NEWCASTLE INSTITUTE FOR ENERGY AND RESOURCES

TECHNICAL PROSPECTUS

UNIVERSITY OF NEWCASTLE AUSTRALIA

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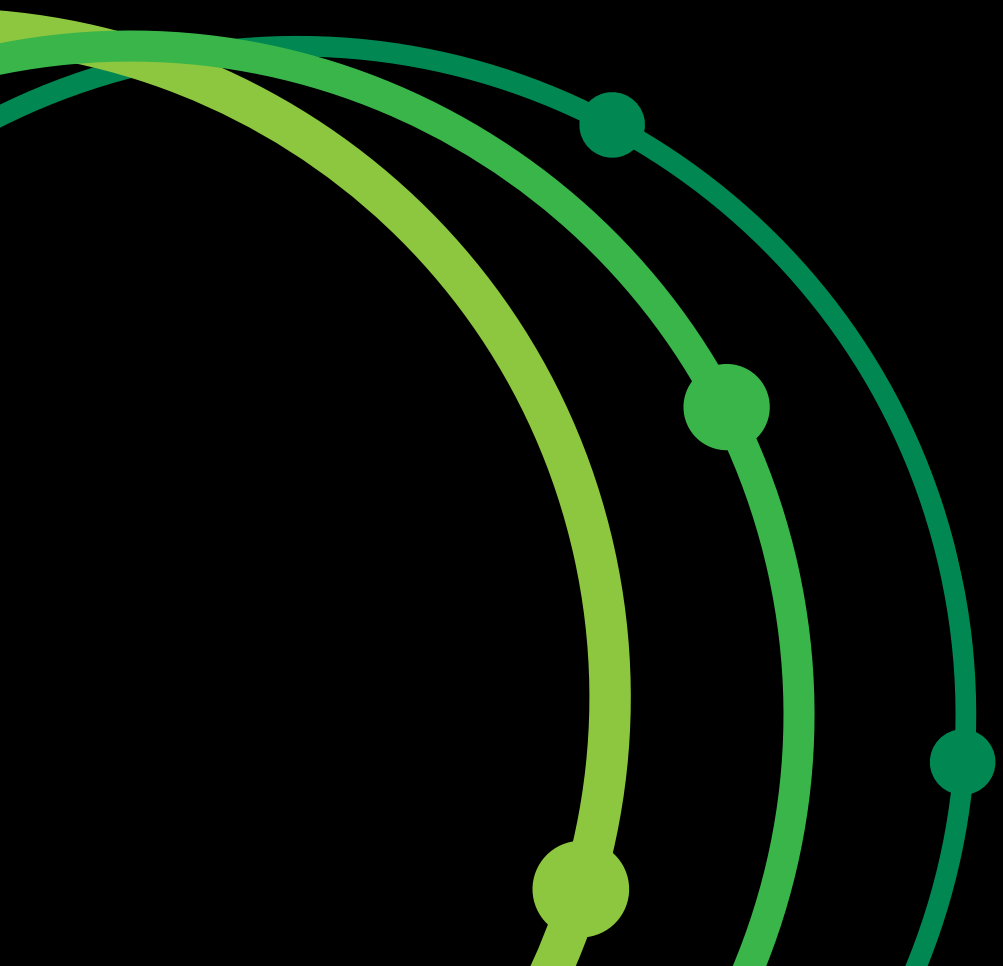
SOLUTIONS FOR GLOBAL CHALLENGES
ENERGY RESOURCES FOOD WATER



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The University of Newcastle acknowledges the traditional custodians of the lands on which our research is conducted: Awabakal, Sarkinjung, Biripai, Worimi, Wonnarua, Gomeroi, and Eora Nations. We pay respect to the wisdom of our Elders past and present. We extend our acknowledgement and respect to all Aboriginal and Torres Straight Islander Nations from which our students, staff, and community are drawn.

INTRODUCTION

From its inception in 2010, The Newcastle Institute for Energy and Resources (NIER) has served as a nationally recognised nexus for industry and academia, driving innovative solutions at the forefront of clean energy and sustainable resource development in our region and beyond.

NIER is focused on delivering sustainable advancements to meet the challenges of a changing world. As global demand for energy, metals and minerals, food, and water continues to grow, so does the need for smarter, more sustainable ways to manage these resources.

Through industry-led research, collaboration, and technological progress, we are developing new ways to secure these sectors of global significance well into the future.

RESEARCH THEME AREAS

POWERING THE FUTURE

Unlocking new energy solutions, new economies, and a net zero future through innovative technologies, materials, and fuels

NEXT GENERATION RESOURCES

Meeting the resource needs of the future through sustainable innovations that support our minerals, metals, food, and water sectors

ENVIRONMENTAL SUSTAINABILITY AND SECURITY

Balancing environmental, economic, and social priorities to protect regional resilience, sustainability, and prosperity

THE NIER ADVANTAGE

DRIVING GLOBAL IMPACT THROUGH RESEARCH PARTNERSHIPS

NIER's research partnerships are shaped by deep local expertise and a commitment to solving real-world challenges. These focus areas are not only critical to Australia's future, they are internationally relevant, attracting global interest and funding.

NIER maintains a strategic approach to industry engagement, supported by frameworks that enable interdisciplinary collaboration and guide researchers through every stage of their projects. The NIER model connects academic excellence with market needs, working alongside major national and international companies to overcome industry challenges and unlock innovation.

With a high-performing team offering specialised support in contract negotiation, commercial oversight, and project administration, NIER removes barriers to international collaboration and accelerates the delivery of impactful solutions.

TESTING FOR SUCCESS

The NIER Precinct offers a unique ecosystem of advanced infrastructure, including manufacturing and prototyping facilities, and expert support for researchers, students, and industry partners to come together to test and validate ideas, technologies, and services.

Facilities such as pilot plants, mineral and chemical labs, glasshouses, and demonstration units enable testing, development, and scale-up of new technologies. These assets are backed by dedicated Precinct support and robust safety systems, ensuring smooth and secure operations.

SKILLSETS FOR THE JOBS OF THE FUTURE

As industry evolves and the need for specialised knowledge and new skills rises, NIER is facilitating PhD-industry partnerships that have a reciprocal advantage with all project members working together towards real outcomes for industry challenges.

These partnerships offer value for companies to gain access to cutting-edge research and emerging talent, while candidates receive tailored training, industry exposure, and practical experience that enhances their employability. These programs are cultivating a new generation of innovators equipped with the knowledge, experience, and mindset to drive smarter solutions for industry.

POWERING THE FUTURE

UNLOCKING NEW ENERGY SOLUTIONS, NEW ECONOMIES AND A NET ZERO FUTURE THROUGH INNOVATIVE TECHNOLOGIES, MATERIALS, AND FUELS

- Low Emission Technologies
- Renewable Energy Systems and Sustainable Fuels
- Advanced Materials for Industrial Innovation
- Nanotechnologies
- Organic Electronics

LOW EMISSION TECHNOLOGIES

Innovative solutions that reduce greenhouse gas emissions and environmental impacts.

FOCUS AREAS

EMISSIONS ABATEMENT AND POLLUTION CONTROL

- Ventilation Air Methane (VAM) abatement technologies, safety, deflagration to detonation, chemical looping, stone dust and catalytic reduction of VAM
- Combustion flue gas cleaning technology and smog reduction
- Environmental pollution control - particularly destruction and utilisation of Per- and Polyfluoroalkyl Substances (PFAS) contaminated media (water and soil)

CARBON CAPTURE AND UTILISATION

- Novel options for carbon dioxide capture and storage using mineral carbonation and post combustion capture, including Ventilation Air Methane (VAMCO) technology for point source capture of greenhouse gas emissions
- Fuel and material utilisation in manufacturing, process, and chemical industries such as coking coal in ironmaking and carbon dioxide utilisation for food industries, enhanced oil recovery, chemicals, and fire suppressants
- Advanced coke oven manufacturing carbon utilisation processes
- Carbon nanofibres from coal
- Carbon dioxide in water nanoemulsions for carbon sequestration

ENERGY EFFICIENCY AND WASTE MINIMISATION

- Waste minimisation techniques including biochar, char from coal tailing, and chemical looping of municipal solid waste (KIMIYA technology)
- Waste heat recovery systems using co-generation plants and heat pumps
- Low-emission technologies for sustainable gas well dewatering
- Metallurgical processing such as slag granulation and inclusion reduction
- Energy efficient desalination
- Energy efficient wastewater treatment plants involving aeration power reduction, dewatering, and enhanced oxygen transfer efficiency
- Integrated waste processing and utilisation with recovery and generation
- Life cycle analysis and sustainable waste processing

