

NEWCASTLE INSTITUTE FOR ENERGY AND RESOURCES

ANNUAL REPORT 2022 - 2023



THE UNIVERSITY OF
NEWCASTLE
AUSTRALIA

nier

SOLUTIONS FOR GLOBAL CHALLENGES
ENERGY RESOURCES FOOD WATER

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Front page cover image: Among heavy industries, the iron and steel sector ranks first when it comes to CO₂ emissions, and second when it comes to energy consumption (*International Energy Agency 2020*). However, new knowledge created through strong partnerships is helping to improve sustainability, efficiency and productivity across all phases of the steel making process.

SUSTAINABLE SOLUTIONS

Rising demand for energy, metals and minerals, food and water is a global challenge. These critical resources underpin social, environmental and economic prosperity and no nation can exist without them.

NIER is finding better ways to meet the resource needs of the future.

ENERGY

The energy industry impacts all others, and affordable, reliable energy is a necessity to reduce global poverty, improve living standards and prosperity. The imperative to energise industries and communities while reducing emissions and reliance on finite resources is driving new thinking and unique solutions.

RESOURCES

Every day, billions of people across the world rely on minerals and metals to meet their basic human needs of homes and infrastructure, food and water, transport, energy and communications. The challenges of resource depletion, high energy and water use, and the adverse environmental impacts of the industry are being addressed with research and technologies. Improved efficiency and environmental outcomes are conserving the materials needed to protect our way of life, as well as the planet.

FOOD

Our future depends on securing healthy, quality foods for a growing population within a changing climate. While consumers are demanding more variety, convenience and nutrition, supply chains are subject to instabilities, shortages and disruptions. Research is helping forge a sustainable, resilient food future to feed the planet without destroying it.

WATER

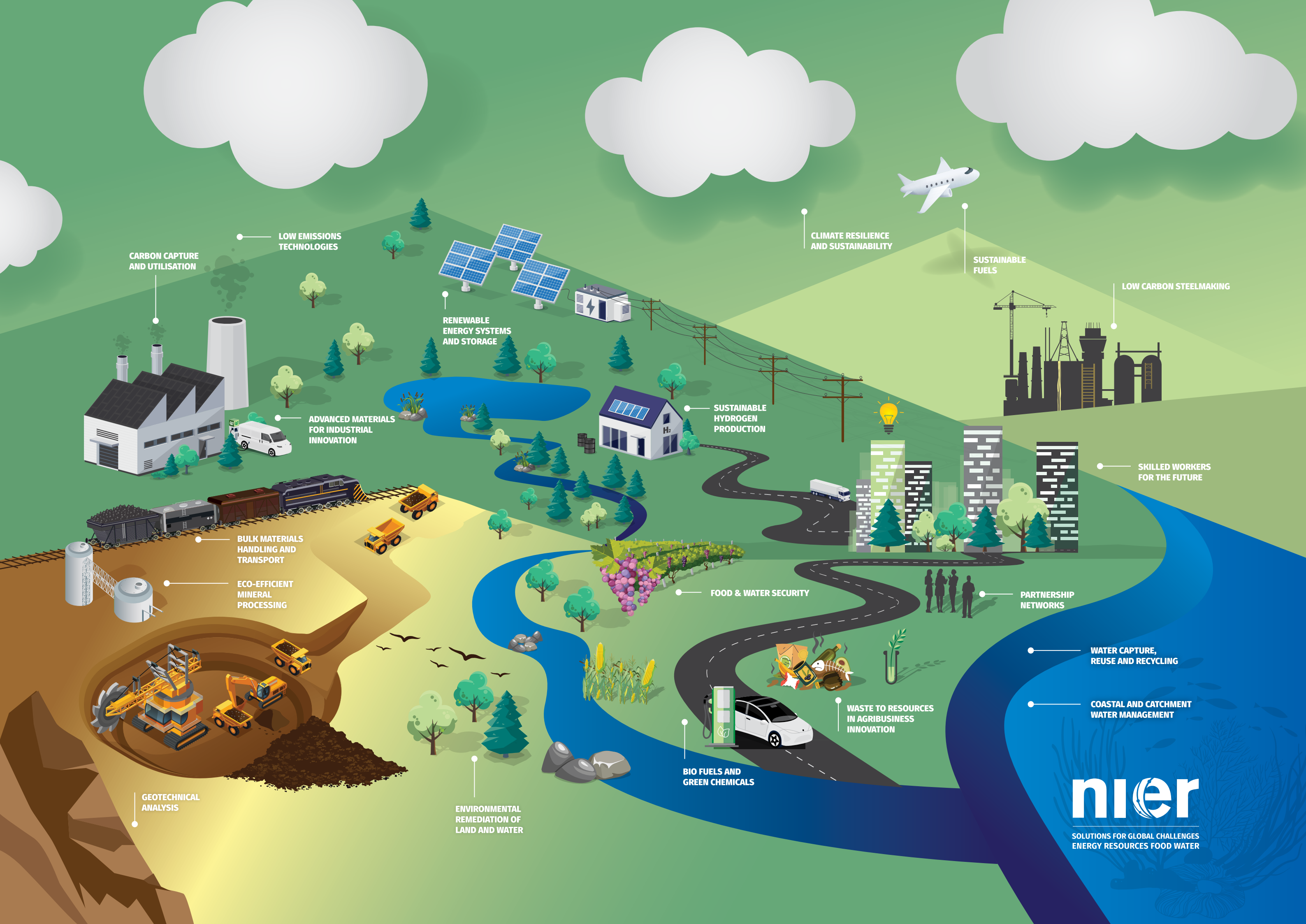
Ensuring everyone has access to safe and sufficient water is a challenge that requires action at a local, national and global level. Water scarcity and climate change, water pollution, aging infrastructure and population growth are all putting pressure on the ability to meet our water needs. Research and innovation is helping to sustain healthy communities, support regional economic prosperity, and restore ecosystems and biodiversity.

PARTNERSHIP NETWORKS

Collective capacity and collaboration means deep and diverse webs of knowledge, leading to new approaches and novel problem solving.

SKILLED WORKFORCE

The workforce of the future will need skillsets we've never seen before. Research education for more sustainable processes, practices and technology use is happening now.



CARBON CAPTURE
AND UTILISATION

LOW EMISSIONS
TECHNOLOGIES

RENEWABLE
ENERGY SYSTEMS
AND STORAGE

ADVANCED MATERIALS
FOR INDUSTRIAL
INNOVATION

BULK MATERIALS
HANDLING AND
TRANSPORT

ECO-EFFICIENT
MINERAL
PROCESSING

GEOTECHNICAL
ANALYSIS

ENVIRONMENTAL
REMEDIATION OF
LAND AND WATER

SUSTAINABLE
HYDROGEN
PRODUCTION

FOOD & WATER SECURITY

BIO FUELS AND
GREEN CHEMICALS

CLIMATE RESILIENCE
AND SUSTAINABILITY

SUSTAINABLE
FUELS

LOW CARBON STEELMAKING

SKILLED WORKERS
FOR THE FUTURE

PARTNERSHIP
NETWORKS

WATER CAPTURE,
REUSE AND RECYCLING

COASTAL AND CATCHMENT
WATER MANAGEMENT

WASTE TO RESOURCES
IN AGRIBUSINESS
INNOVATION

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SOLUTIONS FOR GLOBAL CHALLENGES
ENERGY RESOURCES FOOD WATER

FOREWORD

In the everchanging landscape of global challenges, NIER's intent is to maintain relevance by contributing to the research, innovation and technological advancements needed to guide us towards a more sustainable future.

The outcomes and impact of NIER's research reflect what's important to our partners, our regions, and society. Our research leverages the strengths of the University and our geographic location, and benefits from the breadth of our collaborations, industry experience, and collective expertise. The Sustainable Solutions fold-out graphic inside this Annual Report shows the span of NIER's research across the energy, resources, food and water sectors.

This year has been an important milestone for the energy and resources industries, with the closure of Liddell Power Station in April marking another step towards the new energy economy. The energy industry is of critical importance as it impacts all others. Here at NIER, we continue to invest in projects to support the evolution of the energy industry and unlock energy productivity and efficiencies for other industries. Major initiatives we are part of include the Australian Trailblazer for Recycling and Clean Energy, NSW Decarbonisation Innovation Hub, ARC Centre of Excellence for Enabling Eco-Efficient Beneficiation of Minerals and the BHP Low Carbon Iron and Steelmaking Research Program.

