification of upcycling and recycling pathways. The Monash decommissioning researchers were contacted by the Department of Industry, Science and Resources to provide insight into the National Roadmap for Decommissioning, published in December 2024.
- The Facility Network Optimiser for rapid evaluation of hydrogen and ammonia supply/demand opportunities was deployed, after extending it to optimise carbon incentives and locations outside USA.



Deployment of cold spray as a coating repair technique for offshore structures. Read more about this project in pages 18 and 24.

2024 HIGHLIGHTS

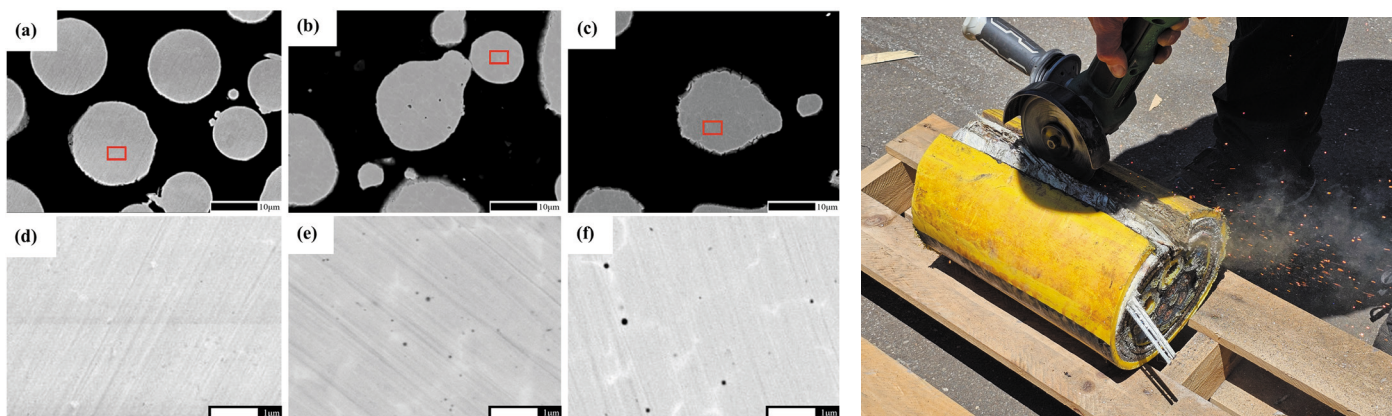
INDUSTRY IMPACT

- MonSol, a spin-out from the Low-Cost PV Project under the Woodside Monash Energy Partnership, that aspires to significantly contribute to the renewable energy sector with its novel Concertina PV Array. This innovative technology is designed to lower the costs of solar energy deployment, accelerating the transition to a carbon-neutral future. By enhancing efficiency and affordability, MonSol is contributing to sustainable energy solutions.

Further solidifying its impact, MonSol has been awarded the IG240100795 grant under the Australian Energy Agency (AEA) for the Development of a Low-Weight and Low-Cost Photovoltaic Array for Temporary Power Applications. This grant will support MonSol's efforts to advance its pioneering solar technology, enabling more scalable and accessible renewable energy solutions.

Read about MonSol here: <https://MonSol.energy/concertina-pv/>

- The Australian Renewable Energy Agency (ARENA) has granted AUD 2,300,000 in funding to advance Monash University's pioneering project, the 'Advance Renewable Hydrogen Production Technology.' Spearheaded by Associate Professor Alexandr Simonov, an ARC Future Fellow in the Monash School of Chemistry, this project marks a significant step towards commercialising renewable hydrogen production. In addition to ARENA's contribution, collaborative partners, including Monash University, the University of Sydney, CSIRO, Endua, Ixom, and Woodside Energy, have further bolstered this initiative with an additional AUD 1,000,000 investment.
- The Crew Rostering system was finished and deployed to be used not just for Pluto, but any Woodside asset. It is now being extended to quickly find candidates for backfilling a crew member's leave with minimal cost and disruption, thus reducing over cycle.
- The enhanced Tech-Max formula developed by Woodside for production modelling was studied with a focus on modifying non-controllable variables. The study produced very helpful insights into the effect of dehydration system pressure drop.
- Developed a bird counting AI system for the Trinidad and Tobago platforms that uses a live video feed from a known camera to accurately count the number of birds on or flying near the facility. The camera is small enough to be installed in the facility and fast enough to count birds in near real-time.



Left: Oxides present in feedstock powders have a significantly detrimental effect on mechanical properties of LPBF components; right: Sectioning of decommissioned flowline samples

2024 HIGHLIGHTS

ACADEMIC AND STUDENT ACHIEVEMENTS

- **Inaugural Ariel Liebman Impact Award** went to Matthias Klapperstueck, Frits de Nijs, Ilankaikone Senthoooran, Jack Lee-Kopij, Maria Garcia de la Banda, and Michael Wybrow for their work on Hydrogen/Ammonia Supply/Demand Network and Facility Optimisation - recognising their outstanding contributions in academic publications or software tools in the field of optimisation that demonstrate real-world impact, innovation and alignment with the mission of Optimisation Technologies, Integrated Methodologies, and Applications (OPTIMA).
- **Marc Peters was a finalist** in the ACA Victorian branch Brian Cherry Award 3-Minute Thesis competition.
- **Young Researcher Award by the International Association of Catalysis Societies:** Garv Bhardwaj and Fergus McLaren were awarded the Young Research Award by International Association of Catalysis Societies to attend the 18th International Congress on Catalysis in Lyon, France.
- **Monash 4th Annual Postgraduate conference**
 - » Raihan Arfin – Best Poster Presentation Energy and Renewables.
 - » Satya Sireesha Rameswarapu – Best Poster Overall Presentation.
 - » Cristian Costa - Best Poster in Infrastructure and Environment award.
- **Andrew Legacy Bursary:** Satya Sireesha Rameswarapu Awarded Prestigious Andrew Legacy Bursary for Catalysis Summer School from 24-28 June 2024. Sireesha's selection for this prestigious bursary stands as a testament to her unwavering dedication and expertise in the field of catalysis.
- **Miriam Blaine received the Best Oral Presentation** award for her work on Carbon Intensity of Biomethanol Production: Sensitivity of Feedstock Accounting Methodology at the 14th International Conference on Future Environment and Energy (ICFEE 2024).



Above: Professor Maria Garcia de la Banda accepting the Ariel Liebman Impact Award from Dr Charlotte Hurry, Centre Manager for the ARC Training Centre in OPTIMA.
Right: Best Poster in Infrastructure and Environment awarded to Cristian Costa.



2024 HIGHLIGHTS

ACADEMIC AND STUDENT ACHIEVEMENTS

- Professor Fang Lee Cooke has been named an inaugural Highly Ranked Scholar** by ScholarGPS in May 2024. Her rankings are No. 8 highly ranked scholar (lifetime) and No. 2 (prior 5 years) in the human resource management specialty. ScholarGPS provides rankings overall (in all Fields) in 14 broad Fields such as Medicine, Engineering, or Humanities, in 177 Disciplines such as Surgery, Computer Science, or History and over 350,000 Specialties such as Cancer, Artificial Intelligence, or Ethics.
- People's Choice Award and 3rd place, City of Melbourne Open Innovation Competition**
Joel Wong and Evangeline Leong pitch to integrate WMEP's Direct Air Capture with existing building HVAC infrastructure emerged secured People's Choice Award and placed 3rd in the City of Melbourne's Annual Open Innovation Competition. This year's theme was focused on accelerating Melbourne's transition to a zero-carbon future by promoting climate and clean technology innovations, fostering job creation, and empowering local businesses and communities.
- National Industry PhD Program – Department of Education**
Satya Sireesha Rameswarapu was awarded a National Industry PhD Program scholarship by the Department of Education during Round 2. Read more about the award in Monash News.
(<https://www.monash.edu/news/articles/monash-secures-funding-for-multiple-climate-research-projects-under-the-national-industry-phd-program>)

Building on this success, **Anrie Helberg, Lex Simons, and Andy R Watt have also been awarded National Industry PhD Program scholarships** in Round 3 of 2024. As recipients, they have joined Monash University's Industry Doctoral Program (IDP), an industry-led PhD initiative where the scope, project, and research focus are shaped by industry needs. As Woodside Industry Researchers, they will contribute their expertise to pioneering industry-driven research for Woodside.



Miriam Blaine with Takuji Matsumoto, Associate Professor, Faculty of Transdisciplinary Sciences for Innovation, Kanazawa University, Japan



Evangeline Leong (centre) and Joel Wong (right) receiving third place in the City of Melbourne's Annual Open Innovation Competition



HIGHLIGHT

ENERGY PARTNERSHIP NEWS SPOTLIGHT

UNFOLDING THE POWER OF THE FUTURE

Alexander May, Jacek Jasieniak,
Jose Lobo Del Canto

MonSol, the first spin-out from the Low-Cost PV Project under the Woodside Monash Energy Partnership, aspires to significantly contribute to the renewable energy landscape with its innovative Concertina PV Array. This novel technology promises to reduce the costs associated with solar energy deployment, paving the way for a carbon-neutral future.

In 2018, the Woodside Monash Energy Partnership (WMEP) was formed as a strategic collaboration between Monash University and Woodside, aimed at spearheading innovation in carbon emission mitigation and advancing lower carbon hydrogen technologies. Under the WMEP Low-Cost PV Project, Professor Jacek Jasieniak led this interdisciplinary initiative as Project Leader, with PhD IDP student Jose Lobo Del Canto contributing significantly to its research and development. The project was dedicated to engineering ultra-low-cost solar solutions to make clean energy more accessible and economically viable. These advancements aim to support carbon-neutral technologies such as carbon capture and hydrogen electrolysis, furthering efforts to create a more sustainable and energy-efficient future.

Emerging from the Woodside Monash Energy Partnership, MonSol is dedicated to pioneering straightforward yet groundbreaking solutions that enhance global access to clean power. Its mission is to drive down the cost of electricity produced by renewable sources, striving for a more sustainable and affordable energy future for all.

MonSol's flagship innovation, the patented Concertina PV Array, is setting a new standard for portable solar power. This lightweight, modular, and deployable solar solution provides a competitive alternative to traditional diesel generators, particularly in remote and temporary power applications. Designed for versatility, the Concertina PV Array enables rapid deployment, making it an ideal solution for industries and communities in need of reliable, clean energy.

The Concertina PV Array bridges novel PV module design with deployment innovation to achieve major cost reductions. It was identified that 40% of the cost of utility-scale solar lies in deployment activities. By making these processes quicker and less labour-intensive, the Concertina PV Array enables ultra-low-cost solar PV deployment to be realised.

The Concertina PV Array utilises semi-flexible solar panels made from high-performance polymers, ensuring durability and longevity. Its low, streamlined system design minimises exposure to high wind forces, reducing material usage. Additionally, the system packs more than three times the amount of power per container, significantly cutting freight costs.

This revolutionary solar array is not only highly durable and lightweight for rapid deployment but is also easily retractable at the end of its use. It is ideal for temporary energy requirements, such as construction or maintenance projects, offering a clean alternative to noisy and polluting diesel generators.

MonSol's founders have been integral to the project since its inception and now hold a patent on the system's storage and deployment. The technology has been proven through pilot scale deployment at 7.5kW and 30kW. The larger array is being utilised as a "living laboratory", by providing power into the grid, as well as the ability to iterate on the deployment in real-time to enable necessary upgrades and improvements.

Learn more about MonSol's mission and technology at MonSol.energy.





HIGHLIGHT

ENERGY PARTNERSHIP PROJECT IN FOCUS

ENERGY GRANT SET TO SUPERCHARGE AFFORDABLE RENEWABLE HYDROGEN TECHNOLOGY

The Australian Renewable Energy Agency (ARENA) has awarded \$2.3 million in funding to Monash University's Advance Renewable Hydrogen Production Technology project in support of its efforts to revolutionise the commercialisation of renewable hydrogen production.

Energy grant set to supercharge affordable renewable hydrogen technology.

Led by Associate Professor Alexandr N. Simonov, ARC Future Fellow in the Monash School of Chemistry, the project also received an additional AUD 1,000,000 from collaborating partners, including Monash University, the University of Sydney, CSIRO, Endua, IXOM and Woodside Energy.

Under the guidance of its leadership team made up of members of the collaborating partners – including Associate Professor Simonov, Professor Douglas Macfarlane, Professor Huanting Wang, Professor Antonio Tricoli, Dr Sarb Giddey, Dr Paul Sernia, Dr Khozema Kaka, Ben Hart and Dr Jitendra Joshi – the project aims to harness high-efficiency water electrolysis technology with proton-exchange electrolytes to achieve significant cost reductions in renewable hydrogen production.

Through meticulous research and development, the project will use scalable, industry-ready methods to aim to develop cutting-edge proton-exchange water electrolyzers using noble-metal-free catalysts, high-conductivity membranes and porous transport layers. The effectiveness of the new materials will be first demonstrated in the laboratory-scale electrolyser devices under conditions that mimic industrial settings. The ultimate aim of the project is to take the technology from the lab to the real world by transitioning the devices to a larger demonstration scale and ensuring they work in a variety of environments, including when fed by saltwater.

These advancements are set to eliminate the reliance on highly expensive components such as iridium, other noble metals and fluorinated membranes. If successful, the resulting technology has the potential to enable multi-gigawatt installations and expected to provide capital expenditure savings for water electrolysis plants, corresponding to immediate cost reductions of renewably generated hydrogen by up to 16%.

"We are thrilled to partner with ARENA on this groundbreaking initiative" said Professor Paul Webley, Director of the Woodside Monash Energy Partnership. "This funding enables us to push the boundaries of renewable hydrogen production, bringing us closer to a sustainable energy future."

The project represents a collaborative effort between academic partners, CSIRO and key industry stakeholders, underscoring the collective commitment to driving innovation in renewable energy technologies.

Read online - ARENA Grant first published - Monash News



FUTURELAB



The Woodside FutureLab at Monash is a globally-connected innovation hub that supports technological innovation and collaboration in materials engineering, additive manufacturing, and data science.

FutureLab enables blue-sky thinking and creates shared opportunities for developing innovative solutions to complex industry challenges.



LEADERSHIP AND THEME LEADERS



Front Row (L-R):
 Voula Terzoudi (Head of Partnerships, Woodside Energy),
 Professor Christopher Hutchinson (Co-Chair and Materials
 Lead, Monash University), Dr Erin Brodie (Research and
 Innovation Lead, Monash University), Dr Sebastian Thomas
 (Materials Durability Lead, Monash University)

Back Row (L-R):
 Andrew Melouney (Vice President Digital, Woodside Energy)
 Dr Claudia De Los Rios Perez (Woodside Monash Partnership
 Advisor, Woodside Energy), Professor Maria Garcia de la Banda
 (Co-Chair and Data Science Lead, Monash University)

WOODSIDE SUBJECT MATTER EXPERTS



Michael Brameld
 GM Engineering -
 Technical & Energy
 Development



Lendyn Philip
 Decommissioning



Dr Mohamed Ibrahim
 Data Science Lead



Dr Lee Djumas
 Additive Manufacturing



Ryan Beccarelli
 Vice President Climate
 Strategy



Geoffrey Byfield
 Principal Process
 Engineer



Russell Spradling
 Systems Modelling and
 Facilities Engineering
 Manager



Sandip Deshpande
 Principal
 Product Manager

TECHNICAL FOCAL POINTS



Dr Jaffer Ghouse
Systems Integration
Data Scientist



Jack Lee-Kopij
Data Scientist



Matteo Miceli
Data Scientist



Matthew Zed
Systems Integration
Data Scientist



Madeleine Hardy
Data Scientist



Ruth Boardman
Product Owner



Imogen Fitzgerald
Data Scientist



Maria Gracia
New Energy Graduate



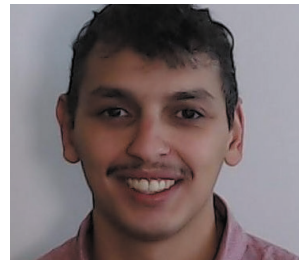
Seen Yan Lee
Graduate Data Scientist



Bernard Cena
Data Scientist,
Technologist



Dr Qi Chu
Data Scientist

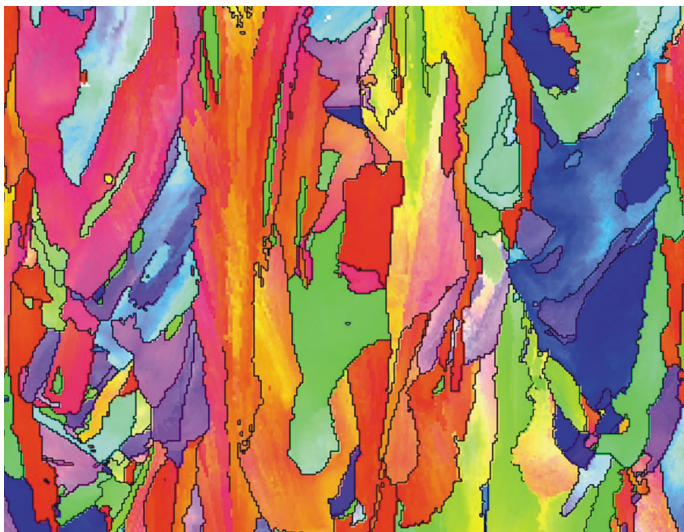


Yazan Arouri
Optimisation Engineer



Andy R Watt
Innovation Advisor

STRATEGIC RESEARCH THEMES



ADDITIVE MANUFACTURING AND MATERIALS INNOVATIONS

DELIVERING ADDITIVE MANUFACTURING PART SUPPLY AS 'BUSINESS AS USUAL' AT WOODSIDE ENERGY AND DESIGNING NOVEL MATERIALS AND CORROSION SYSTEMS FOR INTEGRITY MANAGEMENT SOLUTIONS.



DATA SCIENCE

USING CUTTING-EDGE MACHINE LEARNING, OPTIMISATION, AND VISUALISATION TECHNIQUES TO EMPOWER SOPHISTICATED DECISION-MAKING IN AREAS SUCH AS CREW ALLOCATION, AND ENERGY NETWORK OPTIMISATION.



DECOMMISSIONING

SUPPORTING INNOVATION AND SUSTAINABILITY IN ASSET DECOMMISSIONING.

FUTURELAB PROJECT IN FOCUS

DEPLOYMENT OF COLD SPRAY AS A COATING REPAIR TECHNIQUE FOR OFFSHORE STRUCTURES

Cold spray has emerged as one of the most promising techniques in the field of additive manufacturing.

Driven by the need for a spray system suitable for heat-sensitive environments, this technology utilises a supersonic gas that accelerate particles and enables the deposition of metallic coating at reduced temperatures. This capability makes it ideal for repairing damaged coating in offshore facilities. Additionally, the process's nature allows the construction of relatively compact and user-friendly equipment, accelerating the repair rates and minimising corrosion effects. Consequently, this technique has gained significant interest as a tool for sacrificial coating repair in Woodside assets.

One of the primary questions addressed was the performance of cold spray coating compared to conventional thermal spray method. Throughout 2024, the FutureLab corrosion research team at the Woodside FutureLab at Monash conducted several advanced corrosion and characterisation experiments on cold spray coatings. With the assistance of the Corrosion and Coating Subject Matter experts at Woodside, the corrosion and adhesion

strength were analysed and compared against conventional method, thermal spray. Following successful qualification by FutureLab researchers, the first deployment occurred in June 2024, utilising Titomic's D523 system as a coating repair equipment on offshore crane booms.