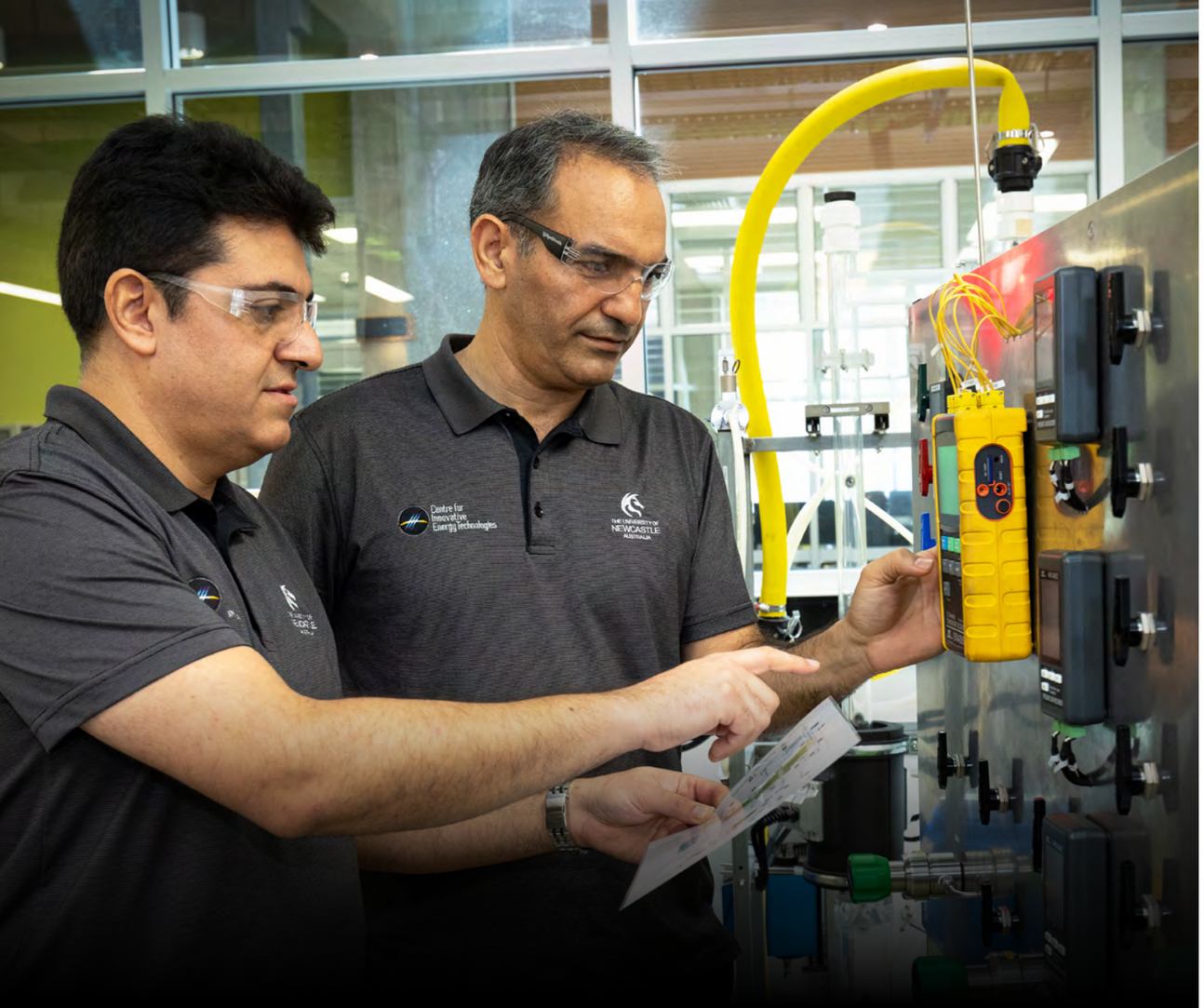
RESEARCH IMPACT

- Large scale demonstration detonation tube for capturing fugitive methane from underground coal mining operations
- VAMCO technology for abatement of greenhouse gas emissions
- PFAS Harvester for destruction/utilisation of PFAS species
- KIMIYA technology for chemical looping gasification of organic waste including municipal solid waste
- The GRANEX™ Heat Engine, a supercritical Rankine cycle-based heat engine specifically designed for waste heat recovery from low-grade heat sources
- Pressurised regenerative calcium cycle energy storage prototype
- Chemical Looping Air Separation (CLAS) energy on demand system
- Carbon arrestor pyrolyzer for biochar making
- Energy harvesting from CO_2 capture
- Development of ionic liquids to capture CO_2
- Combined carbon capture from flue gas streams and mineral carbonation
- Soil remediation technology
- Carbon nanofibre prototype system

CONVERTING WASTE INTO SUSTAINABLE FUELS

Currently, over half of the country's municipal solid waste ends up in landfills. Laureate Professor Behdad Moghtaderi and his team from the Centre for Innovative Energy Technologies are recovering valuable resources from waste through innovative technology.

They're creating a new technology platform that converts organic waste to sustainable chemicals and fuels without emissions through a set of thermochemically assisted processes. When derived from waste, these chemicals can be used as ingredients for eco-friendly products such as sustainable aviation fuels and fertilisers.



RENEWABLE ENERGY SYSTEMS & SUSTAINABLE FUELS

Advanced technologies to power low-carbon energy systems and future-ready industries.

FOCUS AREAS

RENEWABLE ENERGY SYSTEMS AND STORAGE

- Hybridisation of coal fired power plants and technologies for geothermal and solar assisted power generation
- Renewable energy systems for biomass and biosolids utilisation including co-firing chemical looping gasification, direct and indirect geothermal technologies, and small wind systems
- Hybrid energy systems including geothermal assisted power generation, solar assisted power generation, and geothermal solar
- Pyroelectric and thermoelectric energy harvesting
- Building thermal efficiency with passive solar systems
- Utility scale and microgrid scale energy storage involving calcium looping, phase-change chemical looping, and ilmenite looping
- Redox-based thermochemical energy storage
- Hybrid phase change redox based thermochemical energy storage
- Calcination-based thermochemical energy storage
- Energy conversion techniques using direct carbon fuel cells and advanced materials for batteries and super capacitors
- Underground hydrogen storage

GREEN FUELS AND HYDROGEN PRODUCTION

- Hydro Harvester technology for atmospheric water generation and subsequent green hydrogen production
- Chemical looping (air separation, combustion, gasification, and reforming)
- Underground coal gasification
- Coal and biomass pyrolysis, gasification, and combustion
- Ultra-low ash coal for direct injection carbon engines and direct carbon fuel cells
- Sustainable aviation fuels
- Development of technologies for green ammonia synthesis and reforming
- Transportation fuels from coal and biomass to liquid and energy carriers
- Micro energy systems including micro hydrogen generators
- Development of membrane reactor-based hydrogen purification systems

RESEARCH IMPACT

- Green ammonia synthesis
- Chemical looping ammonia reformer for production of high purity ammonia
- Portable and compact desalination technology using closed loop helium-based humidification–dehumidification desalination
- Sorbent chemical looping gasification of biomass and organic waste
- Village-scale bio-digester for biogas production from organic waste
- Hybrid high thermal mass walling system
- Utility scale energy storage
- Energy on demand microgrid scale energy storage
- Hydrogen production through pyrolysis of biomass
- First generation batch plant demonstrating carbon utilisation for building products such as concrete and plasterboard

HYDRO HARVESTER SCALES UP TO QUENCH MARKET THIRST

The Hydro Harvester is a groundbreaking system capable of producing up to 1000 litres of drinkable water per day directly from the air. Using solar thermal energy or waste heat, the device heats air to increase moisture content before cooling it to extract clean water for drinking or irrigation.

With support from the Australian Government's Future Drought Fund, Laureate Professor Behdad Moghtaderi and his team scaled the technology from a 20-litre pilot to a modular, market-ready 1000-litre system. The unit is capable of sustaining a small rural community of up to 400 people, offering critical resilience during droughts and emergencies.

Unlike conventional atmospheric water generators, the Hydro Harvester's thermal-based process reduces electricity use and operating costs while functioning effectively across diverse climates.

ADVANCED MATERIALS FOR INDUSTRIAL INNOVATION

Novel options for carbon capture and storage, transportation fuels, energy conversion, and fuel utilisation in non-energy applications.