As strategic objectives change, NIER's relevance will be determined by our readiness, response and adaptability. Our priorities gain traction and direction through alignment with University engagement priorities of next generation resources, growing industries, connected communities and better, healthier living. Alignment with broader strategies and endeavours of the University and all levels of Government is, and will continue to be, paramount to our success. Our activities depend on quality engagement and established partnerships and support multidisciplinary collaboration, commercialisation, living labs and work-integrated learning.

Breakthrough innovations in the four critical sectors of energy, resources, food and water are needed now more than ever and by reinforcing the building blocks of regional engagement, world-class research, research education and innovative solutions, NIER is helping to make transformative industries globally widespread and accessible.

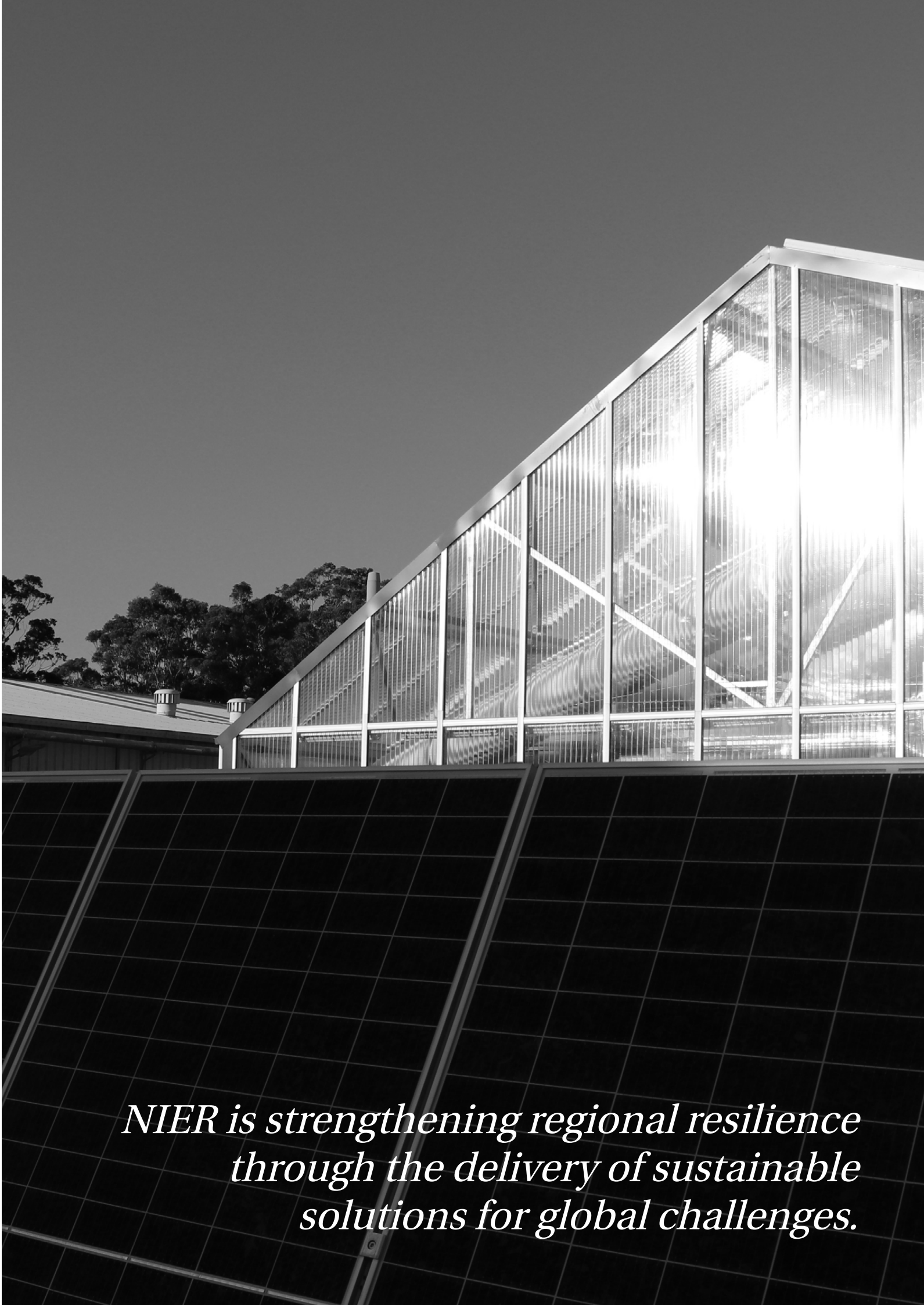


AR Broadfoot
PROFESSOR ALAN BROADFOOT
Executive Director,
NIER



Zee Upton
PROFESSOR ZEE UPTON
Deputy Vice-Chancellor,
Research & Innovation

*NIER is strengthening regional resilience
through the delivery of sustainable
solutions for global challenges.*



GOVERNANCE AND MANAGEMENT

NIER's management, strategic direction and initiatives are steered by a dedicated governance framework representing the research centres and groups that collectively create the NIER model, as well as the industry and regions we support.

The Advisory Board comprises members with a diverse array of knowledge and experience across the industry sectors of energy, resources, food and water, as well as the tertiary education and research realms. The Board contribute to strategic NIER activities and initiatives by identifying opportunity pathways for building capacity, focusing priorities to support our regional industries and communities, and ensuring alignment with the University's overarching Strategic Plan and Engagement Priorities.

In November 2022, the University appointed Professor Craig Simmons to the role of Pro Vice-Chancellor for the College of Engineering, Science and Environment (CESE), and NIER subsequently welcomed him as a member of our Advisory Board. Professor Simmons has been recognised for major contributions to groundwater science, research leadership, education, and policy reform working across the public and private sectors.

The Management Committee is responsible for oversight of high-level infrastructure and utilisation issues, including space allocation, safety and environmental management, large-scale demonstration plant and infrastructure risk management, and other areas of strategic and operational risk specific to precinct activities.

In January 2023, the University appointed Mr Warwick Dawson to the newly created position of Pro Vice-Chancellor for Industry and Engagement. Warwick's extensive leadership experience spans research translation and commercialisation, innovation, entrepreneurialism and industry engagement. As a member of the Management Committee, Warwick's know-how in these areas adds valuable expertise around the effective facilitation of large strategic industry-engaged projects, particularly those with commercial acceleration, capital investment or co-location components.

To represent the interests of the School of Engineering more broadly, the Management Committee also recently welcomed Professor Dianne Wiley, Dean of Engineering. Dianne's membership broadens the engagement of colleagues from CESE in NIER's governance framework and demonstrates our commitment to working collegially across the University to ensure the best outcomes.

NIER extends thanks to Professor Juanita Todd who has represented CESE on both Committees over the past year in her tenure as Interim Pro Vice-Chancellor, CESE. Juanita will continue to represent CESE at the Management Committee as Deputy Head of College.

"NIER enables and facilitates multi-stakeholder networked collaborations. These partnerships help to ensure that world-class research outcomes are directly matched with industry needs and create tangible commercial outcomes and opportunities."

