UNSW SYDNEY

Clean Energy

Capability Portfolio

UNSW, Your Energy Research Partner

Contents

From the Vice Chancellor and President

Professor Attila Brungs

Vice-Chancellor and President

UNSW Sydney

We are at a precipice.

In 2033 the Intergovernmental Panel on Climate Change warned that the window of opportunity to secure a liveable and sustainable future for all is rapidly closing.

At UNSW, building a liveable, sustainable future together is not only a commitment, but a responsibility.

In 1949, our University was established to equip more people with the skills and knowledge to advance society, and to address the great challenges facing Australia and the world. Today, the world faces its greatest ever challenge: the clean energy transition. And we are engaged comprehensively in addressing it.

This is why I am pleased to introduce the UNSW Clean Energy Capability Portfolio.

UNSW has long been at the forefront of research and development in clean energy.

From the ground-breaking development of the PERC solar photovoltaic technology that is now found in almost 90 per cent of solar cells used globally, to our pioneering work in clean fuels, energy consumers, energy markets, energy storage, grid transformation and renewable generation, we have deep, world-leading capability in fields that are fundamental for the energy transition.

This portfolio showcases the breadth of our credentials. Our experts, centres, institutes, facilities and established networks offer unrivalled opportunities to apply innovative, real-world solutions for the transition to clean energy. These pages are an invitation for organisations in Australia and across the globe to consider how UNSW can work with you to deliver a liveable, sustainable future for all.

Furthermore, our culture of collaboration with industry, government and the community for positive impact defines how we work.

Through our clean energy capability and our genuine commitment to progress for all, UNSW looks forward to creating partnerships that secure the prosperity of generations to come.

From the Pro Vice-Chancellor Industry and Innovation

Professor Stephen Rodda

Pro Vice-Chancellor Industry and Innovation

UNSW Sydney

The Industry & Innovation portfolio at UNSW is responsible for providing strategic leadership across all facets of UNSW's industry engagement, knowledge transfer, business development and commercialisation, and oversight of the Entrepreneurial Campus. Our aim is to bring together aspects of innovation and enterprise from students, staff, and alumni across the research spectrum, nurture the entrepreneurial spirit and know-how, to ensure that our research translates to real world outcomes to help position UNSW as Australia's pre-eminent entrepreneurial University.

A critical part of this is our commitment to engaging with partners to deliver mutual benefit and value and importantly societal impact that is represented through social progress and economic prosperity.

UNSW has a long-standing reputation and track record one of the world's leading research and technology innovators in clean energy. As we work collectively as a nation and member of the global community to transition from finite fossil fuel-based energy to cleaner and renewable energy sources, the intensity of ongoing research and innovation in this sector continues to grow.

This is where it is vital that we can work with partners and across UNSW's vast and varied expertise in technology development, policy settings and community engagement activities to translate research outcomes to address the most pressing global energy issues. This includes reliability, affordability, sustainability and accessibility.

UNSW is open for business and with the release of this Capability Portfolio we invite partners from industry, community and government to review the expertise and capabilities showcased and consider how we can work together with you to collaborate, innovate and collectively achieve societal impact that matters to our world.

From the UNSW Energy Institute

Dani Alexander

CEO UNSW Energy Institute

UNSW Sydney

This is the decisive decade for decarbonisation, and UNSW is uniquely placed to support Australia's charge to net zero. We have one shot to decarbonise in time to avoid catastrophic climate change.

The time for talk is over and we need to act. We are in the race.

UNSW has been a forerunner in energy research and technology development for over three decades. We take a systems approach to the energy transformation, often working in transdisciplinary teams. Whether developing new solar technologies to achieve 30% efficiency at 30c/watt by 2030, advancing long-duration battery storage, or placing people at the centre of energy governance and planning, we are committed to creating a sustainable and equitable energy future. This portfolio seeks to represent the depth and breadth of our expertise and societal impact.

Energy experts at UNSW are focused on three critical challenges: delivering a future grid that can integrate close to 100% renewables, securing Australia's global position as a renewable energy powerhouse, and supporting a consumer-led energy transformation. By addressing these priorities to decarbonise the energy sector, we will help Australia achieve over 70% of its emission reduction goals.

Beyond research, we translate our discoveries to achieve societal impact through strategic partnerships with industry, communities, government, and academia. Our world-class facilities allow us to pioneer advancements in energy network, transport, storage, and generation technologies. These innovations support a future where energy is clean, reliable, affordable and equitable for all.

The global energy transformation is a race, but it is not a sprint or even a marathon. It is more like a decathlon. We may not need to win every event, but we must perform consistently across the board to succeed. With a strong foundation across a broad range of energy innovations and a collaborative, cross-sector approach, UNSW is ready and uniquely positioned to lead this effort.

We are chasing the gold medal and invite you to join us.

Renewable Generation

UNSW is striving towards 100% renewables, with a focus on delivering 30% solar photovoltaic cell efficiencies at capital costs below 30c per watt at scale by 2030.

If we are to achieve the national target of 82% renewable energy by 2030, we will likely need to double or even treble the amount of renewable energy installed per annum. With only five years remaining to meet this ambitious goal, we must immediately ramp up the development and deployment of renewable energy technologies.