FOCUS AREAS

ELECTROCHEMICAL SYSTEMS

- High temperature direct carbon fuel cells
- Electrochemical capacitors
- Battery systems
- Energy storage and conversion
- Solar thermal energy storage materials with high energy density and high thermal conductivity
- Recycling of spent battery materials
- Electrochemical process design and analysis
- Solar thermal hydrogen production
- Chemical storage of energy as hydrogen through solar driven thermochemical water splitting
- Integration of carbon electrolysis for carbon capture and utilisation as well as solar thermal manufacturing processes
- Development and fabrication of supercapacitor and battery materials
- Engineering design of high temperature electrolysers and fuel cells
- Predicting energy generation for specific feedstocks in slow pyrolysis green waste-to-biochar systems
- Non-toxic approaches to metal recovery
- Advanced corrosion analysis for electrochemical technologies

ADVANCED MATERIALS

- Thermochemical transformation of biomass into value-added products (including biochar)
- Structural engineering, reliability, and resilience
- Corrosion science, engineering, and technology
- Prototyping and forensic material science
- Creating artificial materials through novel and scalable synthesis strategies
- Advanced carbon materials for energy and sustainable technologies
- Design and characterisation of functional materials and nanomaterials with tailored properties
- Developing precise, efficient, and sustainable chemical processing strategies
- Carbon capture, recycling, and upcycling using advanced materials technologies

RESEARCH IMPACT

- Micro batteries for medical applications
- Demonstration-scale direct carbon fuel cell
- High energy, thin film electrochemical capacitors
- Improved efficiency cathode-active battery systems
- Effective battery recycling strategies
- Biomass processing for next generation products
- Efficient production of biochar as a heavy metal adsorbate
- Efficient integration of electrochemical technology for manufacturing
- Extraction of valuable metals and metalloids from end-of-life renewables and e-waste
- Efficient integration of electrochemical technology for manufacturing
- Extending operational life of electrochemical technologies

CARBON CAPTURE AND UTILISATION

MCi Carbon is advancing a breakthrough pathway for permanent carbon capture and utilisation through its engineered mineral carbonation technology.

Central to this progress is the company's long-running research presence at the Newcastle Institute for Energy and Resources (NIER), where its world-leading pilot plant has operated since 2016.

At NIER, researchers test mineral feedstocks, analyse CO_2 abatement performance, and gather scale-up data to refine and optimise the carbonation process.

The NIER pilot facility enables MCi Carbon to integrate impure flue gases, accelerate mineral reactions, and generate stable carbonates such as magnesium and calcium carbonates for use in construction and manufacturing.

These insights directly inform the design and operation of the Myrtle CCU demonstration plant, funded in part by the Federal Government's $14.5m Carbon Capture Technologies Program, which will convert approximately 2500 tonnes of CO_2 annually into low-carbon products, helping decarbonise heavy industrial supply chains.

NANO-TECHNOLOGIES

Emerging nanomaterials-based technologies for energy, environmental, and health related applications.

FOCUS AREAS

CLEAN ENERGY NANOTECHNOLOGY

- Advanced nanocatalytic materials for solar-driven hydrogen production from seawater
- Nanoporous electrocatalytic materials for fuel cells
- Controlling the structure and pore diameters of nanoporous carbons for hydrogen, methane, and energy storage
- Novel nanomaterials-based electrode materials for battery and supercapacitor applications
- Nanoporous fullerenes as metal-free electrodes for supercapacitors and batteries
- Heteroatom-doped carbon and carbon nitride nanostructures for next-generation, low-cost energy storage and conversion integrated systems
- Graphenes, carbon dots, quantum dots, and carbon nanospheres for energy and sensing applications
- Nanostructured carbon-based materials for carbon dioxide capture and conversion
- Natural biomass-derived activated porous biocarbons for selective carbon capture and soil remediation
- Ammonia production from NOx for coal-fired power plants
- Hydrogenation, dehydrogenation, hydrocracking, hydroisomerisation, alkylation, acylation, oxidation of large organic compounds, and CO_2 utilisation and conversion
- Nanoporous metal chalcogenides for photocatalytic applications
- Electrocatalytic production of ammonia and its utilisation for agricultural activities
- Photocatalytic conversion of CO_2 into fuels of interest

ENVIRONMENTAL NANOTECHNOLOGY

- Porous biochar and its composites for developing slow and controlled release fertiliser for nitrogen and phosphorus
- Nanomaterials to address soil constraints such as carbon sequestration, acidity, hardening, and slaking
- Porous and photocatalytically active nanomaterials for designing solar-powered filtration bags for water purification
- The identification, removal, and degradation of microplastics using innovative nanomaterials-based solutions
- Utilising nanotechnology to create compostable bioplastics from biomass

BIOMEDICAL NANOTECHNOLOGY

- Crystalline and amorphous metallosilicate and heteropoly acids for fine chemical synthesis
- Nanoporous biomolecules for sensing, enzymatic catalysis, and drug delivery
- Innovative nanoparticles for chemo-free cancer treatment
- Production of nanozinc and other pharmaceutical products using a nanotechnological approach
- Core-shell porous silica-based nano-medicines, bio-vehicles and bio-reservoirs – drug delivery systems for cancer diagnosis and treatment
- Nanoporous carbon-based sensors for toxic carcinogens, glucose, and other pathogens

RESEARCH IMPACT

- Alternate and low-cost renewable energy sources for household applications
- Clean and low-cost hydrogen fuel for onboard storage in transport applications
- Low-cost, high-energy density portable energy storage device
- Low-cost fuel cells
- Low-cost and compact batteries with shorter charging times and high energy storage
- Low-cost and compact solar cells for energy conversion
- Alternate solid-state-based low-cost adsorbent for CO_2 capture
- Catalytic conversion of CO_2 to value-added chemicals, including alcohols, ethers, and polymers
- Pre and post processing of crude oil, petroleum products, and by-products
- On demand targeted drug delivery, early-stage cancer detection, and therapy
- Fine chemical production for cosmetics and pharmaceuticals
- Sensing and detection of toxic vapours and molecules
- Clean hydrogen fuel production from organic hydrides for the efficiency of coal-fired power plants
- Delivering innovative fertiliser solutions for farmers to integrate in their farming practices
- Innovative nanomaterials-based solutions for farming communities to solve various soil related issues
- Low-cost innovative water filtration technologies for various types of communities
- Creating a microplastic free environment for aquatic and terrestrial biota
- Sustainable bioplastics for consumers

ORGANIC ELECTRONICS

Delivering the next generation of environmentally friendly energy sources, photonics, and biosensors.

FOCUS AREAS

MANUFACTURING AND UPSCALING

- Large-scale manufacturing of sustainable renewable energy systems
- Large-scale manufacturing of point-of-care diagnostic systems
- Industrial web printing of organic electronic materials and devices
- Industrial continuous web deposition of metals, inorganic and dielectric materials
- Optimisation, characterisation, and upscaling of aqueous solar nanoparticle inks for organic photovoltaics and biosensors
- Thin film and chemical vapour deposition of specialty nanostructured materials and devices
- Design, development, and fabrication of nanostructured electronic materials and devices
- Services in the production of research quantities of specialty nanostructured materials such as electronic polymers and macromolecules for applications including organic light emitting diodes, organic photovoltaics, polymer actuators, non-conventional organic electronics applications, batteries, and energy storage materials

CHARACTERISATION AND FUNDAMENTAL STUDIES

- Surface analysis and characterisation of novel materials and devices
- Synchrotron photoelectron spectroscopy and microscopy of materials and devices
- Femtosecond laser studies of charge generation and conduction mechanisms in organic photovoltaic devices
- Long-term stability and life prediction techniques for solar cells and modules
- Design, development, and application of neutral atom microscopy instruments

RESEARCH IMPACT

- Printed Solar; novel ultralightweight photovoltaic technology
- Printed Transistors; novel flexible low-cost biosensor technology
- Polymer and plastic based electronic materials and devices
- Glucose Biosensor – printed sensors for saliva-based glucose testing
- Hydration Biosensor – printed sensors for sweat-based hydration testing
- Commercial scale Printed Solar demonstration
- Public demonstration of Printed Solar
- Scanning Helium Microscope (SHeM) – world-first damage-free imaging system

PRINTED SOLAR POWERS COLDPLAY CONCERTS

Printed Solar, a 100 per cent recyclable solar material invented by Professor Paul Dastoor at the University of Newcastle, helped power Coldplay's Music of the Spheres world tour from 2024-2025 thanks to a collaboration between the iconic band, Kardinia Energy (the technology's commercialisation partner), and the University's Centre for Organic Electronics (COE).