- Mrs Clare Sykes, Managing Director, Larkin Sykes

NIER ADVISORY BOARD - INDUSTRY REPRESENTATIVES



DR MIRJANA PRICA (Chair)
Managing Director,
Food Innovation Australia



MRS CLARE SYKES
Managing Director,
Larkin Sykes



MR JOHN RICHARDS
Chairman,
Bloomfield Group



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GHD



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Hunter Water Corporation



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Tiger Financial Group



DR PETER MAYFIELD
Executive Director,
Environment, Energy and Water
CSIRO

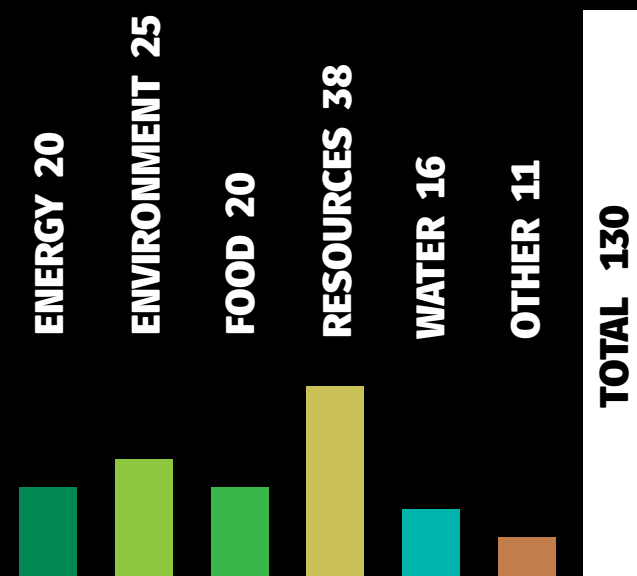


MR FRANK SAMMUT
Executive Director,
Central Coast Industry Connect
Ltd

NIER BY NUMBERS

JULY 2022 - JUNE 2023

Grants by Sector



18

Research Centres
& Groups



145

Engaged University
Researchers



217

PhD Students Supported
by NIER Centres



214

Active Industry
Partners



24

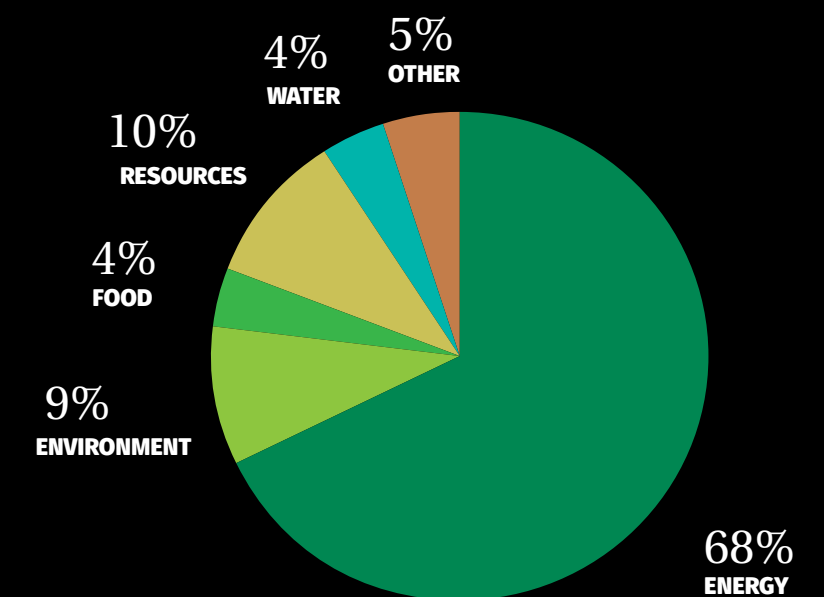
International Partners



3.8 ha

Precinct Size

Funding by Sector



35%

Repeat Clients



360+

Precinct
Occupants



2

Global &
Regional Nodes



5 & 3

Industrial
Workshops

Glasshouses

WORLD-CLASS RESEARCH

Our facilities are what sets NIER apart. Access to large-scale specialised research infrastructure means research teams have the tools needed to deliver proven technologies to market.

FACILITIES

NIER was established on the historical site of BHP's former Newcastle Technology Centre, one of the first industrial facilities in Australia where international research in chemistry, chemical engineering, coal and ore beneficiation, and metallurgy was advanced.

The NIER model is focused on academia and industry collaboration, and the precinct has expanded to meet the increasing requirement to support engaged research groups build collaborative research partnerships with industry.

The precinct is designed to accommodate diverse and evolving research capacity across several key sectors and provides the office space, large-scale industrial research workshops, glasshouses and laboratories needed by research teams to understand the effectiveness and limitations of market-ready technologies.

With advancing markets and business reinvention, the infrastructure requirements needed to support NIER research is constantly evolving. New project-specific, cutting-edge research equipment is often needed to support research projects, with each new piece of equipment requiring major investments of time and resources as well as space, service and safety solutions.

A recent precinct initiative has been containerised solutions, where research projects capable of delivery within modular style mobile containers are accommodated onsite upon large serviceable impervious footprints. This allows safe and controlled access to research infrastructure and activation of new equipment to accommodate and deploy research advancement and serviceability across all research themes.

Due to the complex nature of the research activity that is undertaken onsite at NIER, a comprehensive and collaborative Health, Safety & Environment (HSE) Management System has been developed in line with the University's framework to ensure the safety of all occupants, tenants, guests and visitors.

RESEARCH THEMES



INDUSTRIAL INNOVATION

Unlocking sector potential with a generation of new materials, processes, technology and services.



PRODUCTIVITY & EFFICIENCY

Solutions to reduce waste and optimise the use of the world's resources.



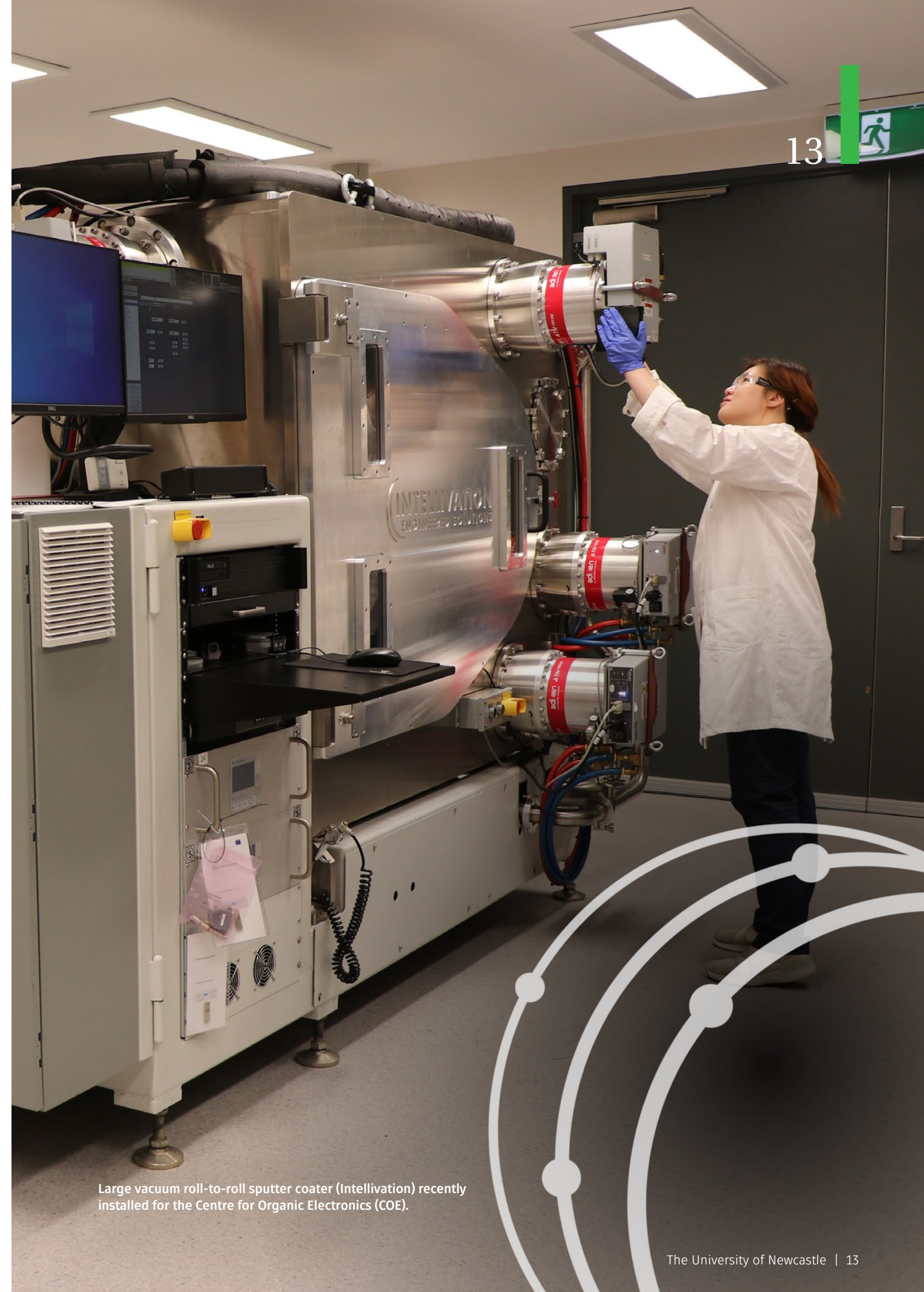
TECHNOLOGIES & UTILISATION

Transferring the latest technology into sectors of significance for sustainability and competitive advantage.