The deployment of cold spray at Woodside marked its first appearance in the oil and gas industry. The initial application involved re-establishing aluminium coating removed for integrity tests. This technique has the potential to enhance the lifespan and cost-effectiveness of offshore structures at Woodside, eliminating the need for extensive disassembly and large equipment transportation. Research in this area is ongoing, with higher deposition rate and coating lifespan prediction tests planned for 2025.



Crane boom tip box section showing the original TSA (darker grey) repaired with CSA (lighter grey), demonstrating the application of cold spray aluminium as an in-situ coating repair technique for offshore structures.

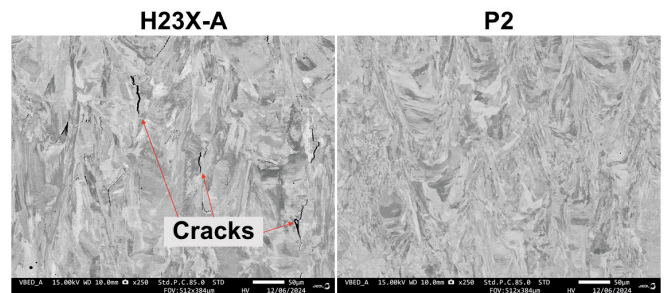


**BY WORKING WITH RESEARCHERS,
ENTREPRENEURS, SUBJECT-
MATTER EXPERTS AND PARALLEL
LEADING INDUSTRIES, FUTURELAB
AIMS TO SOLVE INDUSTRY
CHALLENGES AND CREATE SHARED
OPPORTUNITIES.**

ADDITIVE MANUFACTURING AND MATERIALS INNOVATIONS

ADDITIVE MANUFACTURED ALLOY DEVELOPMENT FOR 'ALL-AREAS' APPLICATION

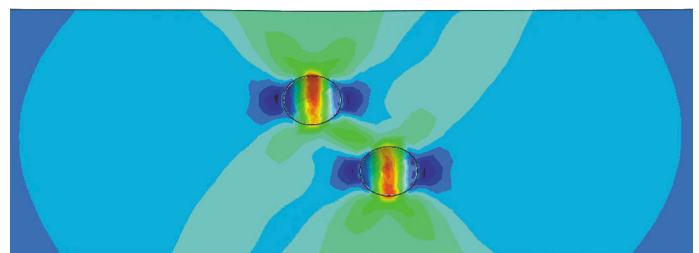
- An optimal “all-areas” AM alloy has been designed, with excellent corrosion and sensitisation resistance. This alloy has been powder atomised and 3D printed successfully using LPBF with a 99.99% density.
- The final stages of mechanical and corrosion benchmarking were completed and compared to the industry leading alloys, showing outstanding performance.
- A dramatic decrease in sensitisation susceptibility has been demonstrated, making it possible to increase service temperatures and weldability of AM components.



Newly developed alloy showing reduced cracking when 3D printed compared to market available alloy H23X

MECHANICAL EFFECTS OF DEFECTS IN ADDITIVELY MANUFACTURED COMPONENTS

- FEA simulations of tensile samples with multiple internal defects were conducted to characterise defect cluster behaviour in LPBF components. Simulations were verified with printed tensile samples.
- The interaction distance between defects was found to be roughly the size of the diameter of a defect.
- Collaboration undertaken with UWA defect monitoring research to model complex defect geometries through geometrically simpler ellipsoidal shapes.

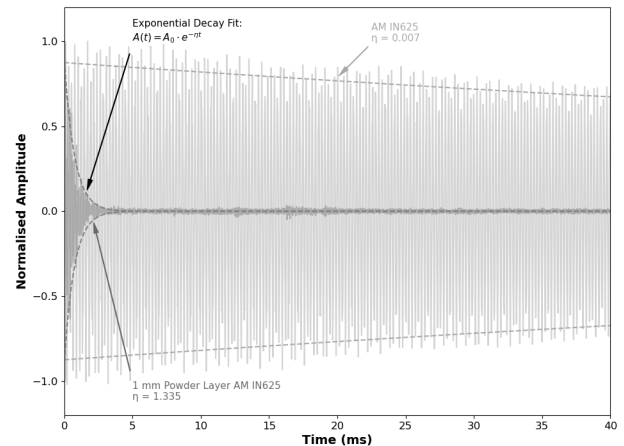


Strain field around 1mm diameter defects simulated in a tensile sample

ADDITIVE MANUFACTURING AND MATERIALS INNOVATIONS

DAMPING OF EMBEDDED POWDER CAVITIES IN ADDITIVELY MANUFACTURED COMPONENTS

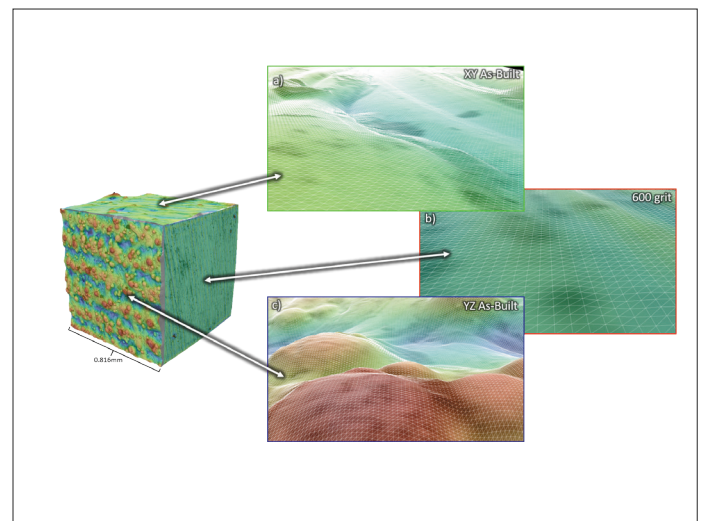
- Designed and printed LPBF plates with embedded powder cavities to interrogate damping capabilities of powder filled components.
- The embedded powder samples showed significantly increased damping under both free and forced vibration loading conditions when compared with solid counterparts.
- Up to 50 wt.% powder content in a cavity improved damping performance, after which a performance plateau was reached.



Free vibration damping response comparing a solid and 3D printed powder cavity component

CORROSION OF AS-BUILT AND POST-PROCESSED ADDITIVELY MANUFACTURED COMPONENTS

- As-built and as-finished LPBF surfaces were investigated using different corrosion techniques to understand the key corrosion mechanisms to reduce part lead times and operational complexity.
- Long term current testing of as-built and as-finished LPBF surfaces showed key differences in metastable pitting onsets and behaviours.
- Characterised the performance of protective films under growth for Cr-containing alloys through Electrochemical Impedance Spectroscopy.

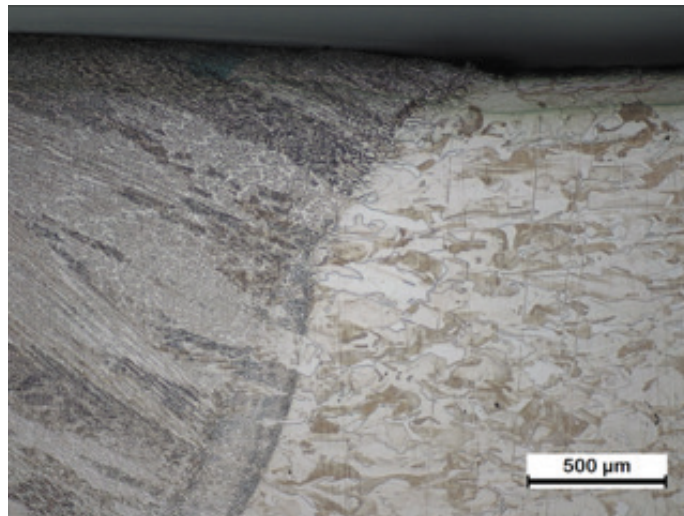


3D reconstructions of Additively Manufactured surface finishes produced by a Scanning Electron Microscope

ADDITIVE MANUFACTURING AND MATERIALS INNOVATIONS

EXPANDING AM COMPONENT USE CASES

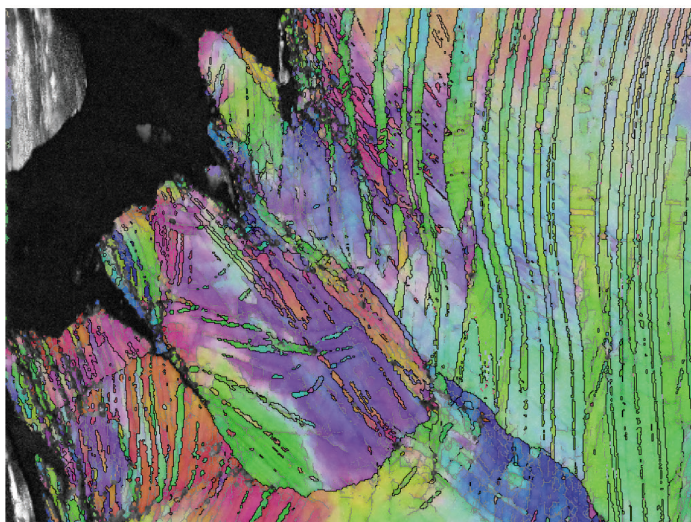
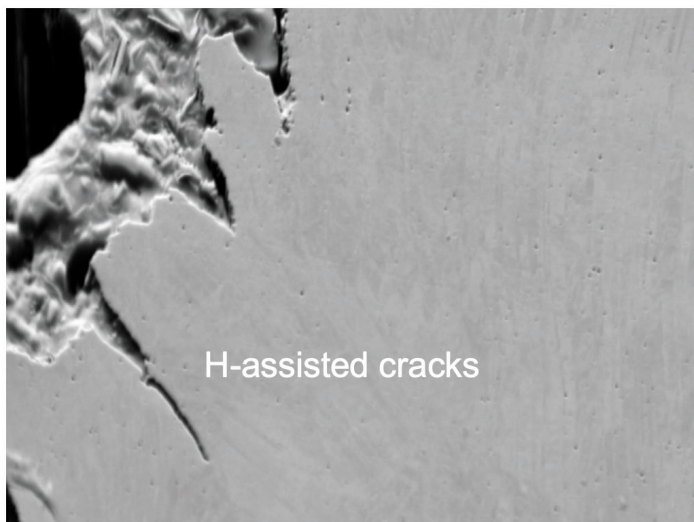
- Conducted comprehensive investigations into the durability and strength properties of welded AM parts across multiple materials systems.
- Explored the failure susceptibility and mechanisms in welded AM parts, focusing on the effects of heterogeneous microstructures.
- Highlighted the impact of microstructural inclusions on the mechanical properties of key materials families for oil and gas facilities, highlighting the importance of high-quality feedstock powders. This work was published and has since been picked up globally by leading AM industries. Published work: Peters et al. (2023) *Materialia*, 32, 101958. (<https://doi.org/10.1016/j.mtla.2023.101958>)



Etched LPBF IN625, highlighting the weld/LPBF material interface microstructure

HYDROGEN EMBRITTLEMENT OF STRUCTURAL AM MATERIALS

- Structural materials face an increased risk of hydrogen embrittlement (HE), which can degrade mechanical properties and lead to safety and economic concerns. Hence, the HE behaviour of AM stainless steels was investigated in direct comparison to conventionally manufactured stainless steels.
- Improved hydrogen resistance is noted in AM manufactured materials after hydrogen charging.
- The findings provide valuable insights into HE mechanisms in AM stainless steels, supporting the development of HE-resistant alloys, and contribute to the safe adoption of hydrogen technologies.



Secondary Electron and Electron Backscattered Diffraction of AM horizontally printed 316L after incremental step loading with H charging, showing H-assisted crack growth along grain boundary: (left) SE image showing morphology of H-assisted cracks. (right) EBSD map showing H-assisted cracking along grain boundary

ADDITIVE MANUFACTURING AND MATERIALS INNOVATIONS

COLD SPRAY FOR COATING REPAIR

- A new metallic coating system was identified, and coatings characterised for bonding strength and corrosion durability.
- Successful qualification investigations led to qualification and offshore application to repair thermally sprayed aluminium coatings on crane booms.
- Research continues to explore further coating compositions to improve corrosion performance and durability.



Cold spray aluminium coating after exposure to salt spray test at 60°C

FATIGUE OF FLEXIBLES IN HUMID ENVIRONMENTS

- In order to understand the fatigue performance of flexible flowlines under humid conditions, the tensile armour layer was characterised.
- The chemical composition and microstructure characteristics of the steel were identified through microscopy and hardness testing.
- The lab characterisation findings were used in conjunction with literature to predict the performance of the steel in completely dry to completely submerged salt and freshwater environments.



Gabi Newman (IDP student) and Dr. Erin Brodie (Supervisor) discuss the structure of the subsea flowline, focusing on sample preparation and collection.

ADDITIVE MANUFACTURING AND MATERIALS INNOVATIONS

AM OF TUNGSTEN CARBIDE DRILL-BITS

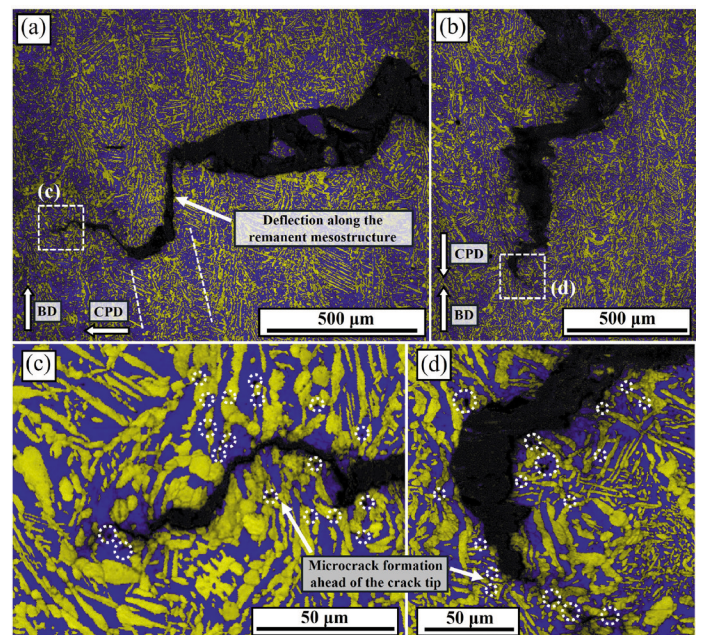
- Tungsten carbide drill bits were investigated to improve the wear properties and hence reduce the usage of drill bits required to drill to a required depth through steel piping.
- The bits were custom designed, printed using LPBF and successfully tested drilling through 316L stainless steel plate.
- Surface roughness, porosity and residual stress from the builds reduced durability of the bits, however further optimisation could increase durability, making manufacturing of tungsten carbide drill bits scalable.



3D printed tungsten carbide drill-bit in use

MIXED POWDERS FOR COMPONENT MICROSTRUCTURAL CONTROL

- A duplex stainless steel was produced by laser powder bed fusion in the as-built condition by mixing 25Cr and Ni powders.
- When compared with conventional duplex stainless steels, the as-built mixed powder alloy showed excellent strength and fracture toughness, even displaying a higher fracture toughness than some conventionally processed steels of the same strength.
- The mesostructure control in LPBF is now able to be exploited for directing crack propagation. Published work: Paul et al. (2025) Scripta Materialia, 255, 116334. (<https://doi.org/10.1016/j.scriptamat.2024.116334>)

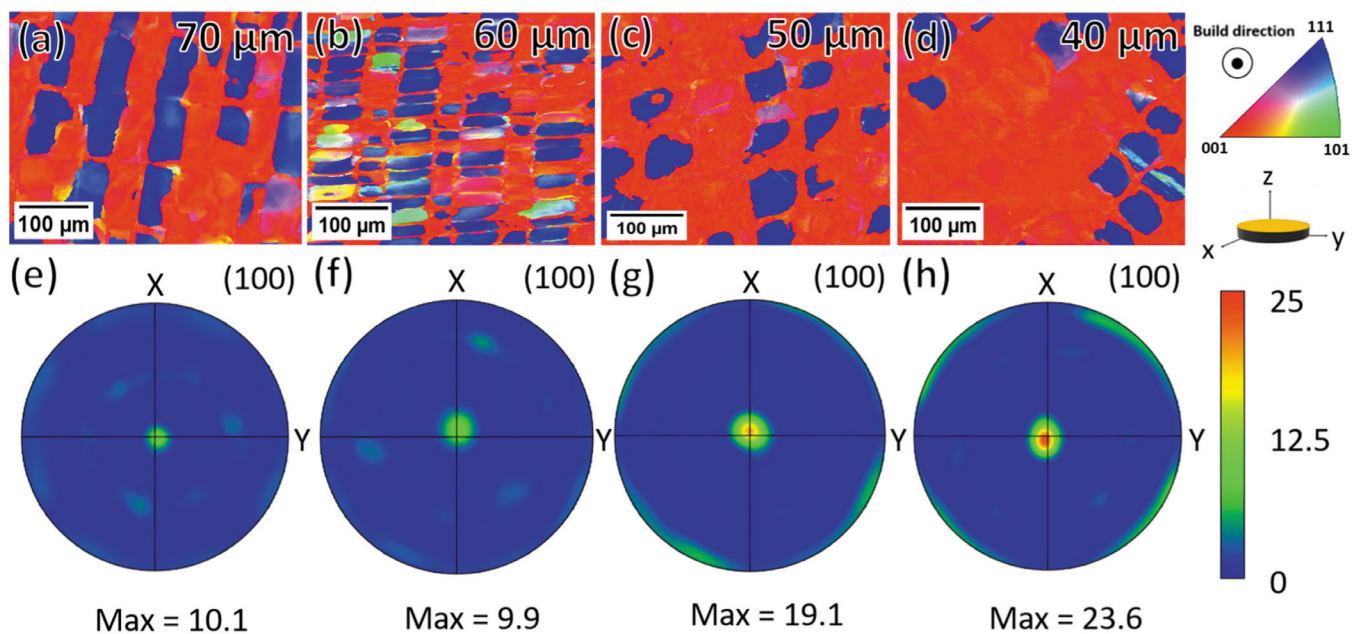


Crack deflection caused by the mesostructure of 3D printed components

ADDITIVE MANUFACTURING AND MATERIALS INNOVATIONS

NEW ENERGY INNOVATIONS

- 15 polymer bioshakers were additively manufactured and assembled to accelerate bacteria counting to assist the conversion of waste gasses into sustainable feeds project.
- Ni monoliths with complex internal flow geometries were additively manufactured for efficient catalytic carbon conversion. Printing of SiC also investigated as a catalytic substrate material.
- Fe-Ga alloys were additively manufactured with enhanced magnetostriction for sensing and energy harvesting applications. Published work: Huo et al. (2025) Scripta Materialia, 257, 116471. (<https://doi.org/10.1016/j.scriptamat.2024.116471>)



Crystallographic control in 3D printed FeGa to enhance magnetic properties

DATA SCIENCE

CREW/ROLE ALLOCATION AND BACKFILLING

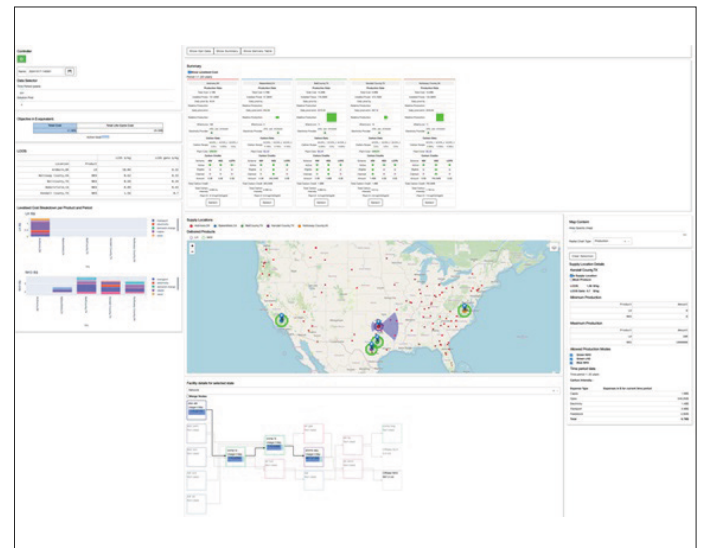
- The prototype developed in 2023 to support the allocation of personnel to a crew and roles in a way that is consistent, compliant and optimal w.r.t. the user-defined objectives has now been extended to assets other than Pluto and deployed at Woodside.
- A complementary new prototype has also been developed to quickly find the set of candidates for backfilling personnel during planned or unplanned leave that yield minimal cost and disruption. Users are shown the top solutions, which can then be explored and compared via a Graphical User Interface.
- The combined system will be deployed at Woodside in early 2025 to help Woodside reduce overcycle, guide operator training plans, and support asset succession planning.