500 square meters (about twice the area of a tennis court) of Printed Solar was placed behind the seats behind the stage and elsewhere in the venue to collect power in battery packs. These batteries were then used to power Coldplay's C Stage and fulfil other ancillary power needs throughout the venue.

NEXT GENERATION RESOURCES

MEETING THE RESOURCE NEEDS OF THE FUTURE THROUGH SUSTAINABLE INNOVATIONS THAT SUPPORT OUR MINERALS, METALS, FOOD, AND WATER SECTORS

- Advanced Particle Beneficiation
- Resource Recovery and Urban Mining
- Sustainable Steelmaking
- Bulk Materials Handling and Transport
- Geotechnical Analysis and Recovery
- Artificial Intelligence and Optimisation

ADVANCED PARTICLE BENEFICIATION

Bringing together multidisciplinary scientific expertise and industry engagement to deliver transformational advances to improve mineral recovery from ore and urban waste sources.

FOCUS AREAS

ECO-EFFICIENT MINERAL PROCESSING: TECHNOLOGY INNOVATION DRIVING SECTOR TRANSFORMATION

- New and improved mineral recovery techniques and technologies
- Reducing mineral beneficiation-related waste
- Reducing energy and water use during mineral processing
- Flotation and particle recovery – Hydrodynamics for enhanced recovery, coarse particle flotation, ultrafast kinetics using downcomers, and turbulent flow effects on bubble-particle attachment/detachment
- Foam and emulsion systems – Stability of foams/emulsions, foam fractionation, and influence of salts on bubble coalescence and interfacial rheology
- Interfacial engineering – Polymer/surfactant adsorption and physical chemistry of complex multi-component systems
- Collectors and flocculants – Rational design, structure–function relationships, and advanced scattering techniques for performance optimisation
- Agglomeration techniques – Ultrafast agglomeration using concentrated emulsions for fine particle processing
- Advanced separation methods – Electrostatic and magnetic forces, gravity separation, and centrifugal techniques for ultrafine particle recovery
- Computational and experimental modelling – Mechanistic modelling, machine learning, and electrolyte influence studies in multiphase systems
- Particle transport dynamics – Lean and dense phase transport for efficient material handling
- Granulated bed properties – Improved processing efficiency

RESEARCH IMPACT

- The REFLUX™ Classifier (RC™) is an industrial machine that separates fine mineral particles based on either density or size (‘density separation’). Commercialised in partnership with FLS, there are more than 240 full-scale RCs installed in over 15 countries across many commodities and mining companies
- The REFLUX concept has also been incorporated into several other innovative products, such as the REFLUX™ Flotation Cell (RFC™), the GradePro™ Classifier, the Graviton™ Separator, and the coarseAIR™ coarse particle flotation cell
- The REFLUX™ Flotation Cell (RFC™) was awarded a Mining Magazine ‘Technology Award’ in 2024
- The GradePro™achieved Mining Magazine’s ‘Mining Technology Excellence Award’ for best new product launch in 2023
- The coarseAIR™ flotation cell enables the recovery of larger ore particles than in conventional flotation
- Under development, the REFLUX™ Graviton uses a spinning centrifuge to achieve powerful desliming
- The Jameson Cell, an innovative flotation unit driven by fluid mechanics using rapid flotation without mechanical agitation - more than 500 Jameson Cells have been installed in over 30 countries, with the technology used in mining operations across Africa, North America, Asia and Europe
- Jameson Cell technology was a catalyst for The NovaCell™ (commercialised by Jord International) offering an energy efficient solution to recovering valuable coarse mineral particles) and The Concorde CellTM for ultrafine recovery, licensed to Metso Inc
- The Nova Cell™ uses a fluidised bed to separate much coarser particles for early gangue rejection in mineral processing to minimise energy consumption in grinding
- Under development with Jord as a commercial partner, XtractORE™ uses a concentrated water in oil emulsion as a binder for ultrafast agglomeration of hydrophobic particles
- Jord International and University of Newcastle researchers developed the Viper technology – a patented system that improves the filtration process used in traditional processing methods

DRIVING INNOVATION IN THE MINERALS SECTOR

Laureate Professor Kevin Galvin and his team from the ARC Centre of Excellence for Enabling Eco-Efficient Beneficiation of Minerals (COEMinerals) are leading breakthrough innovations that are reshaping mineral processing to meet the world’s growing demand for critical resources. As ore grades decline and extraction becomes more complex, their work delivers solutions that improve efficiency, reduce environmental impact, and support global sustainability goals.

Central to this impact is the REFLUX Classifier (RC™), a patented technology that separates fine mineral particles by density or size, enabling companies to recover high-value materials otherwise lost as waste. This innovation enhances water and energy efficiency while saving the global minerals industry billions. More than 240 full-scale units now operate across 15 countries, processing over $75 billion in raw materials and generating an estimated $7.6 billion in net benefits.

The REFLUX concept has since expanded into additional technologies, including the REFLUX Flotation Cell, GradePro Classifier, Graviton Separator, and coarseAIR system, advancing eco-efficient mineral beneficiation worldwide.

RESOURCE RECOVERY & URBAN MINING

Enhancing the recovery and performance of materials for industrial application.

FOCUS AREAS

RECOVERY FROM E-WASTE & RENEWABLES

- Recovering valuable metals from end-of-life renewable energy technologies, using physical separation techniques
- Electrochemical extraction of valuable metals and metalloids from end-of-life e-waste
- Materials characterisation for reuse of end-of-life wind turbine blades
- Bulk handling and characterisation of e-waste streams

CLEANER GAS PRODUCTION

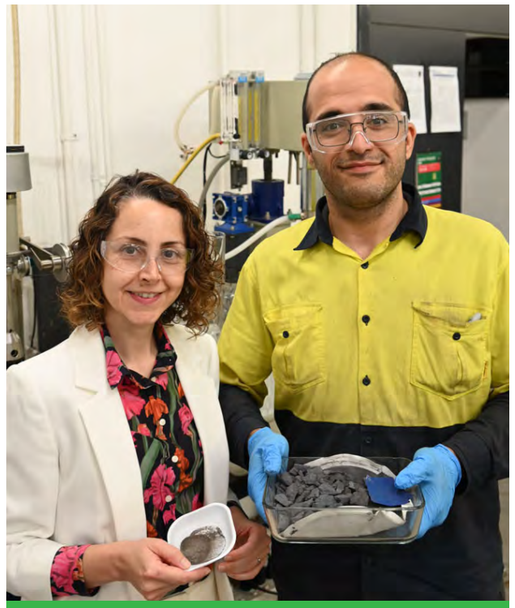
- Novel and sustainable lift technology for low-emission gas production

TRANSFORMING MINE TAILINGS

- Mineral/metal recovery from tailings
- Specialised testing and modelling framework for wet and sticky materials, taking into account adhesion and flow behaviour
- Dewatering of tailings for soil preparation

RESEARCH IMPACT

- Development of a fast, new way to recover high-grade silver from end-of-life solar panels
- Tin from Tailings: researchers are addressing this challenge by reprocessing tin tailings with new technology as high-grade deposits become scarce
- Recovering iron ore from tailings waste, using bio-based reagents: researchers are exploring the use of new bio-based ‘reagents’ derived from cashew nuts to reclaim hematite—an iron ore mineral— from tailings waste as a proof-of-concept project
- Using coal tailings for agronomic benefit through a "tailings to topsoil" program
- Effective electrochemical battery recycling strategies
- Repurposing retired turbine blades as additives in cement and other construction materials



RECOVERING HIGH-GRADE SILVER FROM END-OF-LIFE SOLAR PANELS

University of Newcastle researchers have developed a breakthrough acid-free method to recover high-grade silver from end-of-life solar panels, achieving more than 97 per cent silver recovery in just minutes. The new process replaces slow, chemical-heavy techniques with a physical separation approach that is faster, safer and far more environmentally sustainable.

The method combines mechanical comminution, which involves crushing and grinding panels into fine particles, with froth flotation, a technique widely used in mining but never before successfully applied to metallic silver recovery from recycled solar panels. Using only water, air bubbles and small amounts of standard flotation reagents, valuable silver floats to the surface while waste materials sink.