SUSTAINABILITY & SECURITY

Balancing environmental, social and economic activity for regional resilience.



Large vacuum roll-to-roll sputter coater (Intellivation) recently installed for the Centre for Organic Electronics (COE).

REGIONAL ENGAGEMENT

NIER forms collaborative partnerships to address the unique challenges of regions and work towards improved sustainability, diversified economic growth and a resilient future.

CENTRAL COAST

Dealing with our waste streams has become more problematic, but in recent times, waste has begun to be seen as a valuable resource.

Last August, NIER was involved in the Central Coast Industry Festival, where NIER Executive Director, Professor Alan Broadfoot and Professor Paul Dastoor, Director of the Centre for Organic Electronics, participated in a workshop, 'Circular Economy Makes Good Business Sense,' providing insight into how a circular economy provides tangible benefits to business.

The workshop was part of a series of events focused on building resilience in manufacturing and agricultural production, where local businesses participated in a program of knowledge exchange on topics including strengthening supply chains, attracting skilled workers, being agile, innovating, operating sustainably and collaborating for growth.

This work forms part of NIER's collaborative engagement with partners in the Central Coast region to help improve energy and water security, and balance the increasing demands of urban communities whilst protecting critical resources.

CENTRAL-WEST ORANA

The Central-West and Orana region of NSW is a nationally recognised hub for agribusiness, mining, manufacturing and construction, and presents an opportunity for research activity and partnerships to complement the strategic goals and flagship initiatives of the University.

Significant local potential in critical minerals, resource recovery, and renewable energy, teamed with accessibility of the Central-West to major capital ports and cities has resulted in a rapidly diversifying economy, with several opportunities for investment and engagement.

The NSW Government has mapped the economic and industrial opportunities in the region, with the identification of the Parkes Special Activation Precinct (SAP), and the Central-West Orana Renewable Energy Zone (REZ).

Investment and activity related to these initiatives will drive innovation and opportunity for these critical sectors:

INNOVATIVE AGRICULTURE – The region boasts an established agricultural sector, set to grow by 3.6 per cent by 2025.

CRITICAL MINERALS – With over 15 critical mineral projects in the region, proximity to several critical mineral resources, existing infrastructure and a highly skilled workforce, there is scope for further growth.

RESOURCE RECOVERY – The Parkes SAP has the potential to become Australia's leading circular economy precinct, with a proposed Energy from Waste Facility, and the first dedicated recycling precinct with direct rail access.

RENEWABLE ENERGY – The generation, transmission, and storage of replacement energy sources is critical

to delivering NetZero by 2050 and the Central-West and Orana REZ will be key in replacing the state's coal powered electricity generation over the next 15 years. The region is suitable for a variety of renewable energy projects including wind, solar, bioenergy and pumped hydro.

There is strategic opportunity for the NSW Decarbonisation Innovation Hub, co-hosted by UNSW and the University of Newcastle, to propel its decarbonisation objectives in the region under its focus areas of:

- Electrification and Energy Systems
- Land and Primary Industries
- Power Fuels including Hydrogen

Additionally, the Trailblazer for Recycling and Clean Energy (TRaCE), a partnership with UNSW in conjunction with industry and government, is working to transition Australia to a low carbon economy, with initiatives that also align to the SAP and REZ:

- Next Generation Solar Photovoltaics and Systems
- Electrification, Energy Systems and Storage
- Sustainable Fuels and Chemicals Manufacturing
- Recycling, Reforming, and Reuse of Materials

HUNTER REGION

With the closure of Liddell Power station in April 2023, there is growing attention on a clean energy future for the Hunter region. As community, industry and government work together to steer energy and economic diversification for the region, NIER has a role to play in delivering leading research and innovation for a thriving future.

Utilising the unique and sweeping local advantages of the Hunter region, NIER is drawing particular interest due to our work in hydrogen as a clean energy solution.

This year NIER was on the list of attractions for several state and federal minister visits, as well as international delegations. There is broad interest in the region's energy capabilities, including how NIER's clean energy research is being connected with industry to commercialise technologies.

The delegations are particularly focused on challenges and opportunities associated with the Hunter's energy and economic transformation, what actions are underway, and how government can partner with the region to accelerate industry and jobs as the world decarbonises.

Through these tours and events, NIER is working with all levels of government and industry representatives locally and across the globe to better understand how our research and partnerships can make the most of the opportunities in the Hunter region.

Upper Hunter Insights

Sectors, businesses, and communities in the Upper Hunter are evolving and adapting to a new economy, leveraging the unique and significant advantages of the region which will ensure that Upper Hunter industry steps proudly into the future.

In November 2022, NIER facilitated the Upper Hunter Insights event which was an opportunity for industry, government, and the community to connect with University of Newcastle research expertise to find commonalities for delivering economic, environmental, and social enhancements in the region.



Scan the QR code to find out more about the hydrogen research and partnerships underway at NIER.

The event was a showcase of existing and new innovative research activities being undertaken in the region by University of Newcastle researchers, in partnership with industry. It was a chance to highlight how industry is engaging with University initiatives and expertise to support areas including industrial innovation, technologies and utilisation, security and sustainability and productivity and efficiency.

Hosting this event in the Upper Hunter allowed us to explore possibilities around the integration and adoption of emerging technologies and research infrastructure, building on existing strengths and partnerships to advance the region and drive further economic activity.

Hydrogen and the Hunter

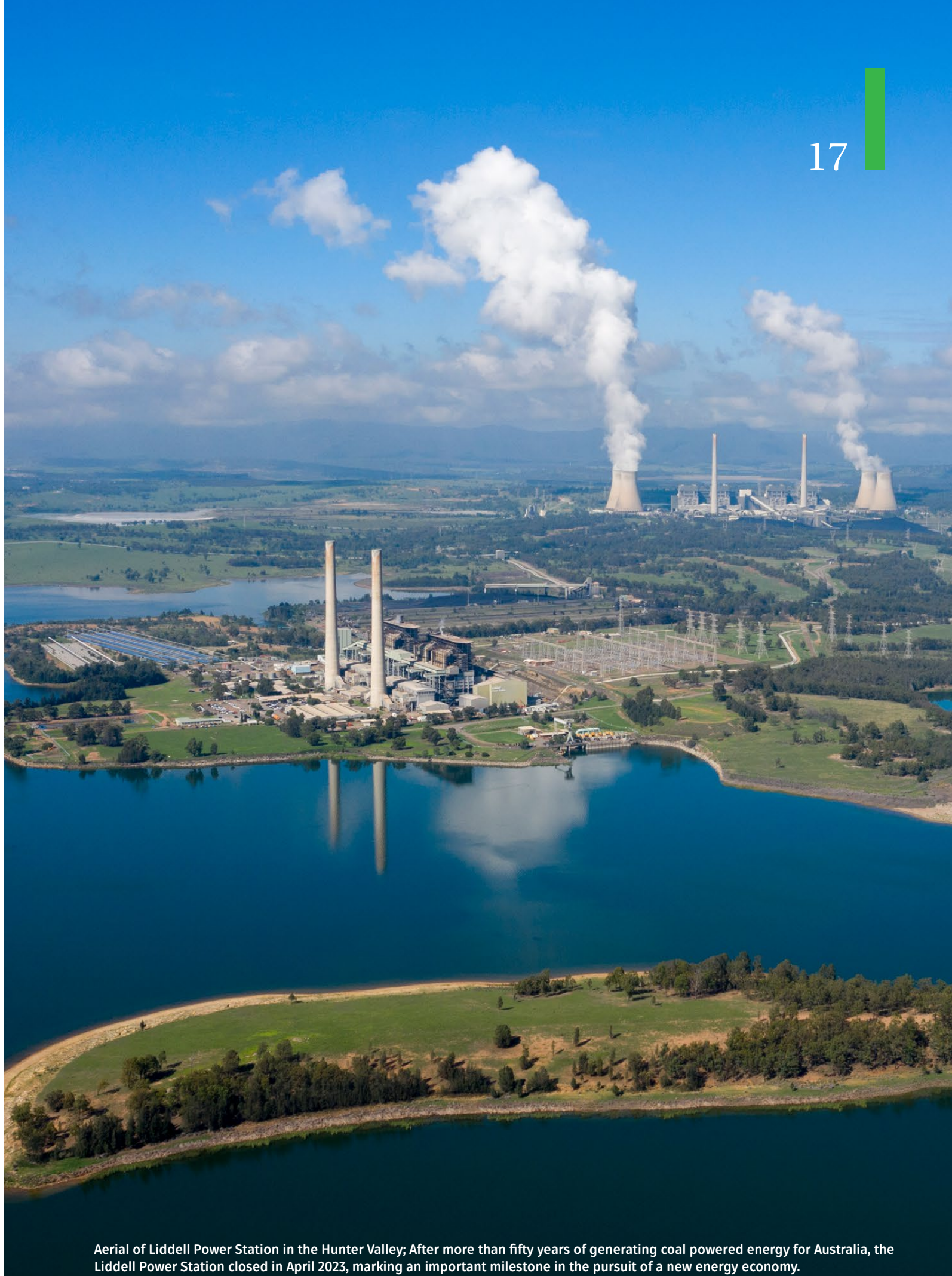
As an energy, research and innovation powerhouse, the Hunter region has complementary research, infrastructure and industrial expertise to accelerate renewable hydrogen generation, storage and use.