Five different suggestions to cover the leave of a crew member during seven days of their shift

HYDROGEN/AMMONIA DEMAND/SUPPLY NETWORK AND FACILITY OPTIMISER

- The decision support system developed in 2023 to quickly evaluate potential hydrogen and ammonia supply/demand opportunities, has been deployed at Woodside.
- In addition, the system has been extended to take advantage of carbon incentives schemes during optimisation, and to support supply/demand locations anywhere in the world.
- The system is now in use, providing Woodside with unique flexibility and capability for rapid, end-to-end supply chain optimisation and evaluation.
- This work obtained the inaugural Ariel Liebman Impact Award.

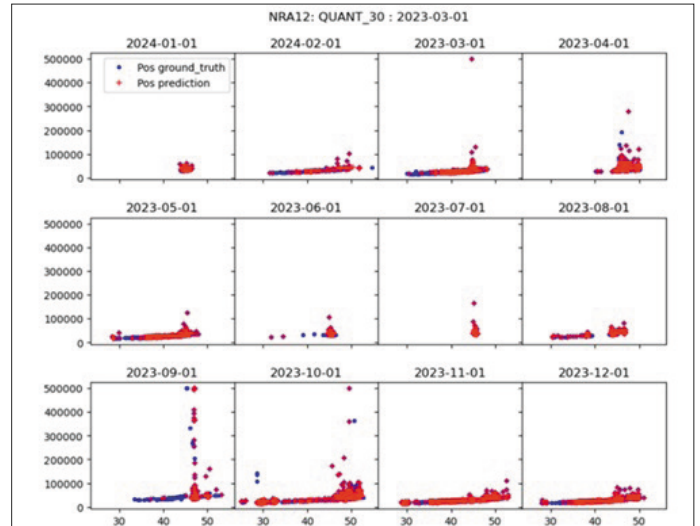


Possible solution for a network containing five facility locations and their configurations

DATA SCIENCE

PREDICTING SAND EVENTS IN A WELL

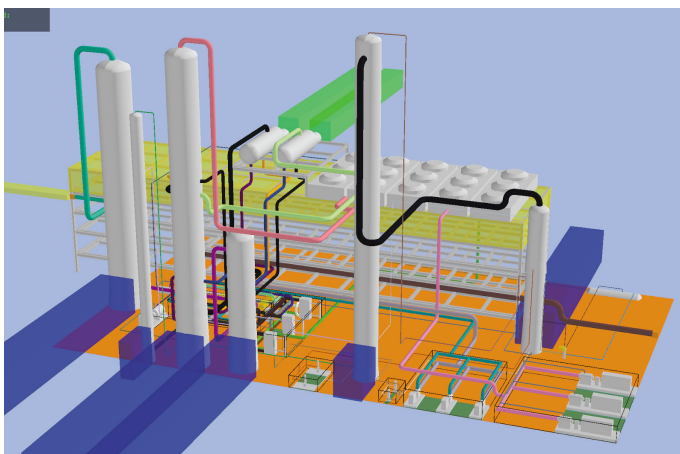
- Reducing the reliance on manually extracted expert rules for detecting and predicting sand events in a well is useful, as this is a time-consuming, non-scalable task that needs to be repeated as wells age.
- To determine whether such reduction is possible, we first evaluated the ability of 8 machine learning methods to replicate the sand event predictions made by expert rules using acoustic, velocity, and choke position data from three wells. The results show that Monash’s new interval time-series method (QUANT) achieved 80%+ accuracy (the others didn’t reach 50%).
- We then evaluated QUANT’s ability to predict sand events in wells. The results show that while predictions without any expert data are not reliable, predictions with less than 10% expert data are comparable to those using 100%.
- During this project, Monash also organised for Professor Tony Bagnall’s team at the University of Southampton to workshop their cutting edge open-source time-series toolkit (which includes QUANT) to Woodside staff, for their use in future projects.



Acoustic sand detection vs velocity measurements coloured red/blue for prediction/actual values

PIPE ROUTING (PHD PROJECT)

- We have adapted and implemented checks for complex pipe-routing safety and engineering constraints within the context of 3D search algorithms. This allows us to quickly verify our grid-based solutions against those that are feasible in the real-world, and to experimentally iterate variations of solution layouts.



- We implemented obstacle dilation (growing of modules, supports, pipes) by appropriate sizes in 3D space to ensure pipes of any diameter are collision free in our solutions; maintaining adequate safety distances from all other obstacles.
- Our pipe-routing method was shown to be orders of magnitude faster than the pipe routing method included in Woodside’s plant layout software (the previous state-of-the-art). While we verified our solutions satisfy the safety and engineering constraints, future work is needed to make this a guarantee for all problems.

A possible solution for routing pipes of different diameters with non-collision and safety distance constraints



DECOMMISSIONING

DECOMMISSIONING OF MIXED-MEDIA INDUSTRIAL EQUIPMENT AND OPPORTUNITIES FOR PLASTIC WASTE UPCYCLING AND RECYCLING IN AUSTRALIA

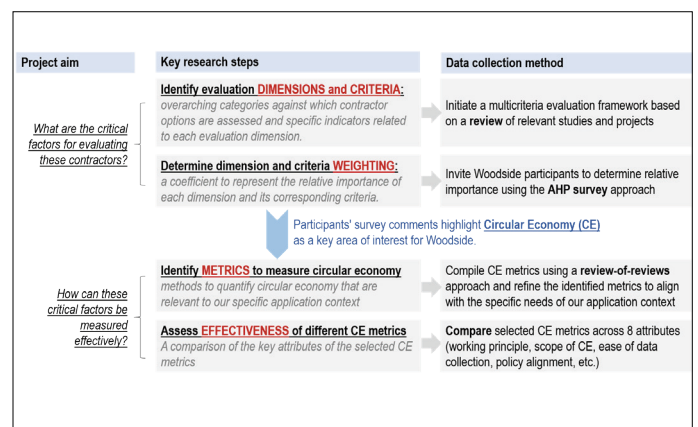
- Received a variety of used flowlines and umbilicals, which are undergoing polymer characterisation in order to inform the material properties at end of life and hence determine options for upcycling and recycling.
- Collaborated in a cross-university ideation session with Curtin University and the University of Western Australia to look at the broader picture of decommissioning.



Gabi Newman, IDP student, visiting the VISY recycling plant

A MULTI-ATTRIBUTE DECISION ANALYSIS FOR DECOMMISSIONING WASTE MANAGEMENT

- This project aims to identify the critical factors that should guide technology or contractor evaluation and resolve multi-variable complexity in order to rank the most suitable options.
- A draft evaluation framework has been proposed based on insights from previous research and survey findings. Ongoing efforts are focused on expanding the collection of survey data to create a more robust model.



Project flowchart highlighting the importance of circular economy in the decommissioning approach

DECOMMISSIONING

PROCESSING OF FLOWLINES, UMBILICALS AND TYRES INTO USEFUL ENERGY RESOURCES

- Pyrolysis experiments on both unused flowlines and used umbilicals have demonstrated efficient conversion of polymers into liquid fuels and gas, with no residual solids left for landfill.
- The commercial opportunities for the liquid fuel and gas products are under investigation.



Decommissioned umbilical pipeline cross-section

DECOMMISSIONING DATABASE

- Development of a database of material emerging from oil and gas decommissioning was initiated in collaboration with the Western Australia Government Department of Jobs, Tourism, Science and Innovation, the Centre of Decommissioning Australia, and oil and gas operators. The intent is to give visibility of future incoming waste to the waste supply chain, regulators and policy makers.
- Multiple waste processors were surveyed and interviewed to understand what information is critical for waste acceptance and logistics planning.
- A first iteration of the database format was created, test populated with operator Subsea Umbilicals, Risers and Flowlines (SURF) data and recommendations made for further development and future gap analysis to support Australian recycling infrastructure.



Deconstructed umbilical separated into polymer classes to explore recycling pathways

ENERGY PARTNERSHIP

Our research and development initiatives are aligned to the United Nations Sustainable Development Goals, with a focus on leadership and novel technologies in the hydrogen value chain and carbon abatement.

The Energy Partnership focuses on transformational research to activate technology breakthroughs and accelerate novel technologies of scale and impact

LEADERSHIP AND THEME LEADERS



Front Row (L-R):

- Dr Claudia De Los Rios Perez (Woodside Monash Partnership Advisor, Woodside Energy)
- Voula Terzoudi (Head of Partnerships, Woodside Energy)
- Aneeka Meyers (WMEP Operations Coordinator, Monash University)
- Dr Jitendra Joshi (Carbon and New Energy Theme Lead, Woodside Energy)

Back Row (L-R):

- Gareth Wright (Energy Leadership Theme Lead, Woodside Energy)
- Professor Paul Webley (Energy Partnership Director, Monash University)
- Professor Akshat Tanksale (Carbon Theme Lead, Monash University)
- Dr Tom Hughes (New Energy Theme Lead, Monash University)
- Evangeline Leong (Research Officer, Monash University)

ABSENT



Professor Murali Sastry (Global Partnerships Theme Lead, Monash University)



Peter Metcalfe (Energy Leadership Theme Lead, Woodside Energy)



Lilyanne Price (WMEP Operations Manager, Monash University)

WOODSIDE ENERGY SUBJECT MATTER EXPERTS



Neil Kavanagh* Chief Scientist



Sussan Johnson* Business Development Manager



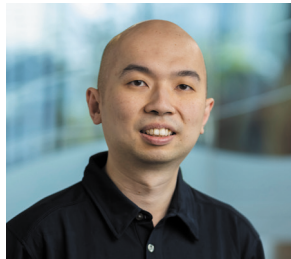
Cameron Remeljej Head of Carbon Capture and Storage

*No longer at Woodside

TECHNICAL FOCAL POINTS



Geoff Byfield, Principal
Process Engineer



Dr Sui Boon Liaw
Senior Scientist



Dr Qiqing Shen
Process Engineer



Dr Pratigya Sharma
Process Engineer



Dr Sahil Garg
Process Engineer



Karan Chhangani
Graduate Electrical
Engineer



Mirhadi
Seyyedsadaghiani
Process Engineer



Michael Lawrence
Strategic Advisor
Climate Strategy and
Policy



Harold Yap
Senior Power Advisor



Zac Douglas-Moore
New Energy Graduate



Shervin Fani
Renewable Network
Integration Lead

STRATEGIC RESEARCH THEMES



NEW ENERGY TECHNOLOGIES

HIGH-EFFICIENCY AND LOW-COST SOLUTIONS TO GENERATE, STORE, AND EXPORT CARBON NEUTRAL ENERGY, INCLUDING HYDROGEN AND ITS CARRIERS.



CARBON CAPTURE, CONVERSION, AND UTILISATION

COMMERCIALY SUSTAINABLE SOLUTIONS THAT REDUCE ATMOSPHERIC CARBON DIOXIDE EMISSIONS THROUGH CHEMICAL, THERMAL, AND BIOLOGICAL APPROACHES.



ENERGY LEADERSHIP

UNDERSTANDING AND ENABLING THE INTERPLAY OF ECONOMICS, ENERGY SECURITY, POLICY AND GOVERNANCE ON THE TRANSITIONING ENERGY SYSTEM, INCLUDING CARBON MARKETS.



ENERGY PARTNERSHIP STUDENT OUTREACH

SITE VISITS

The Woodside Monash Partnership (WMP) has brought together an ecosystem of high performing students and early career researchers (ECRs) since its establishment in 2016.

With a focus on the strategic themes of the partnership which include new energy, carbon capture and utilisation, additive manufacturing; a new initiative launched in 2024 by students for students and ECRs aimed to create further industry engagement opportunities. The initiative wrapped up its inaugural year very successfully with nine site visit excursions that saw over 130 students, ECRs and staff participating in one or more of the following site visits:

1. AGL Loy Yang Mines, which provides feedstock to the Hydrogen Energy Supply Chain (HESC) Project.
2. J-Power Latrobe Valley Coal Gasification and Refining Plant for Hydrogen Production Plant, which makes up Stage 1 of HESC.

3. Kawasaki Port Hastings Hydrogen Liquefaction, Liquid Hydrogen Storage and Suiso Frontier Ship Loading Site where hydrogen is shipped off to Kobe, Japan (Stage 3 of HESC).
4. ElectraLith, a world-renowned start-up in Direct Lithium Extraction (DLE) and Refining.
5. Jupiter ionics, experts in lower-carbon ammonia production and innovation.
6. Yakult Production Facility.
7. Toyota Hydrogen Experience Centre.
8. UNEEK Bending, leaders in metal bending, rolling, and welding solutions.
9. SPEE3D, Cold Spray Additive Manufacturing (CSAM) Technology.

We are excited to see our WMP students and ECRs further enhance and expand their industry engagement portfolio in the years to come.

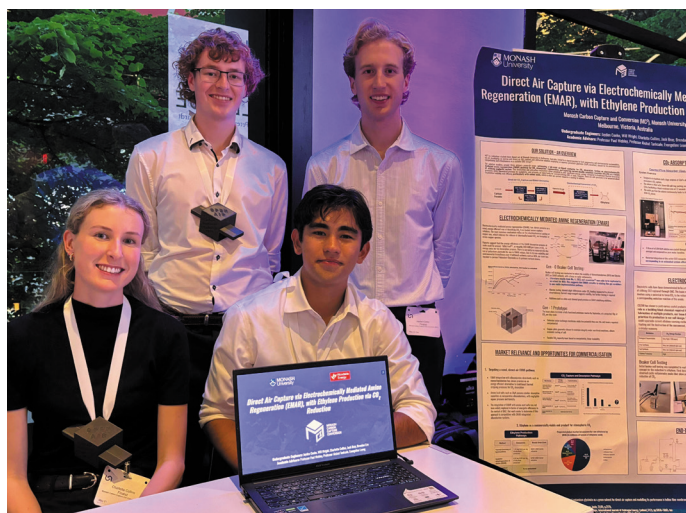


(L-R from top left): Toyota Hydrogen Experience Centre, AGL Loy Yang Mines, ElectraLith, J-Power Latrobe Valley Coal Gasification and Refining Plant, SPEE3D, UNEEK Bending, Yakult Production Facility, Jupiter ionics, Kawasaki Port Hastings Hydrogen Liquefaction, Liquid Hydrogen Storage and Suiso Frontier Ship Loading Site

OPENAIR COLLECTIVE'S 2024 CARBON REMOVAL CHALLENGE

Jayden Cooke, William Wright, Charlotte Collins, Jack Bray, comprising the innovative team behind the project 'Monash Carbon Capture and Conversion - Direct Air Capture via Electrochemically Mediated Amine Regeneration (EMAR), with Ethylene Production via CO₂ Reduction' achieved recognition as finalists for the prestigious OpenAir Collective's 2024 Carbon Removal Challenge, showcased in New York City on May 21st, 2024.

This commendable achievement highlights their dedication to tackling environmental challenges. The team was awarded a stipend of USD 2,500, supplemented by an additional USD 1,000 grant from XPRIZE, along with exclusive Carbon Removal Challenge Swag, in recognition of their ground breaking efforts.



Will Wright, Jayden Cooke, Charlotte Collins and Jack Bray at the OpenAir Collective's 2024 Carbon Removal Challenge.

SHOWCASING INNOVATION: RED PROGRAMME STUDENTS AT THE 2024 RED SHOWCASE EVENT CELEBRATING YOUNG RESEARCHERS

The RED Showcase event on 11 July 2024 celebrated the work of students in the Research, Education, and Development (RED) programme, highlighting their research conducted over a four-week intensive period at Monash University. The event featured projects supported by RECARB HUB and WMEP, focusing on carbon capture and sustainability.

Research Topic 1: Carbon Capture Devices (CCD) in Urban Spaces

Team 1's project explored the integration of carbon capture devices (CCD) into urban areas to reduce carbon emissions and educate consumers. Their research focused on the potential impact of CCDs, strategies for incorporating them into city infrastructure, and methods to enhance public acceptance.

The team, known as "Carbon Copies," identified a significant knowledge gap and public skepticism surrounding CCDs. To address this, they developed an interactive and immersive educational experience, allowing consumers to engage with real-world carbon challenges and future solutions.

Their approach aimed to drive awareness, behavioural change, and greater societal acceptance of carbon capture technology.

Team 2, known as "Catalytic Converters", worked to improve public perception via education at expos, focusing on influencing companies in the food and beverage sector. Their project focused on working with a real brand, such as Asahi's "Solo" beverage, to produce "Solo Green Edition", a beverage using captured carbon dioxide for its fizz. This could not only be sold but would also be a great stepping stone to educate consumers on the capability of CCD, as well as educate other companies in food and beverage on the opportunity.

Research Topic 2: Market Analysis and Consumer Awareness of Carbon-Abated Products

The second project, led by the Sustainable Consumer Intelligence (SCI) team, focused on market analysis and consumer awareness of carbon-abated products. Their research examined consumer behaviour, market trends, and strategies to promote sustainable purchasing decisions. A key finding was the growth potential of carbon-abated cement, particularly in flooring for new homes. To drive adoption, the team developed a business case and marketing strategy, emphasising consumer education, awareness campaigns, and industry collaboration. Their work, showcased at the RED Showcase event, highlighted the power of interdisciplinary research in tackling environmental challenges and demonstrated the impact of RECARB HUB and WMEP's outreach programmes in fostering innovation and sustainability education.





**WE ARE COMMITTED TO WORKING
WITH WOODSIDE TO HELP
THE COMPANY DEVELOP NEW
LOWER-CARBON PRODUCTS AND
SERVICES.**

NEW ENERGY TECHNOLOGIES

ULTRA-LOW COST SOLAR PV

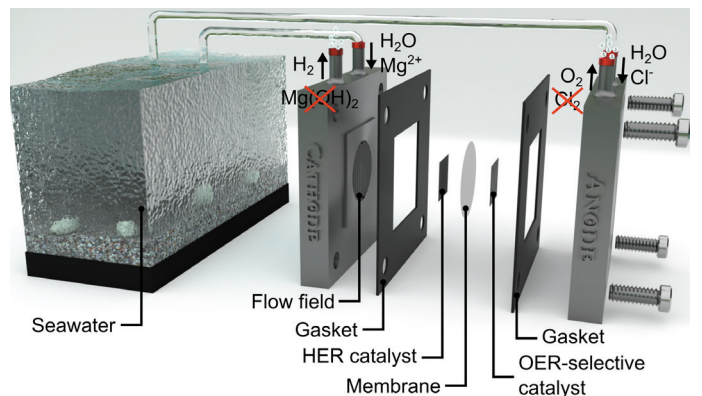
- Novel approaches to reduce the cost of solar electricity through the deployment of lightweight PV modules were demonstrated at real scales.
- System-level technology developments were patented, certified and assessed to validate their techno-economic and commercial feasibility.
- The research also included long-term developments toward improving the stability and longevity of lightweight PV modules and the demonstration of semi-automated PV system deployment approaches.