Led by Associate Professor Mahshid Firouzi from the Centre for Critical Minerals and Urban Mining (CRITIUM), the work addresses a major waste challenge: by 2050, Australia alone is expected to generate more than one million tonnes of solar-panel waste containing 300–500 tonnes of silver. This rapid, chemical-reduced process supports circular-economy goals and demonstrates a viable pathway to reclaim critical materials at scale.

SUSTAINABLE STEELMAKING

Driving innovation in the behaviour of Australian iron ore and steelmaking coal to support the steel industry's transition to net zero.

FOCUS AREAS

ALTERNATE IRONMAKING

- Production of Direct Reduced Iron (DRI) from Australian iron ores, including hydrogen based DRI in shaft and fluid bed processes
- Prevention of sticking in hydrogen fluidised bed DRI production
- Electric smelting of Australian hematite-goethite DRI
- Understanding the fundamental mechanisms of DRI smelting, including carburisation and use of Electric Smelting Furnace (ESF) slags for cement
- Development of a molten salt direct iron electrolysis process operating with Australian iron ores at intermediate temperatures (~700°C)
- Physical and chemical properties of Australian ores associated with new processing technologies
- Smelting reduction processes
- Melting of DRI in scrap electric arc furnaces and electric smelting furnaces

MODIFIED BLAST FURNACE IRONMAKING

- Comprehensive characterisation of ironmaking raw material quality
- Prediction of coking performance of metallurgical coals using data mining techniques
- Fundamentals of coke reactivity and failure mechanisms for conventional and low emission modified blast furnace technologies
- Fundamentals of sinter formation and drivers of quality for conventional and low emission modified blast furnace technologies
- Characterisation of mixed burden softening and melting performance under low emission modified blast furnace conditions, including hydrogen injection and top gas recycling
- Synchrotron X-ray, CT and finite element analysis to understand failure of ironmaking raw materials (coke and sinter)
- Synchrotron X-ray and Neutron CT analysis of blast furnace softening and melting experiments to investigate cohesive zone behaviour
- Optimal ore and coal blends
- Energy efficiency in sintering and cokemaking
- Raw material evaluation for low carbon cokemaking and ironmaking processes
- Renewable additives for cokemaking

RESEARCH IMPACT

- Modelling and assessment of low emission iron and steelmaking routes suitable for Australian iron ores and steelmaking coals in customer steel plants
- Advanced research facilities for evaluating the performance of Australian iron ores and steelmaking coals in conventional and low emission blast furnace processes
- Development of alternate, low emission ironmaking process routes, such as DRI-ESF and molten salt electrolysis
- Fundamental physical models for the formation of coke
- Enhanced understanding of coke and sinter quality drivers for modified blast furnace operations
- Comprehensive thermochemical model of the sintering process
- Blend optimisation to improve coke quality and reduce blast furnace fuel rate
- Use of CT structures to enhance analysis and understanding of stress, reactions, and fluid flow models of ironmaking
- Product evaluation for low carbon cokemaking and ironmaking
- Laboratory tests evaluating renewable additives for cokemaking

ELECTRIC SMELTING FURNACE

Researchers at the University of Newcastle's BHP Centre for Sustainable Steelmaking Research (SSR) are advancing transformative pathways to decarbonise steel production - an essential global challenge as demand for steel continues to rise. Their work focuses on developing technologies tailored to Australia's abundant iron ore resources, ensuring low-emissions steelmaking is both technically viable and economically competitive.

A major breakthrough is the Electric Smelting Furnace (ESF) project developed with BHP, which demonstrates how renewable electricity and green hydrogen can replace coking coal in producing hot metal. In this process, Australian iron ore is converted to direct reduced iron before being smelted in the ESF, yielding blast-furnace-equivalent output with significantly lower emissions. Early estimates suggest more than an 80 per cent reduction in CO_2 intensity compared to conventional routes.

Beyond emissions reductions, ESF technology offers flexibility to process medium-grade ores, lower slag volumes and generate a valuable cement substitute.

BULK MATERIALS HANDLING & TRANSPORT

Developing and applying state of the art techniques for the handling and processing of powders and bulk materials across diverse industries.

FOCUS AREAS

HANDLING AND CONVEYING

- Energy efficient conveying of bulk materials
- Reducing the energy intensity of overland transport of bulk materials
- Pneumatic and belt conveying system design and analysis
- Specialised conveyor belt and idler roll test facilities
- Fundamentals of bulk solids handling
- Interface of feeders and transfers in problematic material
- Adhesion and flow behaviour in wet and sticky material
- Vibration effects within bulk material handling systems
- Granular stress fields and permeability interactions in gas–solid flow

DUST, DEWATERING, AND SAFETY

- Minimising dust and material loss during bulk material transport and storage
- Dust suppression in material handling, storage, and transport systems
- Dewatering of ore and tailings
- Second generation dewatering systems
- Transportable moisture limits for safe ship transportation of ores and minerals
- Evolution of moisture migration from oscillatory motion induced by bulk material handling systems
- Research into International Maritime Organisation standards for bulk cargo self-heating

SYSTEMS, SENSING, AND RECOVERY

- Smart sensing technologies for bulk material handling and storage applications
- Waste recovery and utilisation strategies and design
- Optimisation and characterisation techniques for biomass materials handling systems and greenwaste feedstock
- Feedstock interface solutions for second generation ethanol systems
- Handling and characterisation of bulk materials in urban mining applications

RESEARCH IMPACT

- VIPER™ is a novel dewatering technology that enhances conventional vacuum belt filter technology to increase throughput and lower moisture
- The Rail-Running Conveyor™ technology facilitates low energy long distance bulk material transport
- International Maritime Organisation standards for safe, transportable moisture limits for coal exports
- Testing and modelling framework for wet and sticky materials
- Modelling of moisture migration transport phenomena in bulk material handling systems, and train and ship transports
- Multi-physics modelling framework encapsulating computational fluid dynamics and discrete element modelling with multi-body dynamics, smooth particle hydrodynamics, and finite element analysis methods under development
- Australian standard for measuring the energy efficiency of conveyor belts
- Key conveyor design parameters for energy efficient belt conveyors

REVOLUTIONARY CONVEYOR SYSTEM REDUCES ENERGY USE

A breakthrough led by Professor Craig Wheeler and the Centre for Bulk Solids and Particulate Technologies (CBSPT) is transforming how critical minerals are moved across mining operations. Recognising the growing global demand for materials like gold, copper, and iron ore, the CBSPT spent over a decade developing the patented Rail-Running Conveyor™, a world-first system designed to dramatically improve the efficiency of bulk material transport.

Unlike conventional conveyors, the Rail-Running Conveyor™ places the belt on wheeled carts that glide along steel tracks, combining the strengths of rail and overland belt systems. This design reduces resistance, enhances reliability, supports long-distance transport, and adapts to complex terrain. Studies show it can cut energy consumption by up to 50 per cent, reducing both operational costs and environmental impact.

The technology was originally produced in partnership with FLSmidth Mining Technologies in the United States. In late 2025, Fluor – a Fortune 500 engineering and construction company based in Texas – took over the technology licence. It will operate under Fluor's wholly owned subsidiary, Virta Inc to support international demand for bulk material handling.

GEOTECHNICAL ANALYSIS & DISCOVERY

Developing new models and innovative computational methods to better predict the behaviour of geomaterials.