Regional partners and researchers are working together to strengthen the Hunter's position as an international leader in energy, and harness the emerging hydrogen opportunity.

Through our coordinated approach, the region is poised to support diverse opportunities and business models, recognising that the path to hydrogen deployment and industry uptake has potential to unfold in a number of ways.

Our researchers encompass a broad range of expertise, with hydrogen capabilities across the University including:

- Hydrogen Production
- Hydrogen Storage
- Hydrogen Utilisation
- Cross Cutting Technologies



Aerial of Liddell Power Station in the Hunter Valley; After more than fifty years of generating coal powered energy for Australia, the Liddell Power Station closed in April 2023, marking an important milestone in the pursuit of a new energy economy.

WANTOK PASIFIKA

A celebration of Pacific Engagement at
University of Newcastle
Friday 9th September, 2022

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PACIFIC

Climate change and biodiversity loss are causing major social, economic, and environmental impacts for Pacific Island communities, and those impacts are only expected to intensify in the coming decades. The Pacific Node initiative was co-created with our partners in the Pacific to enhance local capacity in national priority areas such as climate change resilience, ecosystem and biodiversity protection, waste management and pollution control and environmental governance.

In March 2023, Executive University representatives Deputy Vice-Chancellor (Research & Innovation), Professor Zee Upton and Deputy Vice-Chancellor (Global Engagement & Partnerships), Professor Kent Anderson joined Dr Sascha Fuller, Pacific Engagement Coordinator, in Samoa to continue forging these valuable collaborations.

The University of Newcastle team met with several government departments to discuss the establishment of a Training and Research Node to produce impactful research outcomes and promote strong links between Pacific students and industry.

In Newcastle, our engagement in the Pacific was showcased at the Wantok Pasifika event in collaboration with the Global Engagement and Partnerships division in September 2022. Students, staff, academics, and members of the Pacific community came together to celebrate the continued friendship and collaboration between the University and

communities in the Pacific region. Event highlights included a traditional Samoan dance, a song led by Fijian students, and several student research presentations.

A video speech from Mr Sefanaia Nawadra, Secretariat of the Pacific Regional Environment Programme Director General, recognised the milestones we have made since the beginning of our partnership in 2016. These included the continuous identification of PhD candidates relevant to the environmental needs of the Pacific, contributing to Pacific participation in a decision to develop a global treaty to end plastic pollution, and the establishment of the Moata'a Living Lab - a key environmental education and eco-tourism demonstration site aimed to build the resilience of the Moata'a community and benefit the ecosystem and socio-economic wellbeing of villagers.

Both the visit and the Wantok Pasifika event were reminders of why the University works with Pacific partners to provide quality education, access to the latest science, and propel research that better responds to Pacific needs. Our Pacific engagement promotes diversity and Pacific-led science which will pave a path forward for education and collaboration in line with international frameworks.

Wantok means one talk or same language in the Tok Pisin language.

Wantok is a system where relationships and reciprocal exchange are paramount for creating strong ties.



INDUSTRY COLLABORATION

As the vital link between academia and industry, NIER activates collaboration and collective capacity to underpin research translation.

ENERGY

Trailblazer for Recycling and Clean Energy

The Trailblazer for Recycling and Clean Energy (TRaCE) is a collaborative program between the University of Newcastle and University of New South Wales (UNSW), supported by the Commonwealth Government and industry partners, that aims to move innovative recycling and clean energy technologies from the research phase to global markets.

Professor Emmanuel Mastio was appointed as TRaCE Executive Director late last year. He has since met with key leaders from industry, government and teams from both universities to shape core initiatives in TRaCE's establishment phase.

The University of Newcastle is working to finalise TRaCE research agreements with industry partners. We are excited to collaborate with Element One, Kardinia Energy, Ascon Group, Lavo and Elmntre toward our shared goal of a more sustainable future.

Projects aim to develop technologies in research areas of next generation solar photovoltaics and systems; electrification, energy systems and storage; sustainable fuels and chemicals manufacturing; and recycling, reforming and reuse of materials.

The TRaCE Business Unit continues to work with key stakeholders to support delivery of these priorities:

- An innovation ecosystem with new infrastructure to enable the rapid development of prototypes and production of technologies, alongside a team of research commercialisation specialists and entrepreneurial support programs
- Critical skills development for the next generation of researchers in Recycling and Clean Energy (RaCE) fields, and the upskilling of industry workers through industry-embedded PhD programs and flexible short courses
- A culture of empowerment by putting new workplace frameworks in place to ensure researchers are acknowledged and rewarded for making discoveries at the forefront of RaCE research

NSW Decarbonisation Innovation Hub

The NSW Decarbonisation Innovation Hub (The Decarb Hub) was officially launched at the UNSW Sydney Kensington Campus in February 2023. The Decarb Hub was established with funding from the NSW Government through the Office of the Chief Scientist & Engineer and The NSW Environmental Trust. Co-hosted by UNSW and the University of Newcastle, The Hub is supported by a consortium of leading universities across NSW.

The proposed objectives of The Decarb Hub and its networks are to:

- Support and accelerate the research, development, commercialisation and adoption of decarbonisation technologies and services in NSW
- Foster collaboration, partnerships and projects between industry, researchers and government that drive decarbonisation in NSW and elsewhere
- Attract investment to NSW that supports the research,

development, commercialisation and adoption of decarbonisation technologies and services

- Support the growth of skills, knowledge and workforce in decarbonisation technologies and services in NSW

The Decarb Hub is the coordination point for three networks covering these priority areas.

- Electrification and Energy Systems – accelerating renewable energy solutions and supporting the uptake of electrification in other sectors
- Land and Primary Industries – coordinating and aligning efforts in the next wave of sustainable and low emissions primary industry practices
- Power Fuels including Hydrogen – growing a sustainable NSW hydrogen industry and unlocking decarbonisation opportunities for many hard-to-abate sectors beyond 2030

Laureate Professor Behdad Moghtaderi, Director of the Priority Research Centre for Frontier Energy Technologies and Utilisation, is leading The Decarb Hub's Electrification and Energy Systems network.

University Joins International Hydrogen Alliance

Hydrogen has immense potential to play a major role in the new energy mix and the Hunter region has the complementary research, infrastructure and industrial expertise to accelerate renewable hydrogen generation, storage and use.

The University, through its partnership with the Port of Newcastle, joined more than a dozen international signatories on a new Global Partnership for Hydrogen Innovation. The official signing took place in May 2023 at the World Hydrogen Summit in Rotterdam, Netherlands.

The partnership sees universities, innovation hubs and international ports from Australia, Brazil, Chile, Portugal, the United Kingdom and the Netherlands commit to working together to accelerate innovation for green hydrogen.

The University brings the broad hydrogen research capabilities of our academics, NIER-facilitated initiatives such as the Energy Doctoral Training Centre, and a consortium of industry partnerships to the alliance.