Lightweight PV modules

EFFICIENT ELECTRODES FOR SEAWATER ELECTROLYSIS

- The project developed electrodes and electrolyser devices that enable robust electrolytic generation of hydrogen from seawater.
- Anodes avoiding the formation of significant amounts of free chlorine during 2 weeks of robust operation, and electrolyser designs preventing cathode passivation with magnesium hydroxides were developed.
- Robust hydrogen generation from seawater using an integrated forward osmosis and electrolysis device was demonstrated.

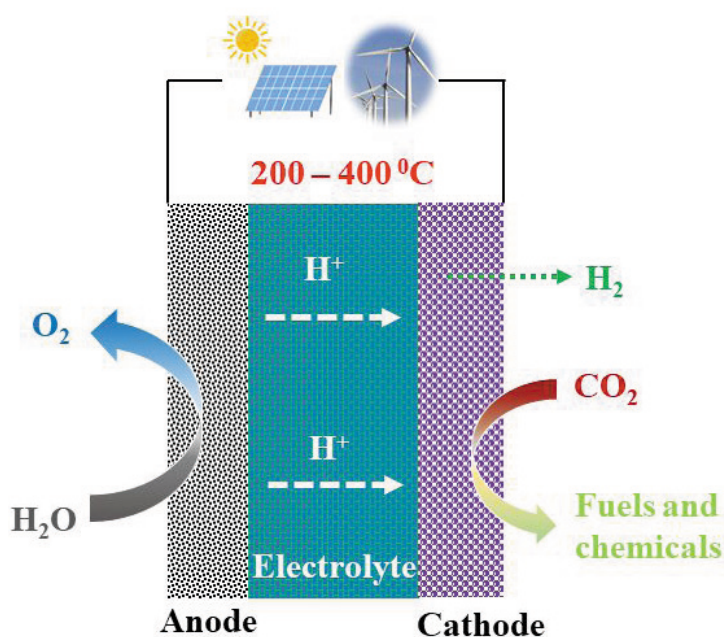


A low-temperature electrolysis cell generating pure hydrogen (H₂) and oxygen (O₂) from seawater avoiding the formation of poisonous chlorine gas and electrode scaling

NEW ENERGY TECHNOLOGIES

LOW ENERGY CERAMIC ELECTROLYSIS CELLS FOR RENEWABLE ENERGY TECHNOLOGY

- Graphene, boron nitride (BN), and solid acid (H₃Sb₃P₂O₁₄) nanosheets were developed to construct high-temperature protonic electrolyte membranes for hydrogen production via water electrolysis and CO₂ conversion into fuels and chemicals using renewable energy.
- Water electrolyzers utilising graphene/BN/phosphoric acid membranes achieved a current density of about 2.26 A cm⁻² at 2 V and 250°C, using IrO₂ and Pt/C as the anode and cathode catalysts, respectively.
- H₃Sb₃P₂O₁₄ nanosheet membranes exhibited high proton conductivity, reaching 110 mS/cm at temperatures up to 250°C due to their strong moisture affinity.



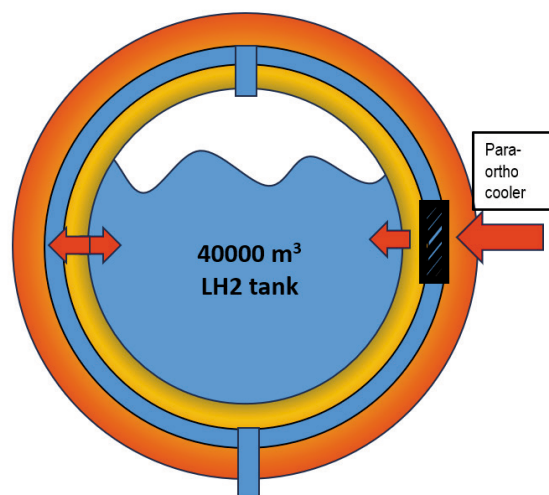
The proposed low temperature protonic ceramic electrolysis cells suitable for high-efficiency and low-cost hydrogen (H₂) production and carbon dioxide (CO₂) conversion into renewable fuels and chemicals

LIQUID HYDROGEN BOIL OFF GAS MANAGEMENT

- Recovering boil off exergy through a vapour cooled shield on a 40000 cubic meter liquid hydrogen storage tank could reduce the net boil off rate by 60%.
- Applying an external magnetic field to a para-ortho catalytic cooler could enhance the conversion rate by 46% which may enable its use for additional cooling in a vapour cooled shield.
- The volume of catalyst required for ortho-para conversion exponentially increases below temperatures of 40 Kelvin and requires additional design optimisation to achieve energy efficient liquefaction.

Published works:

- Wang et al Applied Energy 384 (2025) 125356 (<https://doi.org/10.1016/j.apenergy.2025.125356>)
- Wang et al Applied Thermal Engineering 256 (2024) 124054 (<https://doi.org/10.1016/j.applthermaleng.2024.124054>)



Vapour cooled shield intercepts heat leak and accelerates tank cool down time

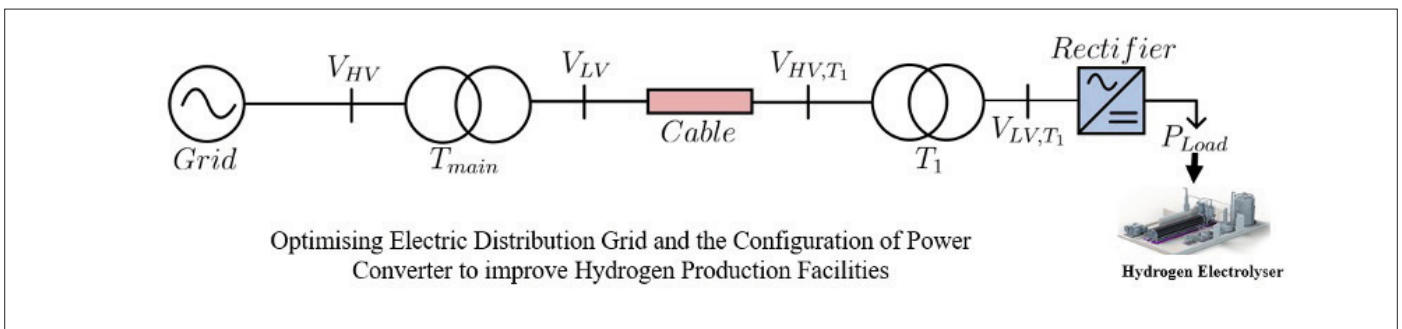
Cross-section of a liquid hydrogen storage tank employing a vapour cooled shield.

NEW ENERGY TECHNOLOGIES

OPTIMUM ELECTRICAL DISTRIBUTION SYSTEM FOR HYDROGEN PRODUCTION FACILITIES: TOPOLOGY, DESIGN, CONTROL AND EFFICIENCY

- **Techno-economic Optimisation:** Developed a Mixed-Integer Quadratic Constrained Programming (MIQCP) optimisation model using PYOMO and Gurobi to minimise the cost and maximise efficiency of the Electrical Distribution System (EDS) for hydrogen production.

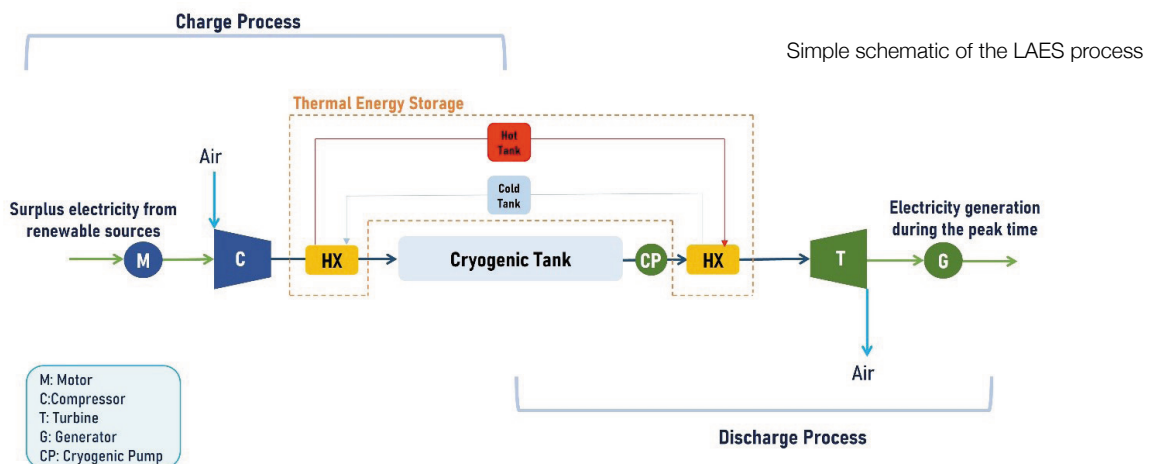
- **Comparative Analysis of EDS Configurations:** Investigated multiple converter topologies to reduce harmonic distortions and enhance system performance, leading to a cost-efficient and high-performance design for both single and parallel electrolyser configurations.
- **Grid Cost Impact and Future Scope:** Demonstrated that grid power cost is a key factor in operational expenses, highlighting the need for investment in renewable energy integration and potential participation in ancillary services such as energy arbitrage and frequency control.



EXPLORING THE INTEGRATION OF LIQUID AIR ENERGY STORAGE WITH SOLAR AND LNG SYSTEMS

- **Standalone Liquid Air Energy Storage (LAES) System Investigation:** This stage involves evaluating the performance of a standalone LAES system. It includes investigating various liquefaction processes used during the charging stage of LAES systems, such as cascade processes and propane-precooled mixed refrigerant processes. The goal is to identify processes that are best suited for this energy storage system.

- **LAES-Solar Farm Integration:** This stage examines the benefits of integrating LAES with solar farms. The integration of solar farms with LAES systems will be analysed, focusing on electricity and heat integration to maximise the system's efficiency and benefits.
- **LAES-Solar Power Plant Integration for Powering LNG Units:** In this stage, the integration of LAES and a solar power plant to supply stable electricity to an offsite LNG unit will be explored. The investigation will determine how the combined system can reliably meet the electricity needs of the LNG unit.

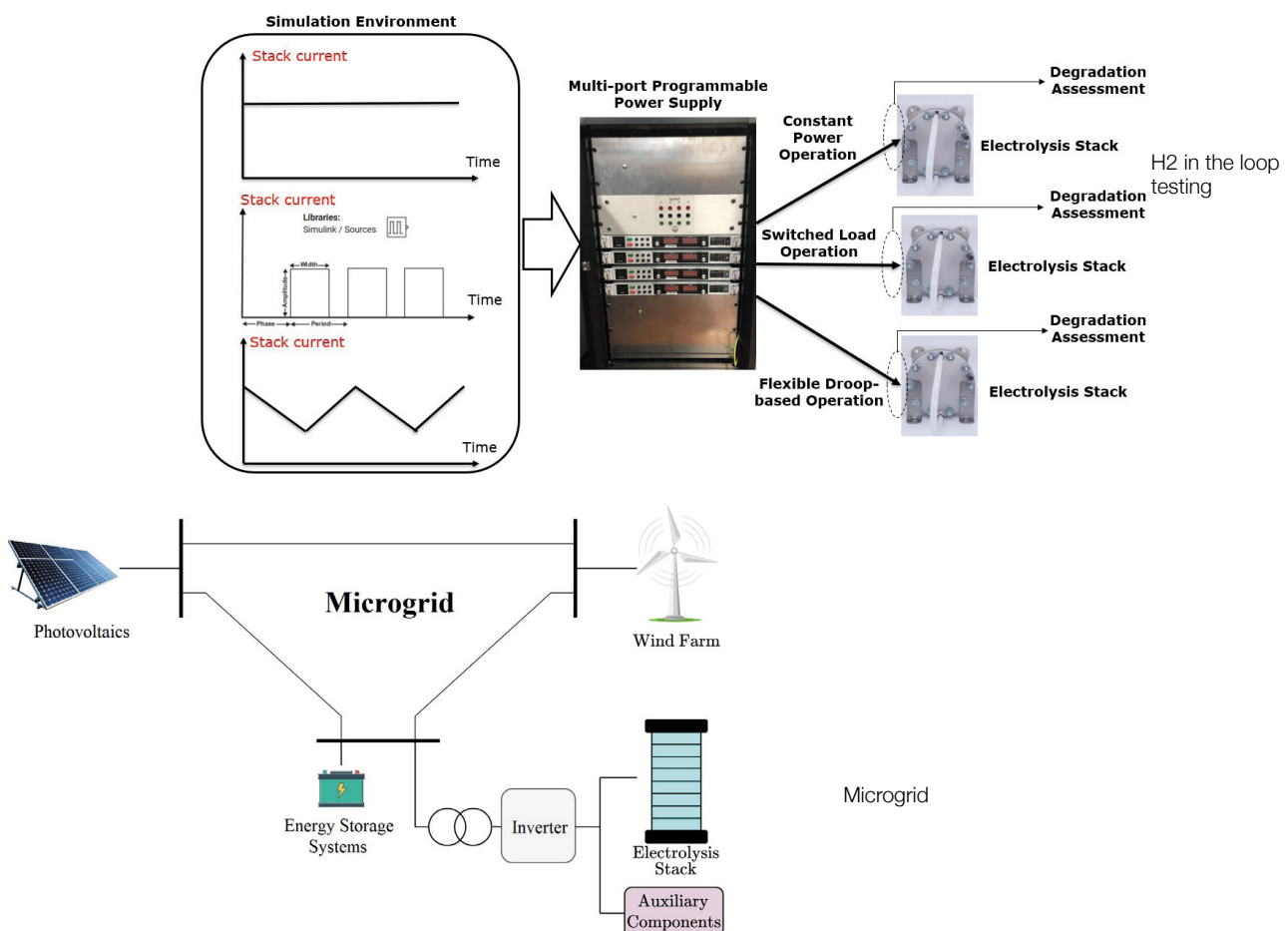


NEW ENERGY TECHNOLOGIES

ELECTROLYSER TECHNOLOGY FOR ENHANCING GRID STABILITY

- Investigation on the potential capabilities of electrolysis plants in supporting stable operation of microgrids with variable energy resources, including abilities in providing frequency control and voltage control support.

- Development of systematic modelling framework for system-level studies of electrolysis plants within microgrids a long with an automated digital-twin-based platform to facilitate multiple system studies with variable wind and solar resources.
- H2-in-the-loop setup and testing on electrolysis stack degradation and scale-up to further validate the possibility of flexibility provision from electrolysis plants, as well as the associated developed modelling framework and simulation models.

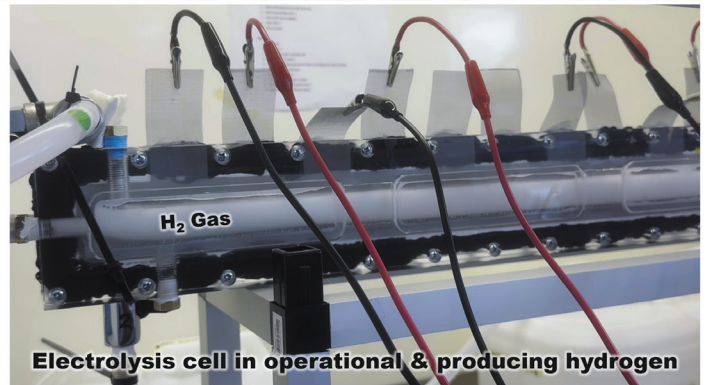
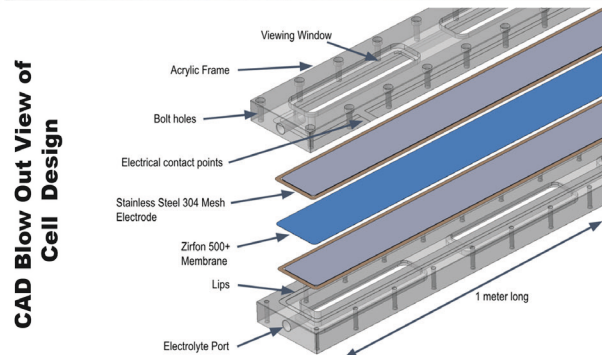
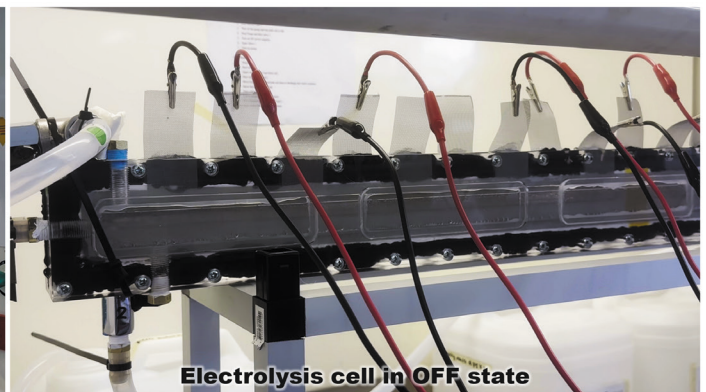
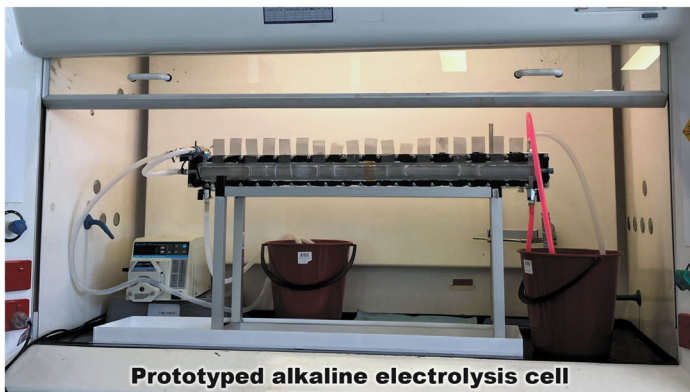


NEW ENERGY TECHNOLOGIES

RAPID PROTOTYPING OF H2 FENCE

- Design and fabrication of 1m long alkaline electrolysis cell.
- Successful hydrogen production from cell with second prototype.

- Achieved maximum current density of 108 mA/cm² and a thermodynamic efficiency of 54.7%.



H2 Alkaline Cell Design and Build

PROCESS INTEGRATION OF NET ZERO ENERGY, HYDROGEN AND AMMONIA PRODUCTION

- The combination of the NET Zero Cycle with alkaline electrolyzers results in a substantial efficiency enhancement, reaching 56.5%.
- A comprehensive sensitivity analysis was performed to evaluate the impact of critical variables, with detailed explanations provided.
- The integrated system achieves a first-law thermodynamic efficiency of 62.5% and an exergy efficiency of 60.6%.