FOCUS AREAS

GEOMECHANICS AND GEOTECHNICAL ENGINEERING

- Rockfall analysis and hazard characterisation
- Unsaturated soil mechanics and reactive soil behaviour
- Geotechnical risk assessment in mining and civil environments
- Probabilistic approaches in geotechnical engineering
- Settlement management of embankments on soft soils
- Soil-structure interaction at large deformation
- Characterisation of mine waste for management, reuse, and disposal
- Advanced discrete element and finite element numerical modelling of rocks and soils
- Rock joint strength and flow behaviour
- Pumped hydro energy storage for underground and open-cut reservoirs
- Performance of buried pipelines
- Advanced testing of geomaterials
- Probabilistic site characterisation

GEOTECHNICAL SAFETY AND HAZARD MANAGEMENT

- Geotechnical analysis for mine safety and productivity including stability analysis of very high spoil piles and large-scale direct shear testing of waste rock
- Improved management of rockfall hazards and development of rockfall hazard metrics for risk reduction
- Quantitative assessments of hazardous areas, experimental testing and numerical modelling, and prediction of shear strength of rock joints
- Continuous slope monitoring using UAVs, LiDAR, stereo-vision and low-cost in-house systems
- Safety berm and barrier performance through full-scale testing and advanced multi-physics modelling

GEODISCOVERY

- Near-surface geophysical surveys including shallow seismic refraction/reflection
- Survey workflow design for integrated acquisition across varied terrains and site objectives
- Processing of ground penetrating radar datasets
- Synthesis of interdisciplinary datasets (geomechanics, geophysics, hydrogeology) for integrated interpretation and decision support
- 3D point-cloud processing, digital twins and automated geological interpretation
- Incorporating remotely sensed data to characterise terrain, structures, and vegetation
- Integrating downhole geophysical logs with surface data
- Applying geostatistics for interpolation, uncertainty assessment, and upscaling across heterogeneous datasets

RESEARCH IMPACT

- Advanced methods for rockfall modelling, fragmentation analysis and protection-system design
- Large and small scale custom-built geotechnical testing equipment for soils, rocks, and full-scale barriers
- Evolving rockfall hazard assessment and management for transportation infrastructure and mining
- Simulation of large-scale underground openings to predict displacements, fracture paths, and the onset of collapse
- Evaluation of geotechnical risks associated with pumped hydro development and mine-void repurposing
- Optimisation of pumped hydro energy storage facilities
- Reliable design parameters for very high waste rock dumps
- Transformative monitoring technologies supporting safer mining, coastal, and infrastructure environments
- AI-enabled hazard prediction models for slopes, rail-track defects, and subsurface interpretation
- New design methodologies for recycled geocellular structures ensuring long-term sustainability
- Reliable long-term settlement prediction using Bayesian updating for improved infrastructure performance
- Robust design of safety berms and edge protectors for quarry and mining environments

KEEPING BEACHES SAFE BY PREDICTING COASTAL ROCKFALL

Researchers at the Centre for Geotechnical Science and Engineering, led by Professor Anna Giacomini, are advancing critical work to better understand and predict dangerous rockfalls along Australia's coastal cliffs. Their research focuses on identifying where unstable blocks originate and how environmental change increases the likelihood of collapse.

By analysing pre-existing fractures within cliff faces and monitoring how these features evolve over time, the team aims to determine which areas are most vulnerable to failure. Climate-driven increases in extreme weather events are accelerating coastal retreat, making this work even more urgent.

To track these changes, researchers conduct regular surveys of Newcastle's cliff lines, capturing high-resolution drone imagery to build comparative 3D models across multiple dates. By detecting even small displacements, they can identify hazardous zones before rockfalls occur.

This proactive monitoring enabled early detection of cliff movement near Newcastle's skate park, prompting swift intervention by local authorities. Ultimately, the research seeks to ensure that coastal spaces remain safe for the communities who enjoy them.

ARTIFICIAL INTELLIGENCE & OPTIMISATION

Advanced artificial intelligence (AI), machine learning, and optimisation techniques to enable smarter decision-making and more efficient operations.

FOCUS AREAS

HUMAN-CENTRED COMPUTING AND SENSING

- Robust software systems solutions that enable the reliable deployment of AI to human-operated environments
- Robotics, autonomous systems, and intelligent sensing applications
- Computer vision and image analysis techniques for intelligent monitoring and recommendations

ADVANCED LEARNING AND PATTERN RECOGNITION

- High-performance computing and large-scale data integration systems
- Machine learning and neural network methods for analysing complex datasets and textual information
- Identifying patterns, connectivity, and hidden structure in multi-dimensional data arising in scientific and engineering systems

OPTIMISATION, SIMULATION, AND FORECASTING

- Optimisation algorithms and simulation models for complex engineering processes
- Predictive modelling, anomaly detection, and data-driven decision support
- Digital twins that support improved design, planning, and operational efficiency

RESEARCH IMPACT

- AI-driven optimisation and modelling for engineering systems, infrastructure, and logistics
- Extracting insights from large and complex datasets, supporting faster and more informed decision-making
- Using computer vision, intelligent sensing, and AI-based monitoring systems for early detection of faults and risks in industrial processes, infrastructure, and environmental systems
- Topological and geometric data analysis techniques for complex scientific datasets
- Digital twin models for simulation and predictive analysis of dynamic and complex systems
- Scalable software platforms enabling deployment of artificial intelligence in industry
- Data-driven decision support tools for sectors including engineering, health, and finance
- AI-driven optimisation and predictive modelling to improve resource utilisation, reduce operational costs, and support sustainable infrastructure and industrial systems
- Robust software platforms and high-performance computing frameworks to enable the reliable deployment of artificial intelligence technologies in industry and large-scale applications

ENVIRONMENTAL SUSTAINABILITY AND SECURITY

BALANCING ENVIRONMENTAL, ECONOMIC AND SOCIAL PRIORITIES TO PROTECT REGIONAL RESILIENCE, SUSTAINABILITY, AND PROSPERITY

- Water and Climate Resilience
- Land Use Management, Environmental Remediation, and Social Impacts
- Food and Agriculture
- Coastal and Catchment Management
- Circular Economy and Sustainable Construction

WATER & CLIMATE RESILIENCE

Understanding, monitoring, and modelling hydrological and climate processes to optimise infrastructure and policy development for resilience.

FOCUS AREAS

WATER SECURITY

- Hydrology and climate-driven catchment interactions
- Understanding and modelling surface water and groundwater interactions
- Riverine, hydrodynamic, and ecological processes
- Simulation and optimisation of urban, regional, and rural water supply systems
- Understanding and modelling river/catchment processes
- Hydraulic and sediment transport modelling
- Climatology and palaeoclimatology
- Sediment transport, water quality, and salinity
- Water quality assessment and contaminant risk
- Water-energy-climate nexus

CLIMATE RESILIENCE

- Impacts of climate variability and anthropogenic pressures on land and water systems
- Multi-hazard risk assessment including flood, drought, bushfire, cyclones, storms, and heatwaves
- Quantification and management of climate-related risks
- Geographic information systems and remote sensing applications in water and natural resources management
- Stochastic modelling for application in water resources modelling and assessing climate risks
- Climate change modelling and adaptation
- Seasonal climate forecasting and decadal climate projections
- Hydrogeology and groundwater
- High-resolution hydroclimate reconstructions
- Compound and cascading extremes analysis
- Climate services, co-design, and decision making under uncertainty

RESEARCH IMPACT

- Decision-support tools for stress-testing and optimising water supply systems under climate variability, extremes, and future uncertainty
- Climate change impacts, vulnerability and adaptation strategies for the sustainable management of catchments, wetlands, and freshwater ecosystems
- Flood and hydrodynamic modelling to support risk reduction, emergency planning, and long-term resilience
- River and bank erosion assessment tools
- Tools to assess landscape evolution and function under climate extremes, drought stress, and hydrological change
- Flood frequency estimation software
- Risk-based approach to hydroclimate and economic modelling and associated long-term water supply planning
- Translation of climate extremes science into actionable guidance for policy-makers, industry, and regional planners
- Climate-informed decision frameworks to improve preparedness for droughts, floods, and heatwaves
- Climate-resilient built environments
- Climate-informed urban and regional planning support
- Hydro harvesting units converting water from ambient air

CLIMATE RECORDS FROM NATURE

Official observed weather records in Australia are typically available from the early 1900s, but what do we know about climate before these observations were available? Researchers use natural climate archives to reconstruct past environmental conditions and extend climate records back hundreds to thousands of years.

At the University of Newcastle, researchers are analysing speleothems (cave mineral deposits) from across the South Pacific to reconstruct past rainfall and climate variability. Changes in rainfall alter the chemical composition of the mineral layers that form in caves, allowing scientists to track shifts in tropical rainfall systems and major climate drivers over thousands of years.

Closer to home, tree-ring records from New South Wales and Queensland are being used to reconstruct past climate variability. Because tree growth responds to climate conditions, tree rings can preserve detailed records of hydroclimate variability and help extend regional climate records well beyond the instrumental period.

Other natural archives, including polar ice cores, also preserve evidence of past atmospheric and environmental conditions. For example, particles such as sea-salt trapped in Antarctic ice cores can reveal past atmospheric circulation patterns linked to Australian climate extremes.

This extended knowledge of Australia's natural climate variations is valuable information for understanding extreme events such as droughts, floods and bushfire weather, and for supporting climate resilience and disaster planning.

LAND USE MANAGEMENT, ENVIRONMENTAL REMEDIATION, & SOCIAL IMPACTS

Focused on the balance between environmental, community, and economic activity in energy and resource intensive regions.