“As a member of the Global Partnership for Hydrogen Innovation, we are reaffirming our commitment to sharing, scaling and supporting hydrogen innovations on a global level.”

- Professor Zee Upton, Deputy Vice-Chancellor (Research and Innovation)

RESOURCES

Sustainability and Emissions Reductions in Iron and Steelmaking

To reduce emissions in the steel industry, major technological breakthroughs must be made to realise high efficiency, low fuel consumption in existing operations, while developing new low carbon processes to meet increasingly stringent global carbon emission regulations in the future.

To provide insight on some of these challenges, over 120 leaders came together earlier this year for the International Symposium on Sustainable Cokemaking and Ironmaking (ISSCI 2023), hosted by NIER’s Centre for Ironmaking Materials Research (CIMR), with sponsorship from BHP, ACARP, Hatch and the Association for Iron and Steel Technology (Australia and New Zealand Chapter). The Symposium saw academic and industry experts examining technological developments in low carbon and sustainable cokemaking and ironmaking.

CIMR researchers are contributing two projects to the Australian Research Council Hub for Australian Steel Innovation, joining their expertise with ten industry partners and eight other universities in the University of Wollongong-led initiative, helping deliver research outcomes to underpin new functional steel products and improve manufacturing processes.

In collaboration with BHP, University of Wollongong and University of Western Australia, researchers from CIMR are working to develop a process to separate phosphorus from steelmaking slag while the slag is still molten. If successful, this project will facilitate recycling of steelmaking slag while separating and upgrading the phosphorous so it can be used to produce valuable fertiliser.

Collaborating with BHP and Australian Coal Association Research Program (ACARP), CIMR researchers are developing innovative techniques for the partial substitution of coking coal with fast-growing biomass in metallurgical coke production, promoting direct fossil carbon avoidance in the blast furnace ironmaking process. By understanding the changes in coal and coke quality requirements, research provides a scientific basis to optimise the use of Australian metallurgical coals in modern and low-carbon ironmaking.

World First Rail Running Conveyor System

Globally, conveying is the preferred method to transport bulk materials over long distances. Compared to other methods, belt conveyors offer continuous operation, high levels of efficiency and high throughputs. As demand for raw materials continues to increase however, any gain in efficiency represents a considerable saving in cost.

Developed by researchers in the Centre for Bulk Solids and Particulate Technologies (CBSPT) and TUNRA Bulk Solids (TBS) under Professor Craig Wheeler and with partners FLSmidth, the Rail Running Conveyor (RRC) combines the benefits of two proven and familiar technologies – heavy rail and belt conveying. For a conventional belt conveyor, the belt is supported by idlers, with this contact accounting for up to 60 per cent of the total drive power of the system. Conversely, rail transport utilises a steel wheel on steel tracks. This steel-on-steel contact represents an order of magnitude gain in efficiency. The RRC replaces the conventional idler sets with support carriages, that travel on conventional steel tracks. By eliminating the belt-idler contact, the operating cost savings of this technology has been estimated to be between 25-60 per cent, when compared to a conventional system.

Two full-scale RRC systems are currently in design for a top-10 copper miner, the first of their kind in the world to be used in industry. The first system is part of a relocated conveyor carrying run-of-mine ore at 5,000t/h over a 3,000m flight. This system is projected to save about 6,500t of CO₂ per year and about \$1 million in power costs compared to the conventional conveyor that it is replacing. The second system also has a length of 3,000m, hauling up to 13,000t/h primary crushed ore starting in July 2024. FLSmidth calculates the annual savings for this conveyor at roughly 13,000t of CO₂ and about \$2 million in power costs.

Momentum Builds for More Sustainable Minerals Processing

The ARC Centre of Excellence for Enabling Eco-Efficient Beneficiation of Minerals (COEMinerals) – which has its administrative base at the University of Newcastle within the NIER precinct - saw a significant ramp-up in activity during this past year. With labs operational and an increase in commencing PhD students, COEMinerals grew to more than 100 scientists comprising students, early career researchers and senior investigators.

The COEMinerals’ first in-person conference, held July 2022, saw industry partners (including Jord International and FLSmidth), researchers and guests engage in some positive collaborative activities focused around critical minerals, minerals processing, sustainability and innovation supporting achievement “net-zero” emissions targets.

“I believe the main conference highlight was the emergence of enthusiasm, energy and motivation from a new generation of researchers who are forming the research community that will underpin their future careers.”

- Laureate Professor Kevin Galvin, Director, COEMinerals.

In October 2022, COEMinerals extended its industry connections and influence by hosting the “International REFLUX™ Flotation Cell (RFC) Upscaling Symposium”. This involved more than 20 centre researchers and propelled local and international awareness of COEMinerals’ research and technology invention to an audience of sustainability experts representing commercial and academic interests.

FOOD

Waste to Resources for the Soy Milk Industry

With a diversity of options on the market and increasingly informed consumers, many people are preferring alternative milk choices. This has led to an increase in the production and sale of soy, oat, and a selection of nut milks, while the consumption of cows milk is gradually declining.

While this has less of an environmental footprint than the production of cows milk, there are new problems associated with an increase in popularity of these dietary options, one being an excess of waste from soy milk production. The soy milk by-product is currently underutilised, and considered to be waste, so is subsequently disposed of. With food security demands and environmental impacts putting increasing pressure on the food industry, the minimisation of waste through the establishment of a waste to resources circular economy is imperative.

Food and Agribusiness Doctoral Training Centre Student, Philip Davy, with his Principal Supervisor Dr Quan Vuong from the Food Science research group are addressing this need with their research project looking at the valorisation of by-products from the large-scale production of plant based milks into saleable novel food items. The team are engaged with Rosewood Research, an industry-based research facility within

the baking industry, and together they are looking to determine possible applications within the food industry.

The research is focused on utilising a by-product from commercial soy milk production which can be incorporated into the foods we consume as part of our daily diet, such as bread. The by-product has been found to provide a cheap source of fibre and other healthful components which provide improved nutritional benefits for the consumer, while delivering a sustainable and economical solution for a challenge in the food industry.

Soil Remediation Solutions

“Forever chemicals,” a category of chemicals like PFAS or per- and poly-fluoroalkyl substances, have been given that name because they don’t break down in the environment. Having been used for many years in industries such as transportation, defence and construction, these chemicals are being discovered as a contaminant across more and more locations, including on our farms.

Low levels of chemicals have been discovered in biosolids, which are used as fertiliser to add nutrients to our soils on Australian farms. We now understand that crops can accumulate these chemicals in fertilisers and pass them on to us, which is the environmental and agribusiness challenge that Laureate Professor Ravi Naidu and his team from the Global Centre for Environmental Remediation are working to solve.

As a global leader in contamination studies, Professor Naidu’s work focuses on the remediation of various environments impacted by agricultural and industrial activity, and the potential impacts of contaminants upon environmental and human health at a local, national and global level.

His research has led to the implementation of policy directives for governments and new technology to manage and remediate polluted environments, both in Australia and abroad.

Options to reduce the impact of this pollutant on farmland include locking chemicals so plants are unable to absorb them. With products already available to do this job, this is an accessible and relatively cheap option. Another is to heat up biosolids to a temperature where the chemicals will break down and become harmless.

More work to find solutions to decontaminate environments and further regulate the use of these chemicals is underway. A broader awareness of forever chemicals is also needed to help mitigate the impacts of the pollutant before they happen.



WATER

Redefining Australia's Drought Risk

Australian rainfall swings between extremes of drought and flood, with drier or wetter than average conditions that can last for decades. Observed records of rainfall and streamflow records usually only go back about 100 years, meaning we do not know how bad and impactful wet or dry extremes can really be in Australia, or where and when the impacts of climate change are already being experienced. This limits how much we can prepare for hydrological extremes, now and in a changing climate.

Existing observed hydroclimatic records do not extend far enough to evaluate Australia's risk due to extremes such as, or worse than, the Millennium Drought (1997-2009). However, emerging evidence suggests extreme megadroughts which occurred in eastern Australia during the early stages of the last millennium went on for periods even longer than the Millennium Drought.

A project by the Centre for Water, Climate and Land, and funded by the ARC Discovery Project is looking into Australia's variable rainfall to determine how dry or wet it can really get to address knowledge gaps associated with the range of hydrological extremes possible in Australia.