Process integration for hydrogen, ammonia and power production

CARBON CAPTURE, CONVERSION, AND UTILISATION

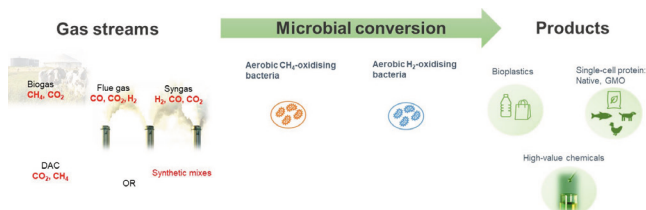
DIRECT AIR CAPTURE OF CO₂

- Design, construction and operation of a 10kg/day DAC plant.
- Design, construction and testing of a heat exchanger system for use in next generation DAC.
- Procurement and testing of a range of adsorbents for DAC application.
- Quantification of the role of water and CO₂ on adsorption performance.

UniDAC Pilot Plant



CONVERSION OF WASTE GASES INTO SUSTAINABLE FEEDS



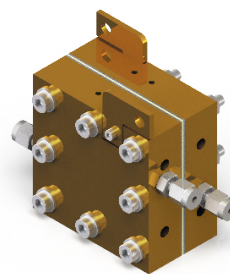
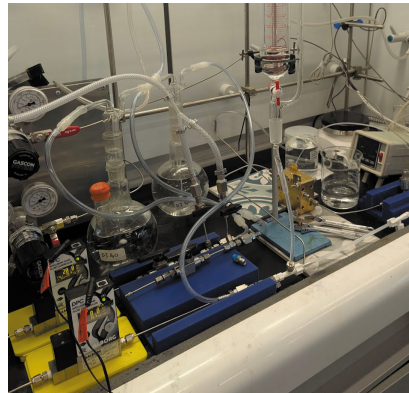
Waste gases into sustainable feeds

- Microbial adaptation to mixed gas environment by optimising the ability of chemoautotrophs, i.e. bacteria that grow using gases as their energy and carbon sources, to microaerobically convert mixed waste gases into commercial products.
- Genetically engineer aerobic fermenter, *Cupriavidus necator* into a syngas fermenter to broaden waste feedstocks and make it a lucrative organism.
- Gas-driven PHB polymer production to make non-fossil-based, biodegradable plastic by *Cupriavidus necator* under formate mixotrophy.

CARBON CAPTURE, CONVERSION, AND UTILISATION

MEDIUM TEMPERATURE ELECTROLYSIS FOR COMMERCIALLY VIABLE CO₂ UTILISATION

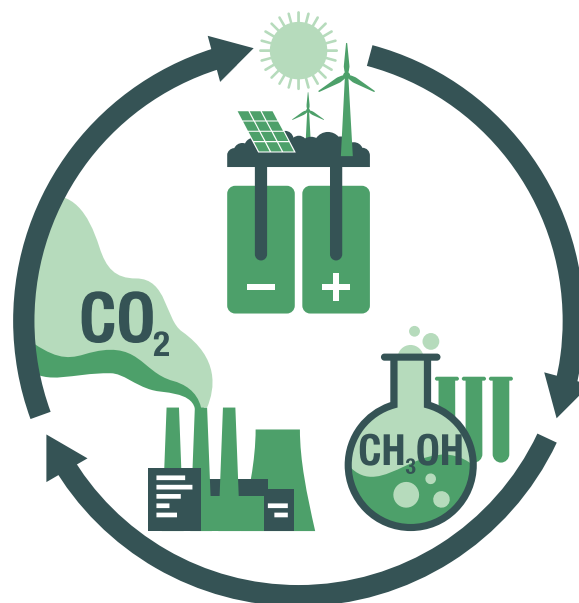
- Realising zero-gap, 'fuel-cell'-like electrochemical reduction of carbon dioxide (CO₂ER) in acidic media using off-the-shelf chemicals and materials, ensuring scalability as well as reliability for commercial applications.
- Achieved an average performance of 35% Faradaic Efficiency (FE%) over a period of 12 hours of continuous operation at 100 mA cm⁻² current density and overall cell voltage of - 1.0 V under partially wet dry gas inlet fed. It managed to sustain peak operation of above 50% FE for 4 hours under the same conditions.
- Focused on enhancing loading capacity of the catalyst towards the additive for higher FE towards CO₂ER at higher current densities.
- Monolith prototypes printed in the FutureLab.



An illustration of the zero-gap electrochemical reactor to split CO₂ into CO and water

VIABLE PATHWAYS FOR LOWER CARBON METHANOL IN THE ENERGY TRANSITION (PHD PROJECT)

- Identifying sufficiently comprehensive environmental assessments of lower carbon methanol production and use is a key step in developing a reliable sustainability assessment framework.
- The sensitivity of common simplifying methodological assumptions in life-cycle analysis of biomethanol production via forest residues has been assessed and compared with conventional production.
- It was found that grid decarbonisation must happen before environmental benefits of biomethanol occur and in a partially decarbonised grid, typical simple carbon accounting methods are insufficient to conclude global warming potential reduction.



ENERGY LEADERSHIP

In 2024, the Woodside Monash Energy Partnership held the Energy Leadership Conference which offered a unique platform to address the multifaceted challenges of climate change and energy transition on a global scale. The conference brought together policymakers, academics, industry leaders, and other key stakeholders internationally to engage in meaningful dialogue about global perspectives and local actions to mitigate the effects of climate change.

Climate change is a complex issue that intersects with scientific, political, economic, and social concerns. A United Nations report from October 2022 emphasised the need for an "urgent system-wide transformation" to a global lower carbon economy by 2030 to avoid the worst impacts of climate change. Although there is consensus on the scale of emissions cuts required, the path to achieving them remains a subject of debate. Different countries have diverse plans and priorities based on their internal political landscapes, energy dependencies, financial situations, resources, and living standards. This variety of approaches can either hinder or support progress toward climate goals depending on how well they are coordinated.

The conference's aim was to bridge these varying perspectives and identify opportunities for better collaboration and coordination across different regions. It aimed to explore the drivers behind differing approaches worldwide and the potential for stakeholders to work together more effectively.

Furthermore, with the rapid advancements in climate and energy-related science and technology, such as the exponential growth of deployable wind and solar energy, carbon capture and utilisation technologies, and the burgeoning hydrogen technology sector. These innovations hold great promise for a sustainable future, but their successful adoption requires strong institutional support and community acceptance.

Through presentations, discussions, and debates, the conference provided an opportunity to challenge conventional thinking and offer fresh insights into diverse climate and energy strategies.

It examined the potential of technological innovation in carbon capture and renewable energy, as well as its feasibility for widespread adoption.

In summary, the 2024 Energy Leadership Conference was an opportunity for global collaboration and progress toward a more sustainable future. By bringing together thought leaders from various sectors, the conference aimed to forge a path toward a coordinated and effective response to climate change and energy transition. It was a landmark of the activity and achievement of the Energy Leadership theme for 2024.

In 2024, the Energy Leadership theme was also delighted to see the development of the following complementary projects to advance knowledge in this field.



ENERGY LEADERSHIP

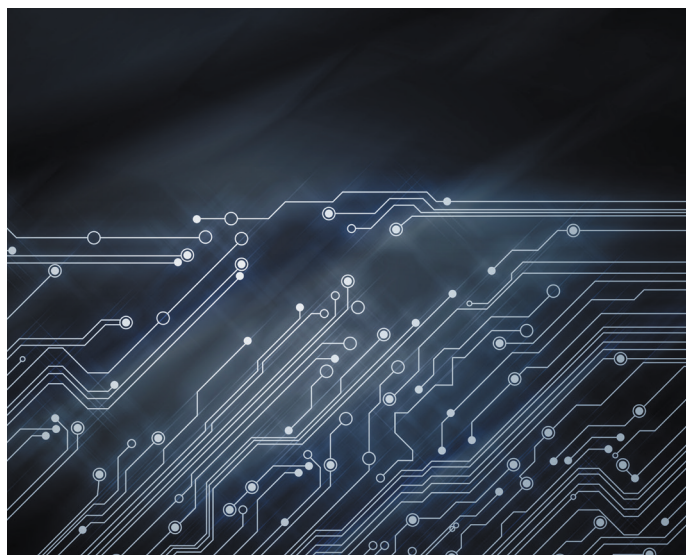
EFFICIENT REGULATORY PATHWAYS TO AUSTRALIA'S LOWER CARBON FUTURE

- Part of the ARC Research Hub for Carbon Utilisation and Recycling, the Energy Leadership has started this project which embarks on an evidence-based, researcher-centric, examination of Australia's legal and regulatory framework applicable to carbon mitigation technologies.



OPTIMISING AUSTRALIA'S ELECTRICITY SYSTEM: THE ROLE OF BLOCKCHAIN TECHNOLOGY

- This project explores the development of a unified and secure system for energy transition and trading, by leveraging informatics and blockchain technologies. This research sheds new light on the interaction between Sustainability Informatics and the operations of electricity systems. Specifically, it offers insights into how blockchain can be used to design an electricity transition scheme with a set of emerging solutions, which can assist the Australian government in providing a more reliable energy supply system.



LIFECYCLE ANALYSIS FOR LIQUEFIED NATURAL GAS AND AMMONIA

- Using a prior developed tool, this project extended current work and conducted a detailed lifecycle analysis for energy export scenarios for two locations in Australia.
- In this phase, the model was extended to incorporate information for the carbon intensity of grid-based electricity under a range of scenarios as an important requirement for certification of hydrogen production for grid-connected projects.



ENERGY LEADERSHIP

CLIMATE ACTIVE CARBON NEUTRAL CERTIFICATION - MOTIVATIONS, MARKETING STRATEGIES AND IMPACT OF VOLUNTARY CARBON NEUTRALITY IN THE AUSTRALIAN ECONOMY (PHD PROJECT)

- Investigates motivations and contextual factors of voluntary carbon neutrality by for-profit companies.
- Explores how Climate Active certified firms market and communicate their carbon neutral status.
- Investigates why some certified companies actively promote carbon neutrality while others stay silent - Green Marketing vs. Green Hushing.
- Assesses the impact of voluntary carbon neutrality on firms and their industries.



FUTURE POTENTIAL OF HYDROGEN DEMAND IN AUSTRALIAN TRANSPORT AND ENERGY-INTENSIVE INDUSTRY SECTORS: A GEOSPATIAL APPROACH (PHD PROJECT)

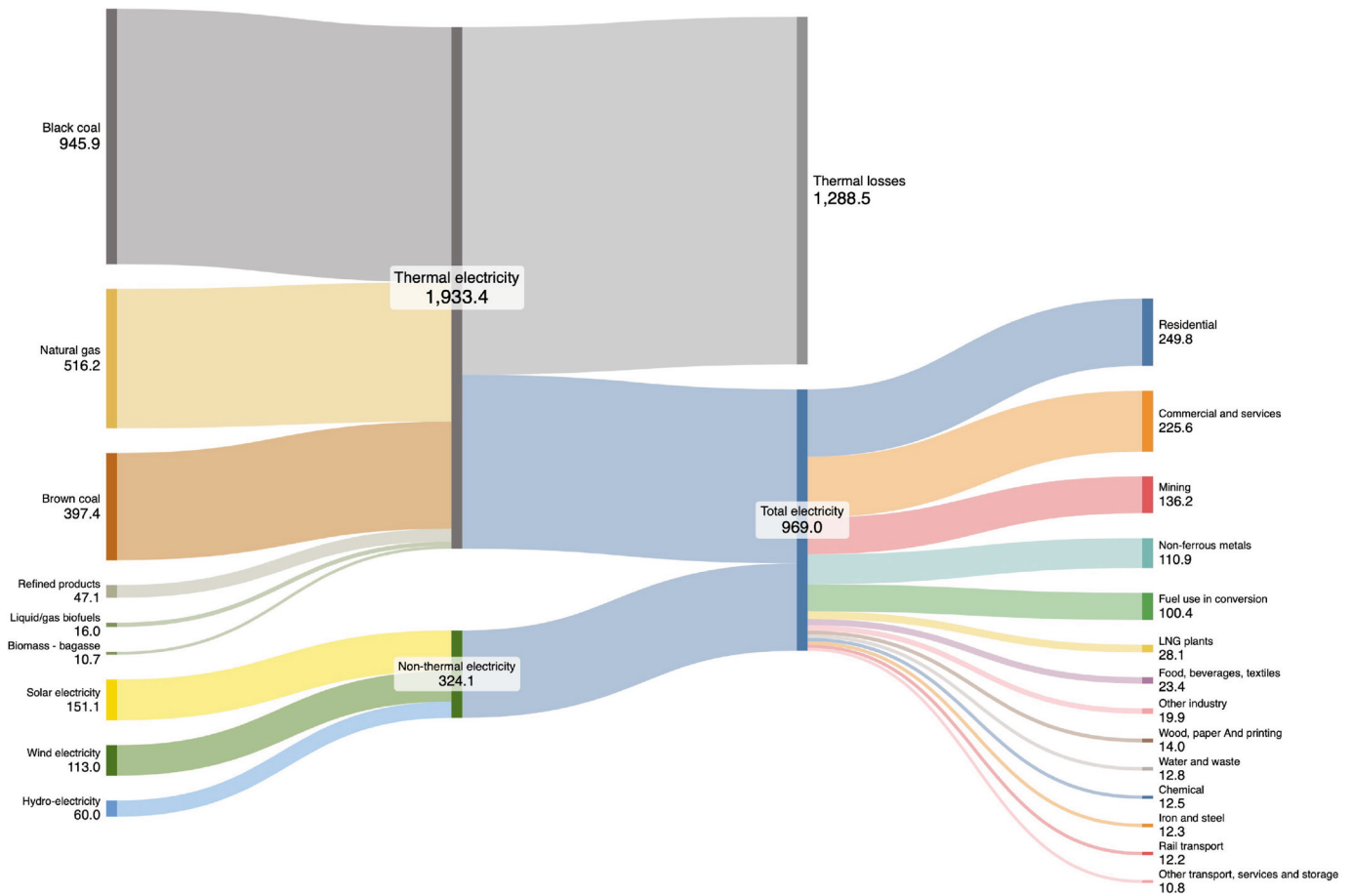
- Understanding hydrogen demand and its spatial variations is critical for efficiently simulating potential markets, planning infrastructures, and optimising costs across various sectors and regions.
- This project aims to quantify and map the future potential hydrogen demand in Australian transport and energy-intensive industries.
- This project strategically locates hydrogen refuelling stations based on the future distribution of hydrogen demand for heavy-duty vehicles.



ENERGY LEADERSHIP

EXPLORING THE MERIT ORDER OF ABATEMENT IN THE AUSTRALIAN CONTEXT

- This project takes a look at how Australia can most effectively decarbonise by examining the whole system together, rather than individual pieces. As shown in the current electricity flow diagram, this is a complex challenge where the system must transition from a coal dominated mix to one that is a lower carbon intensity while serving diverse sectors, from homes to heavy industry.
- The research uses advanced computer models to understand how different technologies could work together in practice. This includes studying how electric vehicles, renewable power, hydrogen fuel, and industrial facilities all connect and support decarbonisation across Australia's economy.
- By looking at the bigger picture, this approach helps identify practical paths to eliminate greenhouse gas emissions across the entire economy. It shows what infrastructure needs to be built and how quickly new technologies need to be adopted to reach Australia's emissions reduction goals. This information helps policymakers create more effective plans for achieving net-zero emissions, including the most effective use of renewables from a carbon abatement perspective.



Australia's Electricity Flows: Generation Sources to End Use Sectors (PJ), 2022-23
Sources: Australian Energy Statistics, OpenNEM

IMPACT

ARC RESEARCH HUB FOR CARBON UTILISATION AND RECYCLING (RECARB HUB)

Industrial Transformation Research Hub (2023 - 2028)

The ARC Research Hub for Carbon Utilisation and Recycling (RECARB Hub) aims to develop technologies to transform carbon dioxide emissions from our energy and manufacturing sectors into valuable products and create pathways to market to drive industry transformation. This hub aims to achieve this by developing novel electro-, thermo-, and bio-chemical methods for converting CO₂ from hard to abate sectors by producing technological pathways for CO₂ recycling. The outcomes of this Hub are likely to be transformative for industries, the economy, and society by transforming the fate of CO₂ from pollutant to feedstock. The benefits to Australia are intended to be the stimulation of a new industry, a skilled workforce for this emerging industry and a contribution to meeting CO₂ reduction targets.

SYNGAS PRODUCTION BY SOLID OXIDE ELECTROLYSIS (SOEC)

- An integrated system, including a high-temperature furnace, electrochemical workstation, Keithley instrument, and Agilent Micro-GC 2014 gas chromatograph, was successfully established to enhance SOEC research.
- Button and tubular cells were developed with optimised configurations, demonstrating improved electrochemical performance and efficiency.
- The Sr₂Fe_{1.5}Mo_{0.5} cathode achieved 2 Acm⁻² at 1.6 V and 800°C in SOEC mode, while a nano-composite BaCo_{0.7}Fe_{0.1}Zr_{0.1}Y_{0.1}O₃-YBaCo₄O₇ cathode exhibited low polarisation resistance (0.1112 Ω·cm²) and high-power density (1373 mW cm⁻² at 700°C), maintaining stability over 140 hours.

Published papers:

1. "Performance deviation analysis and reliability improvement during experimental development of lab-scale solid oxide single cells" available in *Energy and Environmental Science*. 17 (19): pp. 6873-6896. (<https://doi.org/10.1039/D4EE02581D>)
2. "Operando Studies Redirect Spatiotemporal Restructuration of Model Coordinated Oxides in Electrochemical Oxidation" available in *Adv. Mater.* 2025, 37, 2413073. (<https://doi.org/10.1002/adma.202413073>)
3. "Grain boundary engineering: An emerging pathway toward efficient electrocatalysis" available in *InfoMat.* 2024; 6(8):e12608. (<https://doi.org/10.1002/inf2.12608>)
4. "Fuel cells: Materials needs and advances" available in *MRS Bulletin* 49, 451-463 (2024). (<https://doi.org/10.1557/s43577-024-00722-9>)

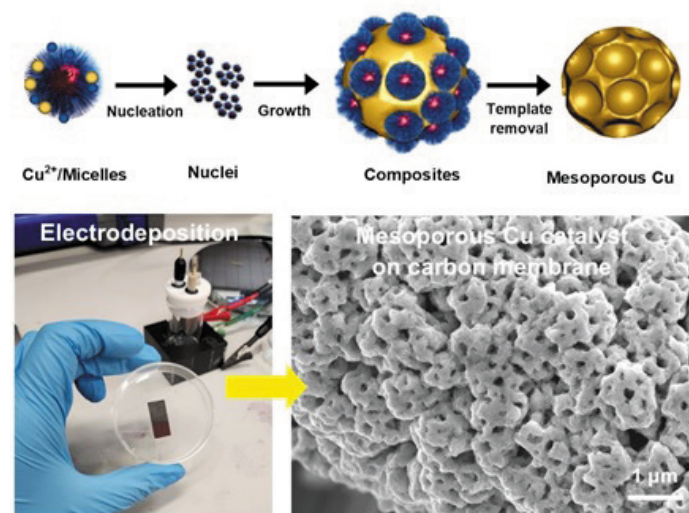


Advanced electrochemical performance evaluation system and gas analysis system

INDUSTRY IMPACT

ELECTRODE ARCHITECTURAL DESIGN FOR ENHANCED CARBON DIOXIDE REDUCTION PERFORMANCE UNDER AMBIENT CONDITIONS

- A novel chemical reduction process using commercial block copolymers enables precise control over pore formation and structural uniformity, allowing for tunable gold-to-copper ratios and controllable pore sizes for broad catalytic applications.
- A new electrodeposition method successfully fabricates mesoporous copper catalysts directly on carbon membranes, optimising deposition potentials (-0.3 V for spherical structures, -0.5 V for dendritic structures) and eliminating the need for dip-coating or catalyst ink preparation.
- The project has developed general soft-templating techniques for synthesising mesoporous metal catalysts, strengthened collaborations with NK Energy Frontier (Japan) and Woodside, and secured an internal grant (\$10,000, UQ-IITD) to further research biomass-derived metal catalysts for electrocatalytic reactions.