FOCUS AREAS

ENVIRONMENTAL REMEDIATION OF LAND AND WATER

- Ecogeomorphologic, soil, and landscape rehabilitation of mine sites
- Rehabilitation of wetlands, in-stream, and estuarine ecology
- Soil carbon and carbon accounting
- Computer models to assess environmental impacts and management of disturbed ecosystems
- Soil and landscape modelling
- Risk-based land management
- Contaminant life cycle assessment
- Speciation and toxicity assessment
- Ecological and human health risk assessment
- Bioaccessibility/bioavailability assessment
- Innovative remediation methods for contaminated soil and groundwater
- Cumulative impacts of multiple developments on air, land, soil, and water resources
- Post mining rehabilitation design assessment
- Final void behaviour and the impact of final void filling and post mining land use
- Environmental and water impacts of coal seam gas extraction
- Alternative policy frameworks for biodiversity offsets
- Indicators of ecosystem structure and function
- Environmental pollution control - particularly destruction and utilisation of Per- and Polyfluoroalkyl Substances (PFAS) contaminated media (water and soil)

SOCIAL IMPACTS

- Strategies to enhance social licence to operate
- Enhanced models for community engagement and participation in decisions about land use, coexistence, and the sustainability of critical regional industries
- Climate induced displacement and resettlement
- Regional planning, economic development, and social determinants of health
- Social impacts of spatial change, including place attachment bonds between individuals and their environments
- Impact of large-scale infrastructure and development projects on community dynamics, identity, and sense of belonging in regional communities
- Intersections of energy development, environmental decision-making, land-use change, community and social licence, and the broader impacts of mining transitions on rural communities
- Arts based methods and co-design methodologies

RESEARCH IMPACT

- Field implemented remediation technologies at hydrocarbon contaminated sites
- Remediated perfluorochemical contaminated soils and water
- Novel analytical methods for contaminant speciation in soil and water
- Novel reclamation technologies for degraded lands and mine sites
- Development of a long-term landform and rehabilitation assessment and design tool using erosion assessment modelling system EAMS-SIBERIA
- Geomorphic landform design tool
- Methodologies for assessing long term water quality in final voids
- Methodologies for assessing long term impacts on groundwater levels from mine dewatering and coal seam gas extraction
- Methodologies for assessing the safety of fracking of coal seam gas wells
- Qualitative methodologies for understanding experiences of, and attitudes to, land use change
- Ethnographic, qualitative, and mixed-method research that enables a holistic analysis of the multifaceted issues and scales of land use and land use change
- PFAS Harvester for destruction/utilisation of PFAS

FOOD & AGRICULTURE

Technological and scientific innovations to secure healthy, quality foods from more sustainable, efficient, and resilient food processes.

FOCUS AREAS

FOOD INNOVATION

- Food safety testing
- Food composition and its influence during processing, transportation, and storage
- Development of functional ingredients and functional food/healthy supplements
- Innovative food packaging and development of new food products
- Consumer food behaviour and food labelling
- Optimising digital and physical food environments for healthy and sustainable choice
- Food bioprocessing using enzymes to generate valuable products
- Smart encapsulation technologies for delivery of bio-functional ingredients and nutrient delivery
- Determination of the effect of different biotic and abiotic stresses on the aroma composition of grapes and wines

WASTE MINIMISATION AND VALORISATION

- Post-harvest technologies for shelf-life extension of fresh produce
- Novel strategies for recovery, stabilisation and utilisation of high-value bioactive compounds from food and food wastes
- Conversion of food waste and by-products into higher value products
- Application of Artificial Intelligence (AI) and Internet of Things (IoT) on food processing and preservation
- Processing and preservation of seafoods and sea materials

AGRIBUSINESS INNOVATION AND FOOD SECURITY

- Using cyanobacteria to enhance plants' ability to capture carbon from the air
- Synthetic and molecular biology approaches to boost crop production
- Using molecular plant biology to increase yield of grain and legume crops without increasing the global carbon footprint
- Domesticating salt-loving plants as new food crops for arid environments
- Identifying mechanisms for salt tolerance and transferring to existing crops
- Improving crop nitrogen use efficiency
- Testing the efficacy of controlled-release fertilisers

RESEARCH IMPACT

- Food and Agribusiness Doctoral Training Centre developing highly skilled, work-ready graduates in partnership with industry
- Strategic partnerships between the University and key regional Initiatives aimed at growing jobs and building competitiveness
- Industry research collaborations supported by the Australian Research Council and AusIndustry Entrepreneurs' Programme
- Reducing costs through optimising the shelf live and supply chain
- Developing new food products and improving quality of foods using functional ingredients
- Cross-sectional studies, surveys, clinical trials, qualitative and mixed methods research, and data analyses to investigate acceptance and impact of new food products, services, and technologies.
- Sensory testing of new food products
- Food innovation laboratory facility access for research purposes
- Research and method consultation services for food, nutrition, and consumer studies
- Mitigating climate change through biological CO_2 capture using biotechnology
- Using plant biotechnology to improve global food security through improved carbon capture and efficient use of water and nitrogen fertiliser
- Using microorganisms of indigenous plants as a novel source of biopesticides

GROWING FOOD CROPS WITH SEA WATER

New research led by the University of Newcastle's Dr Vanessa Melino is unlocking the potential of Salicornia (Samphire), an edible succulent known as "sea asparagus", to pave the way for food crops that thrive in high-salinity conditions. With salt affecting up to 30 per cent of the world's arable land, the team's work offers a promising solution to a major global agricultural challenge.

By studying Salicornia's unique ability to store sodium safely within its cells, researchers have revealed molecular mechanisms that allow these plants to flourish where most crops fail. This breakthrough could enable the breeding of salt-tolerant crops irrigated with saline groundwater or even seawater, reducing dependence on limited freshwater resources.

Beyond its resilience, Salicornia shows commercial potential as a source of vegetable oil and high-protein ingredients, supporting more sustainable food production in a changing climate.

COASTAL & CATCHMENT MANAGEMENT

Undertaking research to support the sustainable use and conservation of the living resources of catchments, coasts, and marine environments.

FOCUS AREAS

ECOSYSTEM PROCESSES AND HEALTH

- Physical and biological processes that occur in estuarine, coastal, and marine ecosystems
- Food web dynamics of estuarine, coastal, and marine systems
- Fish behaviour
- Microbiome of water, habitats, and organisms as indicators of ecosystem health
- Metabolomics as a sub-lethal stressor of aquatic wildlife
- Marine soundscapes and their effect on estuarine and marine communities
- Coral reef biodiversity, health, and monitoring
- Metals in estuarine and marine systems
- Marine molluscan models for impact assessment of estrogenic Endocrine Disruptor Compounds (EDCs)
- Developing eDNA survey techniques to monitor aquatic wildlife populations
- Use of remote technologies such as drones, Remotely Operated Vehicles (ROVs) and imaging sonars to monitor aquatic ecosystems

COASTAL AND MARINE MANAGEMENT

- Social values and management strategies with an emphasis on sustainable use, conservation, and protection of natural resources
- Rehabilitation of saltmarsh systems
- Developing methods to reduce overcatch in oyster aquaculture
- Fisheries bycatch reduction methods

RESEARCH IMPACT

- Event-based impacts on marine environments
- Impacts of environmental pollution in estuarine, coastal, and marine systems
- Elucidated the accumulation pathways and selected mechanisms of tolerance to metals by mangroves
- Reliable biomarkers of metal stress in mangroves including photosynthetic performance, gene expression markers, and the oxidative stress markers
- Developing protocols to prioritise on-ground works for habitat rehabilitation
- Optimisation of oyster aquaculture production methods
- Biodiversity surveys for regulatory reporting
- Identifying habitats that support fishery production for coastal and estuary managers
- Prioritising foreshore stabilisation for ecological benefits
- Biomonitoring of waterways to determine sublethal effects of catchment impacts
- Evaluation of catchment management actions on waterway health
- Ecosystem health monitoring and reporting to inform management actions

RESTORING SAMOA'S MANGROVES AND TACKLING PLASTIC POLLUTION

The University of Newcastle is driving impactful environmental research in Samoa, co-designing solutions with government and community partners to strengthen ecosystem resilience. A major focus is the Moata'a Living Lab, created with the Secretariat of the Pacific Regional Environment Programme and the Moata'a community to conserve and regenerate a mangrove ecosystem reduced to just five hectares after years of development, pollution, and climate stress. Researchers use monitoring data and field studies to guide restoration, while community groups have planted more than 2,500 seedlings and led pollution-reduction efforts.