The team, which includes researchers from University of Tasmania, Australian National University, the Australian Antarctic Program Partnership and the Institute for Marine and Antarctic Studies, are using ice cores from Antarctica to build a comprehensive understanding of Australia's rainfall variability over the last 2000 years.

This project aims to quantify how naturally variable the rainfall coming from the Indo-Pacific mid-latitudes is, allowing recent rainfall extremes and future projections to be assessed in a long-term context. Outcomes are expected to produce new estimates of atmospheric moisture budgets between Australia and Antarctica based on a novel, 2000-year reconstruction of moisture-bearing southern Indian Ocean storms.



Find out more about the NSW Regional Water Strategies by scanning this code.

Understanding the Fate of Toxic Compounds in Biosolids

Any contaminant from soil has the potential to migrate to adjacent groundwater and water bodies and cause risk to plants and animals. For decades, a wide range of industry sectors and households around the globe have used these chemicals, and they have subsequently become ubiquitous throughout the environment, including in our waterways and farmlands.

Collaborating with a broad spectrum of industry partners from the water sector including Hunter Water Corporation, Melbourne Water Corporation, South East Water Corporation, South Australian Water Corporation, Intelligent Water Networks, Water Research Australia Limited, EPA Victoria, and Arcadis Australia Pacific Pty Ltd, along with the University of Melbourne, Professor Megh Mallavarapu and his research team from the Global Centre for Environmental Remediation are investigating the degradation pathways these contaminants have in groundwater, affecting biosolids and biosolid-amended agricultural soils.

The project brings together expertise in environmental science, chemistry, eco-toxicology and remediation to provide in-depth knowledge and develop practical solutions to ensure our waterways and agricultural land remain environmentally sustainable for Australian farmers and communities.

NSW Regional Water Strategies

NSW Department of Planning and Environment is preparing the NSW Regional Water Strategies (RWS) to plan and manage the water needs in 12 NSW regions over the next 20-40 years. These water strategies will be delivered in partnership with water service providers, local councils, communities, Aboriginal people, environmental and industrial groups across NSW, to bring together the best and latest climate evidence and a wide range of tools and solutions to ensure each region has an effective plan in place for future water management.

Associate Professor Anthony Kiem from the Centre for Water, Climate and Land has been supporting the development of the strategy through the generation of stochastic climate data (rainfall and evapotranspiration) that improves our understanding of past climate conditions and plausible climate futures and provides a more accurate picture of the frequency of extreme climate events. This information underpins planning and strategy and is used to assess the impacts of climate variability and climate change on water resource management and planning across the different NSW regions.



RESEARCH EDUCATION

NIER's research education initiatives provide targeted training and skills development for postgraduate students, focused on addressing the workforce needs of future industries.

ENERGY DOCTORAL TRAINING CENTRE

With growing pressure to electrify Australian industries, students are increasingly interested in devoting their PhD projects to furthering research into new energy technologies, or decarbonising existing manufacturing processes. This dedication has inspired the formation of the Energy Doctoral Training Centre (DTC) embedded in NIER.

Since its launch in September 2022, eight students have joined the DTC. Being part of a DTC allows candidates to solve real world industrial problems by collaborating with an industry partner, accessing leading research infrastructure and developing work ready skills.

"There has never been more urgency, or more enthusiasm, for innovation in the energy sector. To make the necessary cuts in emissions across all areas, we need as much cross-sector collaboration as possible. This DTC brings people together with a shared vision of reducing emissions while progressing green energy solutions."

Dr Jessica Allen, Academic Convenor of the Energy DTC

FUTURE LEADERS A FOCUS FOR COEMINERALS

The ARC Centre of Excellence for Enabling Eco-Efficient Beneficiation of Minerals (COEMinerals), located at NIER, is committed to providing high-quality training environments for their PhD candidates and early career researchers (ECRs) to build personal and professional skills throughout their tenure.

COEMinerals started their "Future Leaders Program" in 2022. The program provides PhD candidates and ECRs technical and soft skill training as well as opportunities to engage with industry, whether it be through site visits and tours or networking events.

The Centre's "Future Leaders Committee" (FLC) is managed and operated by internal PhD candidates and ECRs. The FLC helps candidates and ECRs connect and form internal networks with each other across multiple universities in Australia. The FLC is also responsible for driving training and mentoring topics and building awareness of and engagement in COEMinerals-orchestrated activities. Acting as a communication channel between other students and the COEMinerals executive leadership team, candidates and ECRs are able to request the support they need to transition into being the next generation of STEM research and industry leaders.

The FLC has facilitated several meetings between COEMinerals' nodes, conducted a sentiment survey of PhDs and ECRs, and proposed technical and professional development training topics. The FLC also played an important engagement role in the first in-person COEMinerals conference in Canberra, including organising social events such as a trip to Questacon and facilitating participation in formal mentoring activities such as the 3-Minute Thesis competition.

STUDENTS IN SAMOA CO-DESIGN A MODEL FOR REGENERATIVE TOURISM

Dr Sascha Fuller, Pacific Engagement Coordinator, supported a study tour for students to Samoa as part of the Moata'a Living Lab initiative. The Living Lab aims to restore and conserve the mangrove ecosystem and support the socio-economic wellbeing of villagers through a collaboration between government departments, civil society, the private sector, and academia. This is essential for future resilience as mangroves provide shelter and nutrients for fish and other marine species that Moata'a villagers depend on for food and income, as well as acting as a first line of defence against severe weather events that cause flooding.

To begin the trip, University staff formalised our partnership with the village of Moata'a by signing a Memorandum of Understanding. The village held a traditional 'Ava ceremony to celebrate the significance of the moment and welcome the students.

Staff and students worked with the community to co-design a model of regenerative tourism for the village while increasing awareness of the importance of the Moata'a mangrove ecosystem through the trip.

While visiting, the students engaged in a three-day homestay and a cultural day, which included learning how to block paint lava lavas, cook traditional Samoan cuisine and weave baskets.

On their last day they helped plant mangroves and clean up the beach as an example of regenerative tourism activities.

This unique experience of everyday village life left them with important on-the-ground insights from various sectors around societal, cultural, environmental and economic issues related to climate change. They left Samoa equipped with the knowledge and experience to continue working towards innovative solutions for global business and development.

For the village, the study tour raised an opportunity to gain revenue by continuing to host students in homestays and hold regenerative cultural and environmental activities. The village and the local Taumeasina Island Resort will soon start promoting the activities to international tourists.

The trip, led by Dr Phoebe Everingham and Dr Po-Hsin Lai from the University of Newcastle Business School, was supported by the Federal Government through the New Colombo Plan initiative.



DTCs inspire the next generation of industry leaders with new ideas, new ways of working and smarter solutions to industry challenges. Scan to find out more.



Photo: Newcastle City Council

INNOVATIVE SOLUTIONS

NIER's industry-engaged model accelerates opportunities for the deployment of technologies and services that support social, economic and environmental outcomes for sectors of global significance.

HYDROGEN AT HOME

NIER is partnering with local company, Hydrogen at Home Pty Ltd, to help make hydrogen technology more accessible for the clean energy transition by conducting the research and development required to integrate existing and emerging hydrogen technologies with future applications in the community.

The Hydrogen at Home partnership is a collaboration between local industry, government and researchers, formed to develop technology using renewable energy resources in mobile and static applications to achieve energy resilience, independence and control. Hydrogen at Home means solutions using best in class emerging sustainable energy technology for hydrogen; generation, compression, drying, storage, fuelling and fuel cells and includes:

- Zero carbon energy storage systems (stationary and mobile)
- Interseasonal energy storage
- Vehicle to Home (V2H)
- Vehicle to Grid (V2G)
- Virtual Power Plant (VPP)

BATTERY METALS RECYCLING BREAKTHROUGH

Australian battery recycling technology company, Battery Pollution and Professor Scott Donne's Electrochemistry Group have partnered to focus on the development of proprietary processes for the recovery of cobalt, lithium, graphite and nickel from spent electric vehicle and energy storage system batteries.

With an innovative and environmentally responsible approach, they aim to address the growing demand for sustainable cobalt and battery metals and contribute to a greener future.