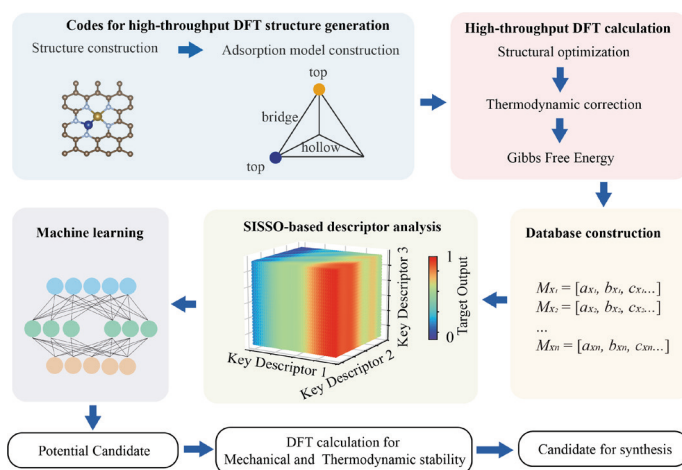
Fabrication of mesoporous Cu catalyst on carbon membrane

PLASMONICS FOR PHOTOCHEMICAL CONVERSION

- Researchers at Monash University and ANU successfully synthesised Ag-Pt nanoparticles in alloy and core-shell configurations, testing their catalytic efficiency for CO₂ conversion in both aqueous and gas-phase reactions, with real-time monitoring enabled by dark-field microscopy.
- ANU researchers integrated machine learning with DFT to accelerate the design of single-atom catalysts on Janus 2D materials, identifying Pt-doped 2D phase materials as highly selective catalysts for methane (CH₄) production.
- The project established an international partnership with IIT Bombay, contributed to two publications under review, was presented at four conferences in 2024, and fostered new national and international collaborations, advancing photocatalytic CO₂ reduction research.

Published papers:

1. “Atomic Dispersed Co on NC@Cu Core-Shells for Solar Seawater Splitting” available in Adv. Mater. 2024, 36, 2406088. (<https://doi.org/10.1002/adma.202406088>)
2. “Perspectives on Cu–Ag Bimetallic Catalysts for Electrochemical CO₂ Reduction Reaction: A Mini-Review” available in Energy Fuels 2024, 38, 7, 5659–5675. (<https://doi.org/10.1021/acs.energyfuels.3c05194>)



Methodology of the project

INDUSTRY IMPACT

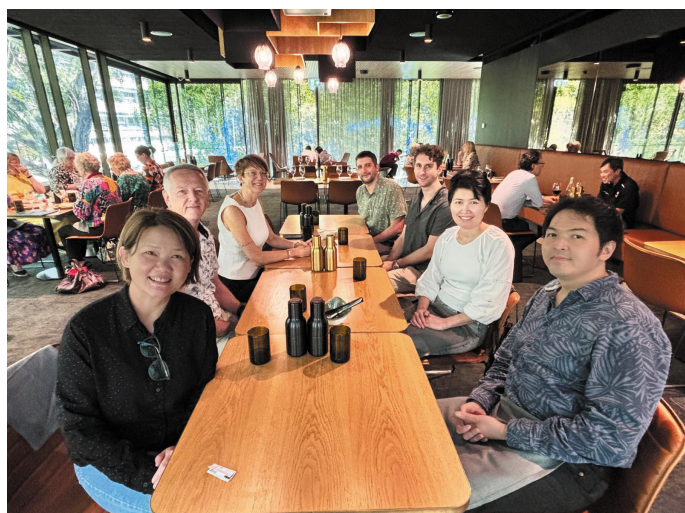
TWO-STEP BIOCONVERSION OF CO₂ INTO METHYL KETONES AND CHEMICAL REFINEMENT INTO JET FUEL

- Researchers at Monash, UQ, and QUT are developing a two-step process to convert CO₂ into methyl ketones for jet fuel. Key progress includes PHA biopolymer testing at Monash, gas fermentation establishment at UQ, and biomass conversion exploration at QUT using hydrothermal liquefaction.
- The project has led to significant dissemination efforts, including a co-authored publication on methyl ketone biofuels, conference presentations in Melbourne and Copenhagen, and ongoing collaboration with RWTH Aachen University for fuel application testing.

In 2025, UQ will focus on continuous gas fermentation and methyl ketone production, Monash will evaluate fermentation-derived methyl ketones as bio-plasticisers, and QUT will refine methyl ketones into jet fuel. Despite Fuchs Oil withdrawing as an official partner, they remain interested in supporting experimental testing and computational analysis.

Published papers:

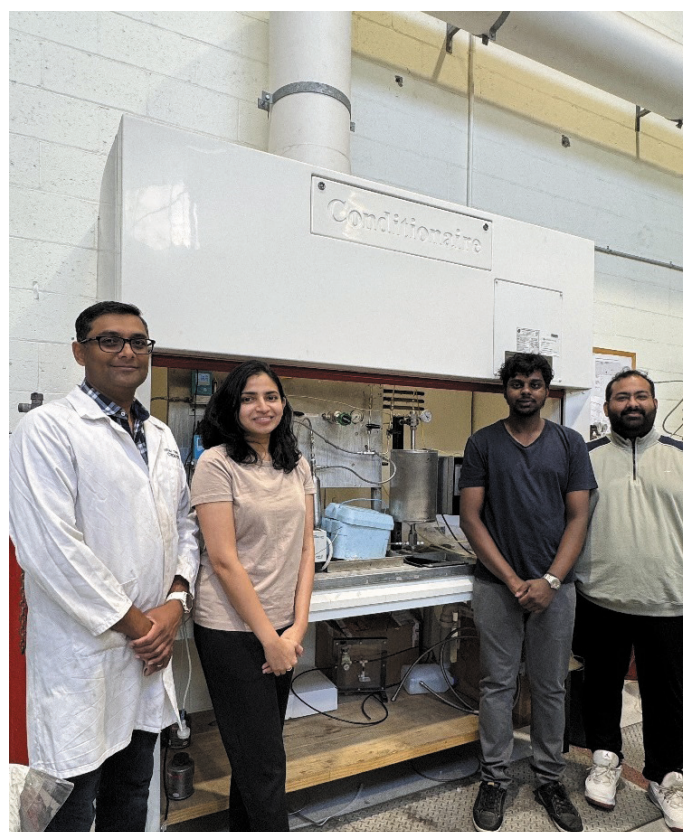
1. "Methyl ketones: a comprehensive study of a novel biofuel" available in Sustainable Energy Fuels, 2024,8, 2059-2072. (<https://doi.org/10.1039/D4SE00035H>)



(L-R): Dr Soo Leong (Hub Manager), Professor Paul Webley (Hub Director), Dr Birgitta Ebert, Professor Esteban Marcellin, Dr Timothy McCubbin, Dr Muxina Konarova, Dr Yusuf Kaneti.

DIRECT CO₂ HYDROGENATION TO ACETIC ACID VIA HETEROGENEOUS CATALYSIS

- Thermally transformed MOFs, including MIL-88b(Fe/Ni) and ZIF-based catalysts, have demonstrated high formic acid yields and selective production of valuable C₂₊ chemicals such as acetic acid and ethanol, highlighting their potential for efficient CO₂ conversion.
- Using techniques like Anomalous Small Angle X-Ray Scattering (ASAXS) and X-Ray Photoelectron Spectroscopy (XPS), the research provides deeper understanding of transition metal active sites in MOF-derived catalysts, improving knowledge of their role in CO₂ hydrogenation.
- The project has secured National Industry Program funding with BASF Australia and engaged in international knowledge exchange, including participation in the University of Liverpool's catalysis summer school, strengthening both academic and industrial impact.



The Carbon utilisation and recycling team- Hydrogenation rig for efficient CO₂ utilisation and sustainable acetic acid production. (L-R) - Professor Akshat Tanksale, Satya Rameswarapu, Dr Rajan Lakshman, Dr Swarit Dwivedi

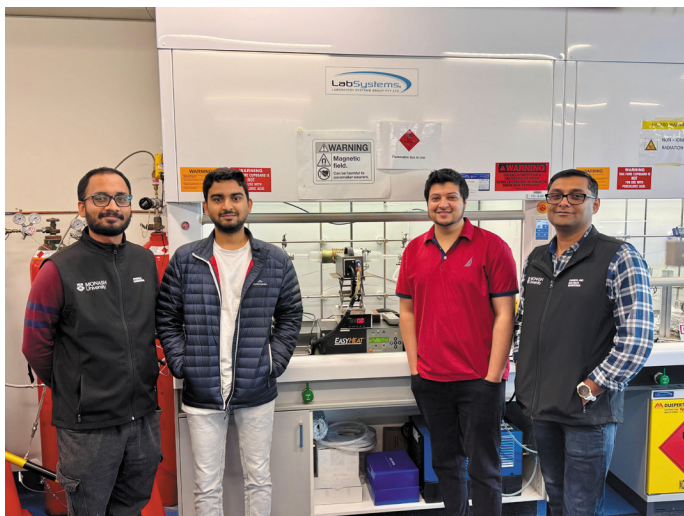
INDUSTRY IMPACT

SCALE-UP OF INDUCTIVELY HEATED DRY REFORMER

- The inductively heated electrified reformer achieved >99% CH₄ and CO₂ conversion in Dry Reforming of Methane (DRM), with successful reactor scale-up from processing 0.5 kg to 3 kg of CO₂ per day, demonstrating its industrial viability.
- The introduction of the tumble-coating method reduced catalyst preparation time from 4 hours (dip-coating) to just 0.5 hours while maintaining comparable catalytic activity, enhancing scalability for industrial applications.
- Perovskite-coated Inconel 625 monoliths were successfully tested for syngas production, supporting the development of an optimised, sustainable dry reforming process for cleaner energy production.

FRAMEWORKS TO SUPPORT TRADE IN EMBEDDED CARBON PRODUCTS

- This collaborative project between ANU and Monash University aims to create strategies for measuring and reducing embedded emissions in low-carbon traded products, supporting global efforts in climate change mitigation.
- 2024 marked the establishment phase, with the recruitment of Dr. Saule Burkitbayeva (postdoctoral fellow, ANU) and Bushra Muneer (PhD student, Monash), along with additional research students, strengthening the project's research capacity.
- The project has actively engaged with media, government, and international organisations, including the WTO, where CI Associate Professor Emma Aisbett advocated for standardised carbon accounting frameworks to ensure transparency and fairness in global trade.



Electrified Reformer Team - Advancing inductively heated reforming technology
 (L-R): Ashwin Hatwar, Mohammad Raihan Arfin, Dr Hamza Asmat, Professor Akshat Tanksale



(L-R) Bede Denman, Dr Saule Burkitbayeva, and Associate Professor Emma Aisbett

EDUCATION AND OUTREACH

GLOBAL CONFERENCE ON CLIMATE CHANGE AND ENERGY TRANSITION WRAPS UP WITH A CALL FOR COLLABORATIVE ACTION

Overview of the Conference

Breakthroughs in science and technology related to climate change and energy transition are accelerating, including the exponential growth in deployable wind and solar energy, advances in carbon capture and utilisation, and the emergence of a rapidly growing hydrogen technology. However, their adoption and dissemination require institutional support and community acceptance.

The inaugural Woodside Monash Energy Partnership (WMEP) Conference on Climate Change and Energy Transition, themed “The Role of Institutions, Technology and Industry,” concluded with a powerful call for coordinated action against climate change. Held over two days from June 28th to 29th 2024 at Monash University Prato Centre, the conference gathered a diverse array of stakeholders, including policymakers, academics, and industry leaders, to explore strategies for tackling the multifaceted challenges posed by climate change.

At the heart of the conference was the recognition that climate change is not just a scientific issue but also a political, economic, and social one, underscoring the need for a holistic approach that embraces diverse perspectives and solutions.

Strategic Vision

Professor Cecilia Hewlett, Monash University’s Pro Vice-Chancellor (Europe), formally launched the conference, emphasising the critical importance of addressing climate change. Highlighting climate change as one of the three priorities in Monash University’s Strategic Plan - Impact 2030, Professor Hewlett outlined that this conference is very much in line with

the university’s commitment to tackling these challenges through research, education, and collaboration with government, industry, and the community.

Professor Fang Lee Cooke, Conference Chair and WMEP Energy Leadership Theme Lead, further emphasised the need for “a pluralistic view and an inclusive approach to tackling climate change as a global challenge with local solutions.”

Diverse Participation and Collaborative Efforts

The conference united a wide range of participants from around the globe, with 50 delegates representing diverse countries and backgrounds, all coming together for this inaugural conference. With over 20 high-impact presentations and sessions, the conference stimulated thought-provoking discussions and fostered extensive dialogue among participants.

An industry panel session led by the Australia Italy Business Association explored the frontiers of energy transition within aligned industries. Valuable insights were provided by Austrade’s William Peasland, Rocco La Rovere from Infinite Green Energy Italia SPA, Francesco Pirovano from Intesa Sanpaolo, and Giovanni Sarti from Baker Hughes.

Another notable panel was the “Meet the Editors Session,” chaired by Professor Stelvia Metos, Co-Editor-in-Chief of Technovation, where detailed insights into how scientific journal reviewers and editors evaluate submissions were shared. Esteemed panelists included Professor Paul Webley, President of the International Adsorption Society and editor of its flagship journal Adsorption; Professor Jeremy Hall, former Editor-in-Chief of the Journal of Engineering and Technology Management; and Professor Fang Lee Cooke, Co-editor-in-Chief of the International Business Review.



Professor Fang Lee Cooke



Conference group

EDUCATION AND OUTREACH

All which was made possible through the support from sponsors such as the Australian Trade and Investment Commission (Austrade), the Australia Italy Business Association, Woodside Energy, the Digital Futures at Work Research Centre (digit), the ARC Centre of Excellence for Green Electrochemical Transformation of Carbon Dioxide (GETCO2), Monash University's Department of Chemical and Biological Engineering, Monash Business School, and Faculty of Information Technology.

Keynote Speakers and Core Themes

Keynote speakers Professor Jeremy Hall (Director of the Science Policy Research Unit (SPRU), University of Sussex, UK), Professor Niall Mac Dowell (Imperial College London, UK), Professor Dr. Sigrid Stagl (Director of the Institute for Ecological Economics, WU Vienna), Peter Metcalf (Vice President, Climate and Sustainability, Woodside Energy), The Honourable Timothy Wilson (former Federal Assistant Minister to the Minister for Industry, Energy, and Emissions Reduction, Australia) [FLC2] highlighted the pivotal roles of institutions, technology, and industry in addressing climate change. One of the key themes explored was the divergent approaches taken by different countries, influenced by factors such as internal politics, energy dependencies, and economic disparities. While these differences present challenges, they also offer opportunities for collaboration and innovation.

Engaging Discussions and Collaborative Solutions

Participants engaged in discussions on a wide range of topics, from the role of policy frameworks in facilitating low-carbon transitions to the impact of social media and activism on climate

action. The conference highlighted the need for collaboration among academia, industry, and government to overcome political polarisation and ensure inclusive decision-making processes. By fostering dialogue and knowledge exchange, the conference aimed to pave the way for more effective and sustainable solutions to the climate crisis.

The conference concluded with an engaging workshop addressing "The Climate Change and Energy Transition: Where Do We Go from Here?". With a focus on immediate and long-term strategies in individual and synergistic ways of making an impact.

Looking Ahead

Participants of the conference expressed optimism about the potential for continued collaboration and innovation in the fight against climate change. By harnessing the collective expertise and resources of diverse stakeholders, they believe that meaningful progress can be made towards building a more resilient and sustainable future for all.

WMEP Conference on Climate Change and Energy Transition: The Role of Institutions, Technology and Industry, served as a timely reminder of the pressing need for decisive action to address one of the greatest challenges of our time. As the world grapples with the far-reaching impacts of climate change, conferences like these play a crucial role in galvanising collective efforts to safeguard the planet for future generations.



EDUCATION AND OUTREACH

MONASH STUDENT TEAM INITIATIVE (MSTI)

The Woodside Monash Partnership is a proud industry partner and advisor to multiple high-performing engineering student teams under the MSTI. Student-led teams, clubs, and societies at Monash University foster an ecosystem of passionate students who develop hands-on skills to solve real problems and compete on the world stage. Teams we have supported include

- Monash Carbon Capture and Conversion (MC3) - a team researching, innovating and designing carbon capture and conversion solutions in the fight against climate change.
- Monash Engineering Club (MEC) - a team passionate about the energy industry, creating opportunities to learn about cutting edge technology in the energy sector.

The Woodside Monash Energy Partnership continues to be a proud supporter of these teams, which have demonstrated the power of student-led initiatives in driving impactful change. Through their collective efforts, they are not only contributing to advancements in climate technology, manufacturing practices, and biotechnology innovations but are also inspiring a new generation of leaders committed to building a more sustainable and resilient world.

RESEARCH EXPERIMENTATION AND DISCOVERY (RED) PROGRAM

The Research Experimentation and Discovery (RED) program is a Flagship Rich Educational Experience that enables students from 93 degrees to collaborate with world-leading Monash researchers from all parts of the University. In RED, students collaborate with researchers on an authentic research challenge focussed on how to amplify research impact, with training and support from the Monash research community. RED elevates students' employability and their capacity to lead change, helps our students experience research before they complete their degrees, and ensures that our students are at the forefront of shaping positive futures across either academic or professional careers. The two projects that the students worked on were;

- Feasibility and Public Perception of Carbon Capture Devices in Urban Spaces - Thriving Communities stream: This project explores the practicality and public acceptance of installing carbon capture devices in urban public spaces such as parks, transportation hubs and commercial districts.
- Market Analysis and Consumer Awareness of Carbon-Abated Products: This project involves connecting current carbon-to-products technology and commercialisation pathways to understand the potential demand for products made from recycled CO₂, focusing on consumer awareness and acceptance.

monash.edu/woodside/news/2024/showcasing-innovation-red-programme-students-at-the-2024-red-showcase-event-celebrating-young-researchers

FOSTERING FUTURE LEADERS IN ENGINEERING: 2024 MONASH ENGINEERING POSTGRADUATE CONFERENCE

As part of our commitment to education and knowledge-sharing, the Woodside Monash Partnership was proud to again sponsor the 2024, 4th Engineering Postgraduate Conference at Monash University. This annual event brought together postgraduate students from all five engineering departments, providing a dynamic platform for collaboration, innovation, and academic excellence.

The conference featured keynote speeches, panel discussions, and student research presentations, fostering meaningful dialogue on cutting-edge engineering advancements. By supporting this initiative, we continue to invest in the next generation of engineers, empowering them with the opportunity to connect, learn, and drive forward solutions that will shape the future of energy and technology.

At the heart of the Woodside Monash Partnership is the belief that innovation thrives in an environment of shared knowledge and diverse perspectives. Events like this conference exemplify our dedication to bridging academia and industry, ensuring that emerging engineers are well-equipped to tackle the challenges of tomorrow.