The University is also supporting Samoa's response to plastic pollution by training students and local scientists to detect and analyse microplastics in waterways. These data inform national reduction targets and strengthen environmental management. Through the broader Pacific Initiative, including climate resilience, biodiversity protection, and waste-management research, the University is helping build long-term regional capability while advancing practical, community-driven environmental solutions.

CIRCULAR ECONOMY & SUSTAINABLE CONSTRUCTION

Advanced construction techniques to design and deliver buildings more efficiently and sustainably.

FOCUS AREAS

SUSTAINABLE BUILDING TECHNOLOGIES

- Resource sustainability and efficiency
- Innovative sustainable construction solutions
- Advanced material applications for long-term sustainability and durability of infrastructure
- Ecologically sustainable construction
- Testing innovative building materials
- Earth materials for regenerative architecture
- Improving construction efficiency through prefabricated architecture
- Hempcrete testing and documentation
- Infrastructure asset management

LOW-CARBON, RESILIENT, AND ENERGY-EFFICIENT BUILT ENVIRONMENT

- Industry collaboration to accelerate adoption of circular economy practices
- Calculation and comparison of embodied carbon in building materials
- Investigating and improving thermal comfort in buildings
- Formulating design processes to collaborate with multiple stakeholders on affordable, social, and public housing
- Structural assessment and improved design of unreinforced masonry construction
- Assessment of structural integrity and deterioration of masonry walls
- Advanced structural analysis and design
- Structural health monitoring
- Critical infrastructure performance and reliability

RESEARCH IMPACT

- Use of cementitious composites for energy efficient and low carbon construction
- Development of high-performance, cost-effective concrete
- Development of eco-friendly concrete using industrial by-products
- Incorporation of phase change materials into building envelopes for thermal comfort and energy saving
- Developing a removable mortar to allow for the easy re-use of whole bricks
- A database for building material selection to meet green building certifications
- FAST SLOW Project to build sustainable housing faster, more affordably, and with natural materials
- Strengthening/retrofitting of existing unreinforced masonry and reinforced concrete structures

THE BRICKS AND MORTAR OF A CIRCULAR ECONOMY

Some of the first sophisticated building supplies humans ever made were bricks and mortar. While they still play a fundamental role in construction today, there has been a growing demand to make these products more sustainable. Current manufacturing processes contribute significant CO_2 emissions, and after demolition, bricks are often sent to landfill because the mortar is too difficult and expensive to remove.

Dr Josephine Vaughan from the Circular Economy and Sustainable Construction Research Group has partnered with Brickworks, Biocarbon and the Royal Melbourne Institute of Technology to develop a removable mortar. The removable mortar is designed so once buildings are demolished, the bricks can be reused at their full value. Through an Enterprise Academic Fellowship project with the Trailblazer for Recycling and Clean Energy, Dr Vaughan aims to expand on this work by creating a complementary mortar from construction, industrial, and agricultural waste.

NEXT GENERATION RESOURCES PARK

The Hunter Region is Australia's largest regional economy, boasting a robust asset base, established supply chains, and a skilled workforce driven by the METS, energy, and manufacturing sectors. As global and national policies shift towards a new energy future, leveraging existing assets and diversifying the Hunter economy will be vital to ensuring long term regional resilience, and fostering the existing and emerging industries which sustain our communities.

Regional participation in the net zero economy will rely on cross-sector collaboration to attract new industries, stimulate innovation, and enable workforce and skills to diversify. The Next Generation Resources Park (NextGen Park) presents a key link to this transformation, providing a unique model of strategic cooperation that will serve the region to maximise participation in the industries of the future. In cooperation with key stakeholders, the NextGen Park will leverage the region's strong industrial heritage and position the Hunter as a critical national asset in the new energy economy.

Harnessing the capability of existing assets and leveraging new investment, the NextGen Park will provide the infrastructure and enabling mechanisms to support the innovation ecosystem in sectors vital for the Region's sustainability and competitive advantage. Through its state of the art manufacturing capability and testbed facilities, the NextGen Park will de-risk and accelerate technology into sectors vital for sustainability and competitive advantage, while delivering strategic education pathways to train and accredit the region's diversifying workforce.

Recognising the need for a coordinated regional approach, the NextGen Park will connect with key initiatives in the Hunter—including the Port of Newcastle Clean Energy Precinct, the AGL Hunter Energy Hub, and Hunter Joint Organisation—to advance regional cooperation, guide strategic investment, and balance environmental, social, and economic priorities to strengthen regional resilience in the emerging new energy economy.

NEW ENERGY SKILLS HUB

State-of-the-art infrastructure alongside a collaborative education model geared to build capacity, strengthen capability, and aggregate workforce and skills development across future energy systems.

RESEARCH, TESTING, AND DEMONSTRATION

With specialised equipment and unique technical capability, the Skills Hub will serve as a testbed for industry, providing the tools and capability to test and enhance systems and components across five functional areas:

- Clean energy technologies
- Electrochemical systems
- Sustainable fuels
- Smart grid and power engineering
- Materials science

EDUCATION AND TRAINING FACILITIES AND PROGRAMS

In co-development between University, TAFE, and industry, the Skills Hub will provide access to an enhanced technical skills and education offering for the region, including:

- Upskilling and re-skilling
- Short courses and micro-credentials
- Competency and technical development accreditation
- Embedded learning pathways for vocational education and training, undergraduate, and postgraduate courses
- Bespoke industrial/commercial courses
- Market driven science, technology, engineering, and mathematic pathways
- Industry placements

MANUFACTURING FACILITIES

MODERN MANUFACTURING WORKSHOP (MMW)

Specialised fabrication and manufacturing machinery with dedicated research and engineering expertise to develop and/or scale up the manufacturing of prototypes, from the incorporation of new technology in commercial designs, to pilot scale manufacture and full commercial deployment.

ADVANCED PROTOTYPING FACILITY (APF)

Central Hub to support next generation manufacturing through access to state-of-the-art equipment and tools for high-end prototyping. The APF brings together machinery, multi-use facilities and expert technical support to design, develop and manufacture new parts and technologies.

AUSTRALIAN NATIONAL FABRICATION FACILITY (ANFF)

ANFF offers specialist equipment and expertise in the design, development, and fabrication of nanostructured electronic materials and devices. The only facility of its kind in Australia, the ANFF Hub offers extensive and unique capabilities in functional printing, rapid prototyping, and surface characterisation.

FUTURE INDUSTRIES FACILITY

A purpose-built co-location facility enabling research experts, industry, and end-users to collaborate on pre-commercial trials and testing. Market driven and industry-led, the Future Industries Facility (FIF) is a catalyst for new technologies, education, and training.

Moving product testing from laboratory to pilot scale represents a major milestone in technology's demonstrated readiness, requiring significant capital investment and resources to validate and accelerate a technology's pathway to commercial readiness.

The FIF will de-risk this essential phase, supporting up to 16 industry-research partnerships simultaneously to pilot and validate new enabling technologies from research phase to market inception.

With two 1000 sqm Industrial scale workshops, the FIF delivers targeted demonstration space designed for large scale prototyping for next generation industries, providing:

- Infrastructure to support prototype solutions capable of addressing full-scale operational considerations,
- An operating environment for testing representative of an actual operating environment at scale,
- Access to a multi-disciplinary community of researchers, academics, and technicians to achieve engineering feasibility validated in actual system application, and
- Opportunities for integrated skills development; access to co-designed industrial experience programs shaping technical skills and practical workforce experiences for a pipeline of trained, work-ready students.

The Building Blocks

1. Modern Manufacturing Workshop
2. Energy Skills Hub
3. Future Industries Facility
4. Advanced Prototyping Facility

ENGAGE WITH US

NIER drives impact by uniting industry and researchers to turn breakthrough ideas into targeted solutions for a more sustainable future. Our partnerships ensure innovation meets real-world needs - locally, nationally, and globally.

Partner with us to create smarter technologies, stronger industries, and a more sustainable world.

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This document provides a broad overview of the research capabilities of the research at NIER, updated in 2026 in consultation with more than 50 researchers.

It is not intended to be exhaustive, as research priorities, expertise, and emerging areas of inquiry continue to evolve. Accordingly, this statement reflects current knowledge at the time of publication and may expand or shift as new discoveries and advancements arise.

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SOLUTIONS FOR GLOBAL CHALLENGES
ENERGY RESOURCES FOOD WATER

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