Cobalt and various battery metals, critical components in lithium-ion batteries, are known for their scarcity and complex supply chain challenges. The state-of-the-art recycling approach being developed utilises advanced chemical processes and proprietary methodologies to extract battery metals, minimising waste and maximising resource recovery. By doing so, this novel scientific approach significantly reduces the need for traditional mining operations, thereby reducing the environmental impact associated with mineral extraction.

The solution leverages pyrometallurgy and hydrometallurgy processes, combined with certain pre-treatment strategies, to deliver high quality separated battery metals fit for reintroduction into the battery manufacturing supply chain – targeting more than 95 per cent plus recovery of key battery metals through the combined mechanical shredding and chemical engineering process.

The work under this strategic collaboration commenced in October 2022 and has progressed through to pilot testing of the battery metals recovery processes. Outcomes will help reduce reliance on mining but also help prevent hazardous battery waste from ending up in landfills.

The development of battery metal recoverable technology is an exportable product, with particular relevance to economies that are considering the development of battery manufacturing "gigafactories".

COE MINERALS' TECHNOLOGY ADVANCES

This year the ARC Centre of Excellence for Enabling Eco-Efficient Beneficiation of Minerals (COEMinerals) saw some ground-breaking innovation as a result of inter-node, cross-discipline collaboration. Centre researchers initiated and explored collaborative research projects, sharing knowledge, skills and technical equipment. This approach resulted in some highly productive, new and unique experimentation opportunities for both members and industry.

Technological advances achieved by COEMinerals in 2022 included:

- Jord International (Jord) progressed two new Centre-related technologies towards commercialisation: NovaCell™ and XtractOre™
- Backed by funding from ACARP – Jord collaborated closely with the Centre to break ground on a full scale XtractOre™ demonstration plant at a site in NSW (for floating coarse particles)
- Jord also secured government funding to deliver a full scale NovaCell™ module at an Australian mining operation. Jord General Manager of Resources Kevin Barber says the company's full-time on campus presence at the University of Newcastle has enabled, "daily interaction" under an embedded partnership model with COEMinerals enabling Jord to be "a very hands-on partner"
- FLSmidth successfully secured European funding to support centre-developed coarseAIR™ upscaling, with involvement from COEMinerals
- West Cobar Metals (ASX: WC1) re-engaged COEMinerals to undertake beneficiation studies on the Newmont Deposit to help unlock a major rare earth mineral deposit

Development of a Heterogeneous Minerals Processing Facility

Laureate Professor Behdad Moghtaderi, Director of the Priority Research Centre for Frontier Energy Technologies and Utilisation, with his team and industry partner EcoTech Pty Ltd, are establishing a Heterogeneous Minerals Processing (HMP) facility as part of a joint project funded by the NSW Government under the 'Critical Minerals and High-Tech Metals' initiative.

This follows the successful rollout of a two-stage thermal roasting and chlorination process developed earlier by the team to increase critical mineral recovery from ores and gold tailings in an effort to make mineral processing more economic and environmentally sustainable.

As part of the new project, the team will trial a scaled unit on the NIER precinct to help design the desired HMP facility.

PhD PATHWAYS

As we work to build the industries of the future, we need to synergise the workforce, which means equipping the next generation of graduates with the most up-to-date knowledge, technical abilities, and a skillset to solve problems that haven't emerged yet.

NIER is committed to the delivery of multidisciplinary education and training. We work closely with our industry partners to deliver a world-class training experience and meaningful research that drives positive change.

Here we meet three candidates at different milestones on their higher degree by research pathways.



TARUN SRIVASTAVA

Former PhD Employed in Industry

Tarun Srivastava is an Engineering Sales Manager at Elastotec, a mining equipment company. In this role, he balances sales responsibilities with research to develop their Lagging Performance Optimisation Tool software and calibrate it to ensure it runs optimally for their clients.

Before this, Tarun completed a PhD project in 2022 at the University titled 'Electrostatic Interaction of Dust Particles to Solid Surfaces'. When transporting coal, the coal dust can lift off from train carriages and pollute the environment. Communities living near these transportation lines can face health consequences from the dust entering their lungs. G H Varley Group, a wagon manufacturing company, funded the project to help determine why the dust lifts off and how they can limit it.

Tarun, supervised by Professor Kenneth Williams from the Centre for Bulk Solids and Particulate Technologies (CBSPT), developed a novel model for electrostatic adhesion. His model determined what size, between 1 micron to 90 microns, particles adhered to surfaces the most and the least. Besides its use in the coal industry, the model can also inform the printing industry how to lay their ink for higher quality products with a better profit.

Tarun thanked the CBSPT team and for their guidance throughout his studies and the technicians at TUNRA Bulk Solids for the experimental construction. He credits his success securing the Elastotec role to their research insights, professional development workshops held by the Resources Doctoral Training Centre, work experience and determination.



JANGHO JO

Recently Commenced PhD

Jangho Jo commenced his PhD at the University of Newcastle in January 2023, working on a collaborative project titled 'Characterisation and Preparation of Waste Plastics for Cokemaking'. The project is co-supervised by Centre Co-Director Dr Arash Tahmasebi and Research Associates, Dr Soonho Lee and Dr Hannah Lomas from the Centre for Ironmaking Materials Research

An essential component of ironmaking, a process in steel production, is cokemaking. Cokemaking involves the carbonisation of coal to produce metallurgical coke. Researchers are exploring waste plastics as an alternative to carbon sources to minimise environmental impacts from the process.

The project focuses on characterising waste plastics from various domestic sources and developing appropriate processing techniques for their utilisation in cokemaking. Jangho and the team will analyse different blends of waste plastics with Australian coking coals using the centre's coke research testing facilities and advanced analytical techniques. From these findings, they aim to provide industry partners with a tool to make the cokemaking process more sustainable and economically efficient, without compromising the integrity of the product.

The project is undertaken in partnership with BlueScope Steel and Veolia Australia, and supported by the Australian Research Council Research Hub for Australian Steel Innovation. Throughout his research, Jangho has collaborated closely with his BlueScope Steel Associate Researchers and research outcomes could lead to industry coke oven trials at BlueScope.



TUYEN THI LUONG

PhD Near Completion

Tuyen Thi Luong is a PhD candidate within the Centre for Water, Climate and Land (CWCL). Her project, co-supervised by Dr Tonelle Handley and Dr Jane Rich from the School of Medicine and Public Health, and Associate Professor Anthony Kiem and Dr Emma Austin from the CWCL investigates the relationships between climate extremes, mental health, adaptive capacity, and climate resilience in rural communities.

Public health experts recognise that droughts, floods, and heatwaves can negatively impact people's mental and physical health. In response, many national and international organisations have established or expanded post-disaster services to include mental health assistance and support. However, little is understood about how mental health within rural communities is affected by multiyear periods, sometimes decades, with increased frequency of droughts, floods, and heatwaves.

Tuyen's project will provide a more nuanced understanding of the factors that cause mental health to decline during extreme climate events. The findings from this research will inform policy and strategies that will improve mental health during and after climate extremes, increase adaptive capacity, and enhance the climate resilience of rural communities.

Following the completion of her PhD Tuyen hopes to continue this research, turning her focus towards the cost and benefit of potential mental health interventions.

The University is conducting this project as part of the Southern Queensland/Northern NSW Drought Resilience Adoption & Innovation Hub.

NIER RESEARCH CENTRES AND GROUPS

- ARC Centre of Excellence for Enabling Eco-Efficient Beneficiation of Minerals
- Australian National Fabrication Facility Newcastle Hub
- Priority Research Centre for Advanced Particle Processing & Transport
- Priority Research Centre for Frontier Energy Technologies & Utilisation
- Centre for Organic Electronics
- Global Centre for Environmental Remediation
- Global Innovative Centre for Advanced Nanomaterials
- International Collaborative Centre for Carbon Futures
- Centre for Advanced Energy Integration
- Centre for Bulk Solids & Particulate Technologies
- Centre for Ironmaking Materials Research
- Centre for Multiphase Processes
- Centre for Resources Health & Safety
- Centre for Water, Climate & Land
- Applied Electrochemistry Group
- Coastal & Marine Science Research Group
- Food Science Research Group
- Nanomaterials Research Group



Image: Aerial shot of the NIER precinct. Credit: earthconnect

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