We look forward to continuing our support for programs that inspire learning, collaboration, and progress in the engineering community.



Professor Paul Webley speaking at the Postgraduate Conference



Poster presentations

WMEP SPONSORSHIP

2024 ICHME AUSTRALIAN AND NEW ZEALAND NATIONAL DESIGN PROJECT PRIZE

In 2024, the Woodside Monash Energy Partnership (WMEP) proudly sponsored the esteemed Institution of Chemical Engineers (IChemE) Australian and New Zealand National Design Project Prize. This sponsorship highlighted WMEP's commitment to excellence and innovation in chemical engineering. By supporting this prestigious award, WMEP acknowledged projects that demonstrated technical prowess, creativity, and dedication to sustainable practices in design and execution. This sponsorship reaffirmed WMEP's pivotal role in advancing chemical engineering and promoting sustainable solutions for the energy sector. Through this commitment, WMEP served as a catalyst for transformative research and development, driving progress towards a more sustainable and efficient energy future.

This year, the prize was awarded to the University of New South Wales, and a very close runner-up, the University of Canterbury in New Zealand. Recipients of the Student Design Prize were formally invited to attend the Chemeca conference gala dinner and presented their certificate by Professor Paul Webley

VICTORIAN CHEMICAL ENGINEERING STUDENTS INDUSTRY NIGHT INDUSTRY SPONSOR

In collaboration with Monash University Chemical Engineering Student Society (MUCESS) and RMIT University Chemical Engineering Student Society (ACES), the Woodside Monash Energy Partnership proudly supported the student teams to host the Victorian Chemical Engineering Students Industry Night. The evening proved to be a valuable platform to introduce students to the diverse opportunities offered by Woodside, including internships, graduate roles, summer programs, and more, extending into the year 2024 and beyond. The evening featured a dynamic panel discussion and Q&A session, followed by a networking segment where company representatives engage directly with aspiring chemical engineering students.

MONASH ENGINEERING CLUB (MEC) INDUSTRY SPONSOR

The Woodside Monash Partnership is proud to be an Industry Sponsor of the Monash Engineering Club (MEC), a student-led organisation dedicated to fostering industry engagement, professional development, and technical excellence among engineering students.

Through this sponsorship, we support MEC's initiatives that bridge the gap between academia and industry, providing students with valuable opportunities to network with professionals, gain industry insights, and develop practical skills that prepare them for the evolving engineering landscape.



Design prize winners from UNSW with Professor Paul Webley: Cameron Suen, Junias Tjanaria, Varisara Laosuksri, Oliver Jackson, Adrienne Thackway



Runner up Benjamin Clouston from University of Canterbury with Professor Paul Webley

WMEP ALUMNI

RECENT GRADUATIONS: CELEBRATING STUDENT SUCCESS

The Woodside Monash Partnership proudly celebrates a milestone achievement with the completion of doctoral studies by our first three PhD alumni—Dr Hamza Asmat, Dr Rajan Lakshman, and Dr Darcy Simondson-Tammer. Their research has contributed valuable insights and advancements in energy innovation, reflecting the core mission of our partnership to drive impactful solutions through academic and industry collaboration.

As they embark on the next stages of their careers, we acknowledge their dedication, expertise, and contributions to shaping the future of energy. Their work stands as a testament to the strength of the WMP initiative in fostering world-class research and developing future leaders in the field.

We congratulate Dr Asmat, Dr Lakshman, and Dr Simondson-Tammer on their achievements and look forward to seeing the lasting impact of their research in academia and industry. They are pioneers in the WMP alumni community, paving the way for future scholars to continue pushing the boundaries of innovation.



Dr Hamza Asmat

Thesis title: *Gas Phase CO₂ Conversion Via Induction Heating For Syngas Production Using Catalyst-Coated Structured E-Reactors*

Dr Hamza Asmat's PhD research focuses on electrified gas-phase CO₂ conversion employing induction heating technology, aiming to produce syngas (H₂+CO) — a valuable fuel and chemical feedstock. His work with catalyst-coated structured e-reactors advances energy efficiency and optimises reaction kinetics, resulting in higher CO₂ conversion rates and a high syngas yield. Key achievements include designing reactors with optimised thermal distribution for scalable, sustainable syngas production, demonstrating the feasibility of carbon recycling and contributing to cleaner energy pathways.

Current Role and Organisation: *Postdoctoral Researcher, Monash University, Australia*

LinkedIn Profile: <https://www.linkedin.com/in/hamzaasmat26/>



Dr Rajan Lakshman

Thesis title: *Carbon Dioxide Hydrogenation to Acetic Acid over Metal Organic Framework Derived Catalysts*

Dr Lakshman's PhD research focuses on developing efficient catalysts derived from metal-organic frameworks (MOFs) for the hydrogenation of carbon dioxide (CO₂) into acetic acid. By harnessing the unique structural and chemical properties of MOF-derived catalysts, this work aims to convert CO₂, a major greenhouse gas, into valuable acetic acid. Key outcomes include identifying optimal catalyst designs and reaction conditions that maximise acetic acid yields, demonstrating a sustainable pathway for CO₂ utilisation, and advancing catalyst design principles for CO₂ hydrogenation.

Current Role and Organisation: *Postdoctoral Researcher, Monash University, Australia*

LinkedIn Profile: <https://www.linkedin.com/in/rajan-lakshman/>



Dr Darcy Simondson-Tammer

Thesis title: *Development of efficient and robust electrocatalytic systems for large-scale hydrogen production by low-cost water splitting devices*

Dr Simondson-Tammer's PhD research focused on developing advanced electrocatalytic systems for cost-effective, large-scale hydrogen production through water splitting. The project aimed to design efficient and durable catalysts that reduce energy consumption, using abundant, low-cost materials. Key outcomes included synthesising catalysts with improved activity and stability, achieving high hydrogen yields at reduced operational costs, and advancing the potential of sustainable hydrogen production technology. This work contributes to the scalability of lower carbon hydrogen as a clean energy source, aligning with global efforts toward carbon reduction and renewable energy innovation.

Current Role and Organisation: *Research Fellow, Monash University, Australia*

LinkedIn Profile: <https://www.linkedin.com/in/darcy-simondson-a0bb45188/>

WMEP ALUMNI

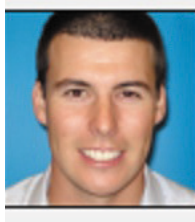
INDUSTRY ENGAGEMENT: MONASH IDP PROGRAM IN ACTION

The Industry Doctoral Program (IDP) at Monash University is an industry-led PhD program where the research scope, project focus, and objectives are determined by the sponsoring organisation. Through the Woodside-Monash partnership, Monash students and Woodside employees have the opportunity to work on industry-driven research projects, leveraging Monash’s world-class facilities, academic expertise, and research resources.

The IDP is open to both Monash-based and industry-based students, fostering a dynamic environment where research and industry align to deliver meaningful outcomes and impactful solutions. Woodside employees participating in the program remain in their current roles while integrating research into their work, while Monash-based students gain valuable industry experience through close collaboration with Woodside professionals.

This unique partnership empowers candidates to explore new ideas, drive innovation, and create competitive advantages while tackling real-world industry challenges. Meet our Industry Doctoral Program candidates below:

WOODSIDE BASED EMPLOYEES



Lex Simons*

Thesis title: *Assessing New Energy and Abatement Technologies: A Strategic Approach to Value Creation and Sustainable Transition*

Overview of PhD research:

The transition to a low-carbon future requires strategic evaluation of emerging energy and abatement technologies to ensure economic viability and environmental impact. This research focuses on assessing and optimising new technologies that support decarbonisation, emissions reduction, and energy efficiency. By integrating techno-economic analysis, policy frameworks, and sustainability metrics, this study aims to identify pathways for value creation and long-term industry transformation. The findings will contribute to guiding businesses and policymakers in making informed decisions, accelerating the adoption of clean energy solutions, and fostering a sustainable, net-zero economy.



Anrie Helberg

Thesis title: *Sustainable Technology: Understanding the Trade-Off and Synergies Between Energy, Greenhouse Gas Emissions, and Food Security for optimised technology solutions*

Overview of PhD research:

The project aims to improve industry’s ability to evaluate the sustainability of technology. With the development of novel solutions to reduce greenhouse gas emissions, there may be synergies and trade-offs between emissions reduction and other resources, such as food security. This project will enhance the evaluation of sustainable technologies by providing a better understanding of the interdependencies between energy, greenhouse gas emissions, and food security.



Andy R Watt

Thesis title: *Optimising Subsea Gas Pipeline Decommissioning via Real-Time Data Gathering and Innovative Tracking*

Overview of PhD research:

The decommissioning of subsea gas pipelines presents technical, environmental, and economic challenges. This research focuses on optimising decommissioning strategies through real-time data gathering and advanced tracking technologies. By integrating sensor-based monitoring, predictive analytics, and innovative tracking systems, the study aims to enhance efficiency, safety, and environmental compliance in pipeline decommissioning. The findings will contribute to cost-effective and sustainable decommissioning practices, reducing risks and supporting industry efforts to meet regulatory and environmental standards while advancing responsible offshore infrastructure management.

Read more about the Monash IDP program
monash.edu/industry-doctoral-program

*No longer at Woodside

MONASH BASED STUDENTS

**Gabi Newman**

Thesis title: *Decommissioning of Industrial Equipment and Opportunities for Plastic Waste Recycling in Australia*

Overview of PhD research:

As industries transition towards sustainability, the decommissioning of industrial equipment presents both challenges and opportunities, particularly in plastic waste management. This research explores innovative recycling pathways for plastic materials recovered from retired industrial assets in Australia. By assessing current decommissioning practices, regulatory frameworks, and emerging recycling technologies, this study aims to identify economically viable and environmentally sustainable solutions. The findings will contribute to circular economy strategies, helping industries reduce landfill waste while maximising resource recovery and reuse.

**Evangeline Leong**

Thesis title: *Integration of Direct Air Capture of CO₂ for Biological Utilisation and Conversion into Value Added Products*

Overview of PhD research:

With the increasing demand by industries across the globe to find sustainable methods for carbon reduction, integrating Direct Air Capture (DAC) with CO₂ utilisation pathways presents a promising roadmap to decarbonisation. This research explores the feasibility of capturing atmospheric CO₂ and converting it into value-added bio-based products through bioprocessing techniques. By optimising system design and process integration, this project aims to enhance the scalability and efficiency of DAC-enabled biomanufacturing. The findings will contribute to advancing carbon circularity, supporting industrial sustainability, and positioning DAC as a viable solution for reducing emissions while enabling the production of sustainable chemicals and materials.

**Jose Lobo Del Canto**

Thesis title: *Innovation, Design and Development of Low-Cost Solar Photovoltaic Systems*

Overview of PhD research;

As the global demand for renewable energy grows, affordable and efficient solar photovoltaic (PV) systems are key to expanding energy access and sustainability. This research focuses on the innovation, design, and development of low-cost PV technologies, exploring novel materials, manufacturing and deployment techniques, and system optimisation strategies. By improving cost-effectiveness and performance, this study aims to enhance the feasibility of widespread solar adoption, particularly for lightweight solar PV systems. The outcomes will contribute to advancing clean energy solutions, supporting the transition toward a more sustainable and accessible energy future.

**Maksis Darzins**

Thesis title: *Mechanical Design Of Direct Air Capture Pilot Plants For Carbon Dioxide Capture And Recycling*

Overview of PhD research:

As climate change mitigation efforts intensify, Direct Air Capture (DAC) technology is emerging as a crucial solution for reducing atmospheric CO₂ levels. This research focuses on the development and scale-up of DAC systems, exploring advancements in mechanical design, process optimisation, and energy efficiency in materials, process optimisation, and energy efficiency to enhance feasibility and cost-effectiveness. By addressing key challenges in scalability and deployment, this study aims to support the widespread adoption of DAC for carbon removal and utilisation. The findings will contribute to global decarbonisation efforts, enabling more effective carbon management strategies and advancing the transition to a sustainable, low-carbon future.

**Joel Wong**

Thesis title: *Effective Strategies for Direct Air Capture Technology Commercialisation*

Overview of PhD research:

Direct Air Capture (DAC) technology plays a critical role in achieving global decarbonisation goals by actively removing CO₂ from the atmosphere. This research focuses on optimising DAC system performance, reducing energy consumption, and developing scalable deployment strategies to enhance its commercial viability. Key aspects include improving heat and mass transfer efficiency, integrating cost-effective materials, and leveraging advanced manufacturing techniques to drive down capital and operational expenditures. Additionally, this study explores policy frameworks, market incentives, and business models that can accelerate DAC adoption across industries. The outcomes aim to provide a comprehensive pathway for scaling DAC technology, making it an economically viable solution for hard-to-abate emissions and supporting the transition to a net-zero future.

PERSONNEL

LEADERSHIP AND OPERATIONS

NAME	INSTITUTION	ROLE	INITIATIVE
Professor Maria Garcia de la Banda	Monash University	Monash FutureLab Co-Chair, Information Technology	Monash FutureLab
Professor Christopher Hutchinson	Monash University	Monash FutureLab Co-Chair, Engineering	Monash FutureLab
Dr Erin Brodie	Monash University	Research and Innovation Lead	Monash FutureLab
Senior Lecturer Sebastian Thomas	Monash University	Materials Integrity Lead	Monash FutureLab
Michael Brameld	Woodside Energy	Principal Materials Engineer	Monash FutureLab
Dr Lee Djumas	Woodside Energy	AM Subject Matter Expert	Monash FutureLab
Dr Claudia De Los Rios Perez	Woodside Energy	Innovation Partnership Advisor	Energy Partnership and Monash FutureLab
Voula Terzoudi	Woodside Energy	Head of Australian Partnerships	Energy Partnership and Monash FutureLab
Professor Paul Webley	Monash University	Energy Partnership Director	Energy Partnership
Liyanne Price	Monash University	Operations Manager	Energy Partnership
Dr Jitendra Joshi	Woodside Energy	New Energy and Carbon Theme Leader	Energy Partnership
Peter Metcalfe	Woodside Energy	Energy Leadership Theme Leader	Energy Partnership
Professor Akshat Tanksale	Monash University	Carbon Theme Leader	Energy Partnership
Senior Lecturer Tom Hughes	Monash University	New Energy Theme Leader	Energy Partnership
Professor Fang Lee Cooke	Monash University	Energy Leadership Theme Leader	Energy Partnership
Professor Murali Sastry	Monash University	Global Partnerships Theme Leader	Energy Partnership
Aneeka Meyers	Monash University	Operations Coordinator	Energy Partnership
Evangeline Leong	Monash University	Research Officer	Energy Partnership

WOODSIDE MONASH PARTNERSHIP EXECUTIVE ADVISORY PANEL

NAME	INSTITUTION	ROLE
Professor Doron Ben-Meir	Monash University	Deputy Vice Chancellor (Enterprise and Engagement)
Daniel Kalms	Woodside Energy	Executive Vice President and COO International
Julie Fallon	Woodside Energy	Executive Vice President Technical and Energy Development
Tony Almond*	Woodside Energy	Vice President Technology
Gabrielle Pennock	Woodside Energy	Vice President Engineering
Jason Crusan*	Woodside Energy	Vice President Energy Solutions
Professor Yiannis Ventikos	Monash University	Dean, Faculty of Engineering
Professor Ann Nicholson	Monash University	Dean, Faculty of Information Technology
Neil Kavanagh*	Woodside Energy	Chief Scientist
Jenny Johnson	Woodside Energy	Head of US Partnerships
Anita Zanchetta	Monash University	Executive Director, Enterprise
Professor Jacek Jasieniak	Monash University	Pro Vice Chancellor (Research Infrastructure)
Dani Howden	Monash University	Senior Director, Development
David Faulmann	Monash University	Deputy Director, Advancement

*No longer at Woodside

FUTURELAB

THEME	TOPIC	PERSONNEL
ADDITIVE MANUFACTURING AND MATERIALS INNOVATIONS	ADDITIVE MANUFACTURED ALLOY DEVELOPMENT FOR 'ALL- AREAS' APPLICATION	Professor Christopher Hutchinson, Professor and Co-Chair
	MECHANICAL EFFECTS OF DEFECTS IN ADDITIVELY MANUFACTURED COMPONENTS	Dr Erin Brodie, FutureLab Research and Innovation Lead Dr Sebastian Thomas, Senior Lecturer Dr Victor Cruz de Faria, Research Fellow
	DAMPING OF EMBEDDED POWDER CAVITIES IN ADDITIVELY MANUFACTURED COMPONENTS	Brett Williams, Technician and Machinist Byron van Deun, Technician and Machinist Marc Peters, PhD Student
	CORROSION OF AS-BUILT AND POST-PROCESSED ADDITIVELY MANUFACTURED COMPONENTS	Shengning Meng, PhD Student Cristian Costa, PhD Student Jingjie Huang, PhD Student
	EXPANDING AM COMPONENT USE CASES	James Bott, PhD Student
	HYDROGEN EMBRITTLEMENT OF STRUCTURAL AM MATERIALS	Gabi Newman, IDP Student Matt Hamod, IDP Student Affiliate
	COLD SPRAY FOR COATING REPAIR	Kit Kirby, IDP Student Affiliate
	FATIGUE OF FLEXIBLES IN HUMID ENVIRONMENTS	Matthew Issko, Undergraduate Intern Phrynne Grant, Undergraduate Intern
	AM OF TUNGSTEN CARBIDE DRILL-BITS	Jing Ng, Undergraduate Intern
	MIXED POWDERS FOR COMPONENT MICROSTRUCTURAL CONTROL	Rori van Huizen, Undergraduate Intern Vivian Wong, Undergraduate Intern
NEW ENERGY INNOVATIONS		
DATA SCIENCE	HYDROGEN/AMMONIA DEMAND/SUPPLY NETWORK AND FACILITY OPTIMISATION	Prof. Maria Garcia de la Banda, Professor and Co-Chair Prof. Geoff Webb, Professor
	CREW/ROLE ALLOCATION AND BACKFILLING	A/Professor Daniel Harabor, Associate Professor A/Professor Michael Wybrow, Associate Professor Dr Mario Boley, Senior Lecturer
	TECH-MAX PRODUCTION MODELLING EXPLORATION	Dr Hamid Rezatofighi, Senior Lecturer Dr Daniel Schmidt, Senior Lecturer Dr Gleb Belov, Research Fellow
	PREDICTING SAND EVENTS IN A WELL	Dr Ilankaikone Senthoooran, Senior Research Fellow Dr Frits de Nijs, Research Fellow Dr Chang Wei Tan, Research Fellow
	TRINIDAD AND TOBAGO BIRD COUNTING USING AI	Matthias Klapperstueck, Research Engineer Chenhui Gou, Research Assistant Shu Yu Tew, Research Assistant
	PIPE ROUTING	Thomas Nobes, PhD Student Grace Moss, Undergraduate Intern

FUTURELAB

THEME	TOPIC	PERSONNEL
DECOMMISSIONING	DECOMMISSIONING OF MIXED-MEDIA INDUSTRIAL EQUIPMENT AND OPPORTUNITIES FOR PLASTIC WASTE UPCYCLING AND RECYCLING IN AUSTRALIA	Professor Sankar Bhattacharya, Professor Dr Erin Brodie, FutureLab Research and Innovation Lead
	A MULTI-ATTRIBUTE DECISION ANALYSIS FOR DECOMMISSIONING WASTE MANAGEMENT	Dr Jenny Zhou, Senior Lecturer Dr Chandan Kundu, Research Fellow
	PROCESSING OF FLOWLINES, UMBILICALS AND TYRES INTO USEFUL ENERGY RESOURCES	Gabi Newman, IDP Student Nethmi Pallimulla, Undergraduate Intern Ovini Ekanayaka, Undergraduate Intern
	WA LNG JOBS TASKFORCE – DECOMMISSIONING DATABASE	



THEME	TOPIC	PERSONNEL
CARBON CAPTURE, CONVERSION, AND UTILISATION	DIRECT AIR CAPTURE	<p>Prof Paul Webley, Primary Chief Investigator Prof Akshat Tanksale, Chief Investigator Dr Joanne Tanner, Chief Investigator Dr Aaron Guo, Postdoctoral Fellow Dr Masood Sheikh Alivand, Postdoctoral Fellow Romalya Ranasinghe, PhD Student Evangeline Leong, Research Officer & IDP Candidate Maksis Darzins, Technical Officer & IDP Candidate Joel Wong, Technical Officer & IDP Candidate Chani Karandagaspiya, PhD Student Mohsen Ghasemian, PhD Student Jayden Cooke, Research Assistant</p>
	CO₂ CONVERSION BY PLASMONIC CATALYSIS	<p>Professor Murali Sastry, Primary Chief Investigator Professor Akshat Tanksale, Chief Investigator A/Professor Philip Nakashima, Chief Investigator A/Professor Laure Bourgeois, Chief Investigator Dr Tuncay Alan, Chief Investigator Dr Sanje Mahasivam, Postdoctoral Fellow Garv Bhardwaj, PhD Student Fergus McLaren, PhD Student Dr Waqar Ahmad, Postdoctoral Fellow Felician Junatan, Intern</p>
	3D PRINTED CATALYTIC MONOLITHS FOR ENERGY EFFICIENT CARBON CONVERSION	<p>Professor Akshat Tanksale, Primary Chief Investigator Professor Matthew Hill, Chief Investigator Professor Kiyonori Suzuki, Chief Investigator Dr Lee Djumas, Chief Investigator Dr Erin Brodie, Chief Investigator Dr Puja Paul, Postdoctoral Fellow Hamza Asmat, PhD Student Mohammad Raihan Arfin, PhD Student Ashwin Hatwar, PhD Student</p>
	CONVERSION OF WASTE GASES INTO SUSTAINABLE FEEDS	<p>Professor Chris Greening, Primary Chief Investigator Professor Esteban Marcellin, Primary Chief Investigator (UQ) Professor Akshat Tanksale, Chief Investigator Dr Surbhi Jain, Postdoctoral Fellow Dr James Heffernan, Postdoctoral Fellow (UQ) Nadeesha Athukorala, PhD Student Hemanshi Galaiya, PhD Student (UQ) Antonia Ebert, PhD Student (UQ)</p>
	MEDIUM TEMPERATURE ELECTROLYSIS FOR COMMERCIALY VIABLE CARBON DIOXIDE UTILISATION	<p>Professor Jie Zhang, Primary Chief Investigator Professor Paul Webley, Chief Investigator Dr Hsiwen Wu, Postdoctoral Fellow Calvin Chow, PhD Student</p>
	ACETIC ACID PRODUCTION BY CO₂ CONVERSION	<p>Professor Akshat Tanksale, Primary Chief Investigator Professor Alan Chaffee, Chief Investigator Rajan Lakshman, PhD Student Sireesha Rameswarapu, PhD Student</p>
	VIABLE PATHWAYS FOR LOWER CARBON METHANOL IN THE ENERGY TRANSITION	<p>Professor Paul Webley, Primary Chief Investigator Professor Damon Honnery, Chief Investigator Miriam Blaine, PhD Student</p>

ENERGY PARTNERSHIP

THEME	TOPIC	PERSONNEL
NEW ENERGY TECHNOLOGIES	ULTRA-LOW COST PV	Professor Jacek Jasieniak, Primary Chief Investigator A/Professor Chao Chen, Primary Chief Investigator - Robotics Dr Matthieu Gresil, Chief Investigator A/Professor Amin Haidarpoiur, Chief Investigator Dr Reza Razzaghi, Chief Investigator A/Professor Stuart Walsh, Chief Investigator Jose Lobo Del Canto, Research Officer and IDP Candidate Alexander May, Research Officer Dr Gaveshana Sepalage, Postdoctoral Fellow Jefferson Lam, PhD Student Charles Troeung, PhD Student Mitchell Mibus, Intern Finn Colman, FYP Student Ali Boyrati, FYP Student Amalie Bullen, FYP Student Maximilian O'Brien, FYP Student Zryus Tejpal, FYP Student
	LOW TEMPERATURE CERAMIC ELECTROLYSIS CELLS FOR RENEWABLE ENERGY TECHNOLOGY	Professor Huanting Wang, Primary Chief Investigator Professor Paul Webley, Chief Investigator Professor Jacek Jasieniak, Chief Investigator Dr Dehua Dong, Postdoctoral Fellow Kaiqing He, PhD Student Kevin Ung, PhD Student
	EFFICIENT ELECTRODES FOR SEA WATER ELECTROLYSIS	A/Professor Alexandr Simonov, Primary Chief Investigator Professor Douglas R MacFarlane, Chief Investigator Dr Darcy Simondson-Tammer, Postdoctoral Fellow Ananta Fareza, PhD Student Mayank Garg, PhD Student Dr Roy Dinh, Postdoctoral Fellow
	LIQUID HYDROGEN BOIL-OFF GAS MANAGEMENT	Dr Tom Hughes, Primary Chief Investigator Professor Paul Webley, Chief Investigator Liam Turner, PhD Student James Wang, PhD Student
	EXPLORING THE INTEGRATION OF LIQUID AIR ENERGY STORAGE WITH SOLAR AND LNG SYSTEMS	Dr Tom Hughes, Primary Chief Investigator A/Professor Roger Dargaville, Chief Investigator Geoff Byfield, Chief Investigator Mohamad Shams, PhD Student
	PROCESS INTEGRATION OF NET ZERO ENERGY, HYDROGEN, AND AMMONIA, PRODUCTION	Dr Tom Hughes, Primary Chief Investigator Professor Paul Webley, Chief Investigator Javad Jeddizahed, PhD Student

ENERGY PARTNERSHIP

**NEW
ENERGY
TECHNOLOGIES**

<p>ELECTROLYSER TECHNOLOGY FOR ENHANCING GRID STABILITY</p>	<p>Dr Mehdi Ghazavi Dozein, Primary Chief Investigator A/Professor Behrooz Bahrani, Chief Investigator Shervin Fani, Chief Investigator Dr Mohammad Ramezani Taghartapeh, Research Fellow Dr Amin Mahdizadeh, Research Fellow Supun Meethiyagoda, PhD Student James McAlister, FYP Student Oliver Kershaw, FYP Student Morris Dumaresq, FYP Student Joshua Sutton, FYP Student</p>
<p>RAPID PROTOTYPING OF H2 FENCE</p>	<p>Professor Paul Webley, Primary Chief Investigator Neil Kavanagh, Chief Investigator Evangeline Leong, Supervisor Angus Costopoulos, Industry Innovation Program (IIP) student Madeleine Buckingham, Industry Innovation Program (IIP) student</p>



ENERGY PARTNERSHIP

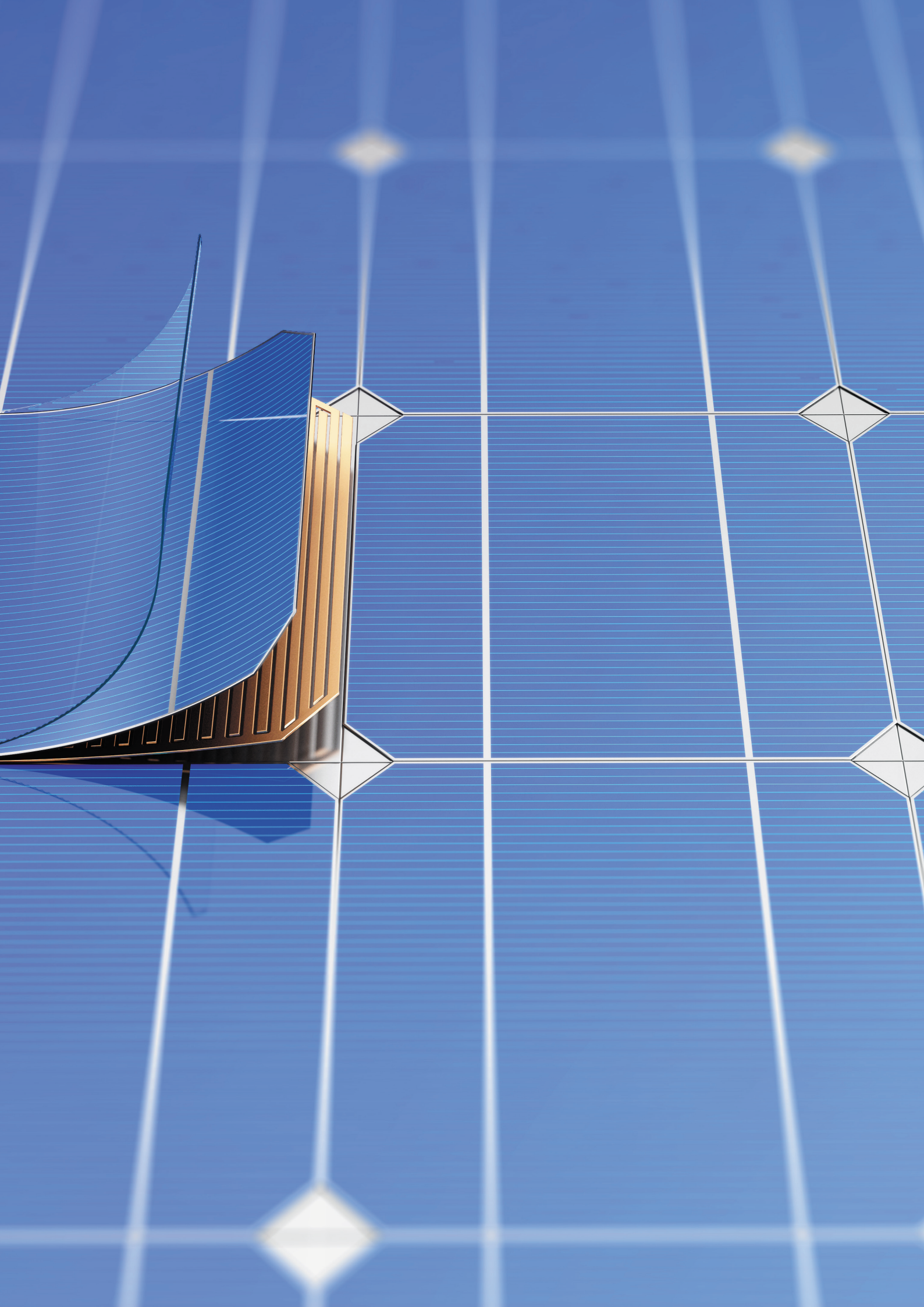
THEME	TOPIC	PERSONNEL
ENERGY LEADERSHIP	EFFICIENT REGULATORY PATHWAYS TO AUSTRALIA'S LOWER CARBON FUTURE	A/Professor Brendan Gogarty, Primary Chief Investigator Peter Metcalfe, Chief Investigator
	OPTIMISING AUSTRALIA'S ELECTRICITY SYSTEM: THE ROLE OF BLOCKCHAIN TECHNOLOGY	A/Professor Xin Ma, Primary Chief Investigator Professor Joseph Liu, Chief Investigator Professor Fang Lee Cooke, Chief Investigator Dr Claudia De Los Rios, Supervisor Gareth Wright, Supervisor
	FUTURE POTENTIAL OF HYDROGEN DEMAND IN AUSTRALIAN TRANSPORT AND ENERGY-INTENSIVE INDUSTRY SECTORS: A GEOSPATIAL APPROACH	Dr Xuan Zhu, Primary Chief Investigator Professor Fang Lee Cooke, Chief Investigator Warsini Handayani, PhD Student
	LOWER CARBON ENERGY IN THE GLOBAL STAGE - TECHNICAL AND ECONOMIC POTENTIALS OF HYDROGEN PRODUCTION	Professor Fang Lee Cooke, Primary Chief Investigator Dr Xuan Zhu, Chief Investigator Stephan Modest, Research Assistant Lynn Wu, Research Assistant Warsini Handayani, PhD Student
	EXPLORING THE MERIT ORDER OF ABATEMENT IN THE AUSTRALIAN CONTEXT	A/Professor Stuart Walsh, Primary Chief Investigator A/Professor Roger Dargaville, Chief Investigator Peter Metcalfe, Supervisor Gareth Wright, Supervisor Dr Graham Palmer, Postdoctoral Fellow Dr Changlong Wang, Postdoctoral Fellow
	UNDERSTANDING THE RELATIONSHIP BETWEEN FOOD SECURITY AND GREENHOUSE GAS EMISSIONS THROUGH SOCIAL AND ENVIRONMENTAL LIFECYCLE ANALYSIS	Professor Paul Webley, Primary Chief Investigator Dr Jitendra Joshi, Chief Investigator Anrie Helberg, IDP Student (Woodside Energy)
	ASSESSING NEW ENERGY AND ABATEMENT TECHNOLOGIES: A STRATEGIC APPROACH TO VALUE CREATION AND SUSTAINABLE TRANSITION	Professor Paul Webley, Primary Chief Investigator Dr Jitendra Joshi, Chief Investigator Lex Simons, IDP Student (Woodside Energy)
	OPTIMISING SUBSEA GAS PIPELINE DECOMMISSIONING VIA REAL-TIME DATA GATHERING AND INNOVATIVE TRACKING AND COMMUNICATION TECHNOLOGY	A/Professor Nemai Karmakar, Primary Chief Investigator Professor Paul Webley, Chief Investigator Dr. Claudia De Los Rios, Supervisor Harry Mackay, Supervisor Andy R Watt, IDP Student (Woodside Energy)

ARC RESEARCH HUB FOR CARBON UTILISATION AND RECYCLING (RECARB HUB)

THEME	TOPIC	PERSONNEL
ELECTRO AND PHOTO CHEMICAL CONVERSION	SYNGAS PRODUCTION BY SOLID OXIDE ELECTROLYSIS (SOEC)	Dr Zongping Shao, Curtin University, Primary Chief Investigator Dr Jitendra Joshi, Woodside Energy, Partner Investigator Dr Sahil Garg, Woodside Energy, Partner Investigator Dr Pratigya Sharma, Woodside Energy, Partner Investigator Cuifang Wang, Curtin University, PhD Student
	ELECTRODE ARCHITECTURAL DESIGN FOR ENHANCED CARBON DIOXIDE REDUCTION PERFORMANCE UNDER AMBIENT CONDITIONS	Dr Yusuf Valentino Kaneti, The University of Queensland, Primary Chief Investigator Dr Naoya Kobayashi, NK Energy Frontier, Partner Investigator Dr Jitendra Joshi, Woodside Energy, Partner Investigator Dr Sahil Garg, Woodside Energy, Partner Investigator Dr Pratigya Sharma, Woodside Energy Partner Investigator Iris Xiaohan Wang, The University of Queensland, PhD Student
	PLASMONICS FOR PHOTOCHEMICAL CONVERSION	Professor Murali Sastry, Monash University, Primary Chief Investigator Professor Zongyou Yin, The Australian National University, Chief Investigator Dr Jitendra Joshi, Woodside Energy, Partner Investigator Dr Pratigya Sharma, Woodside Energy, Partner Investigator Dr Qiqing Shen, Woodside Energy, Partner Investigator Jan Haesner, BASF, Partner Investigator Garv Bhardwaj, Monash University, PhD Student Fergus McLaren, Monash University, PhD Student
BIOCHEMICAL CONVERSION	TWO-STEP BIOCONVERSION OF CO₂ INTO METHYL KETONES AND CHEMICAL REFINEMENT INTO JET FUEL	Dr Birgitta Ebert, The University of Queensland, Primary Chief Investigator Dr Muxina Konarova, The University of Queensland, Chief Investigator Professor Esteban Marcellin, The University of Queensland, Chief Investigator A/Professor Darryn Rackemann, Queensland University of Technology, Chief Investigator Dr Laleh Vash Moghaddam, Queensland University of Technology, Chief Investigator Dr Leonie van 't Hag, Monash University, Chief Investigator Dr Jitendra Joshi, Woodside Energy, Partner Investigator Dr Sui Boon Liaw, Woodside Energy, Partner Investigator Andrew Gilbert, Bioplatforms, Partner Investigator Fatema Zohora, Monash University, PhD Student

ARC RESEARCH HUB FOR CARBON UTILISATION AND RECYCLING (RECARB HUB)

THEME	TOPIC	PERSONNEL
THERMO-CHEMICAL CONVERSION	DIRECT CO ₂ HYDROGENATION TO ACETIC ACID VIA HETEROGENEOUS CATALYSIS	<p>Professor Akshat Tanksale, Monash University, Primary Chief Investigator</p> <p>Dr Muxina Konarova, The University of Queensland, Chief Investigator</p> <p>Dr Jitendra Joshi, Woodside Energy, Partner Investigator</p> <p>Dr Qiqing Shen, Woodside Energy, Partner Investigator</p> <p>Dr Min Ao, Woodside Energy, Partner Investigator</p> <p>Jan Haesner, BASF, Partner Investigator</p> <p>Jodie Kimber, WesCEF, Partner Investigator</p> <p>Satya Rameswarapu, Monash University, PhD Student</p> <p>Dr Rajan Lakshman, Monash University, Postdoctoral Fellow</p>
	SCALE-UP OF INDUCTIVELY HEATED DRY REFORMER	<p>Professor Akshat Tanksale, Monash University, Primary Chief Investigator</p> <p>Professor Tejas Bhatelia, Curtin University, Chief Investigator</p> <p>Dr Milinkumar Shah, Curtin University, Chief Investigator</p> <p>Dr Jitendra Joshi, Woodside Energy, Partner Investigator</p> <p>Dr Min Ao, Woodside Energy, Partner Investigator</p> <p>Dr Sui Boon Liaw, Woodside Energy, Partner Investigator</p> <p>Jan Haesner, BASF, Partner Investigator</p> <p>Ashwin Hatwar, Monash University, PhD Student</p> <p>Mohamad Raihan Arfin, Monash University, PhD Student</p>
MARKET ACTIVATION	FRAMEWORKS TO SUPPORT TRADE IN EMBEDDED CARBON PRODUCTS	<p>A/Professor Emma Aisbett, The Australian National University, Primary Chief Investigator</p> <p>A/Professor Roger Dargaville, Monash University, Chief Investigator</p> <p>Professor Paul Webley, Monash University, Chief Investigator</p> <p>Peter Metcalfe, Woodside Energy, Partner Investigator</p> <p>Dr Matthias Raab, CO2CRC, Partner Investigator</p> <p>Kwong Soon Chan, CO2CRC, Partner Investigator</p> <p>Jodie Kimber, WesCEF, Partner Investigator</p> <p>Bushra Muneer, Monash University, PhD Student</p> <p>Dr Saule Burkitbayeva, The Australian National University, Postdoctoral Fellow</p> <p>Bede Denman, The Australian National University, Research Assistant</p>



FURTHER INFORMATION

PROFESSOR CHRISTOPHER HUTCHINSON
(Co-Chair and Materials Lead - Monash University)

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A partnership between:



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FutureLab