Solar is on track to become the leading source of global energy generation, offering scalable, cost-effective, and sustainable power for all. UNSW has been a world-leader in solar PV since Professor Martin Green first invented the now dominant “PERC” solar cell in 1983. We are now focused on driving down the costs of the next generation of solar PV technology, which can be seamlessly integrated with households, industry and networks. To achieve this, we are focused on research and development in four key areas:

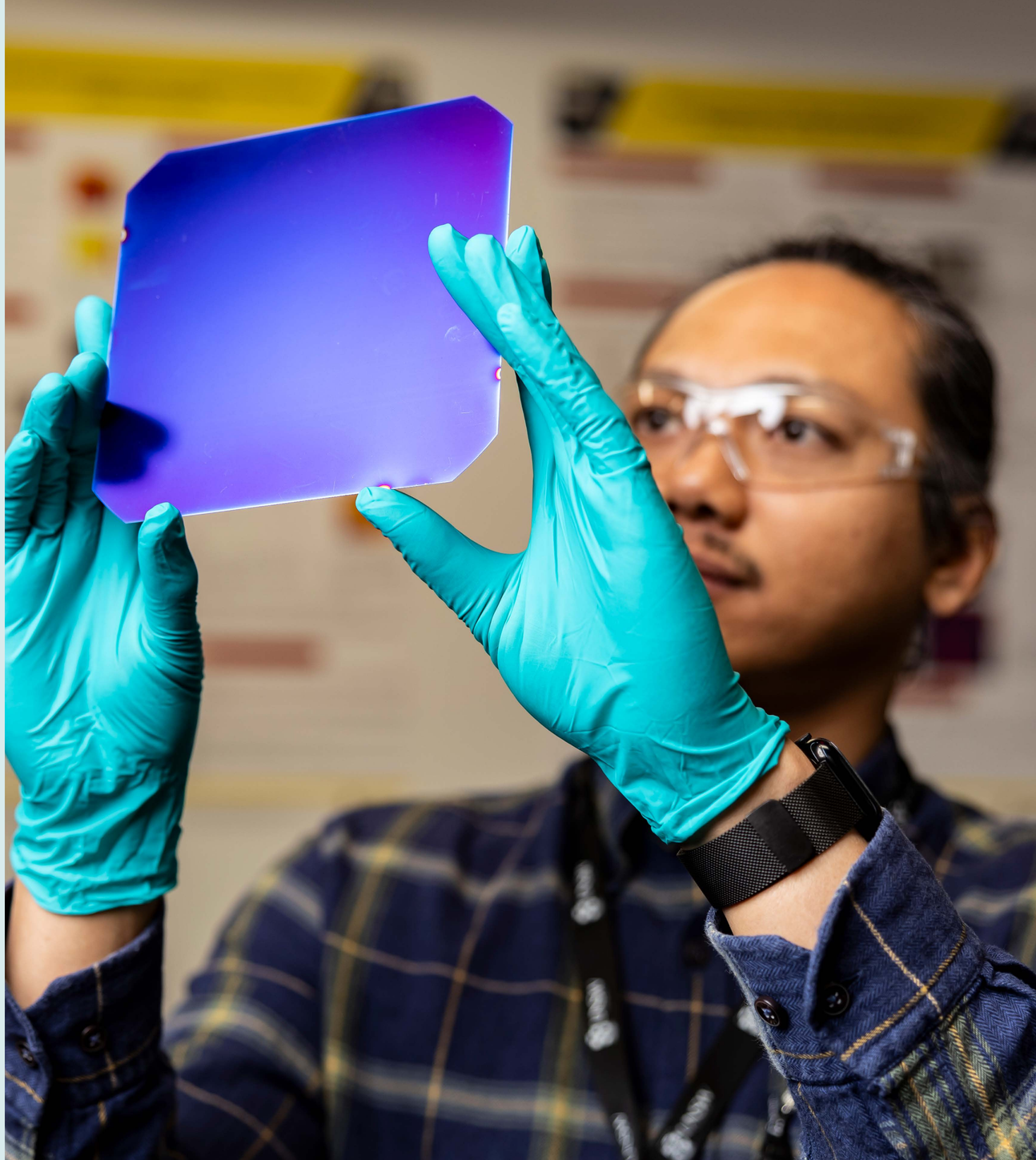
- The development of robust PV manufacturing processes and comprehensive reliability testing
- Exploring new materials that will become the next generation of solar cells including perovskite and organic solar cells
- Developing innovative and practical recycling methods for solar panels
- Developing datasets, models and tools to improve planning and operation of electricity grids with high levels of variable renewable energy

Beyond 2030, we are advancing research into solar-powered hydrogen and concentrated solar thermal technologies.

Achieving UNSW’s ambitious renewable energy goals will not only accelerate the global energy transformation but also solidify Australia’s position as a global leader and record-breaker in solar photovoltaics.

Advanced Characterisation and Machine Learning Models for Photovoltaic Devices and Systems

Advanced inspection systems and characterisation methods have been developed to comprehensively assess the entire photovoltaic (PV) chain of wafers, cell, modules, and systems. These innovative techniques, combined with state-of-the-art machine learning algorithms, are then employed to meticulously investigate defects and degradation mechanisms at any level of a PV system. The aim is to enhance the reliability of these systems and reduce their costs.



Competitive Advantage

- Developed world-class characterisation systems specifically tailored for both silicon and non-silicon materials
- Extensive expertise in conducting temperature dependence measurements of electrical and optical properties of semiconductors, enabling comprehensive understanding of their behaviour
- Pioneered the application of machine learning algorithms in PV, revolutionising conventional measurement and inspection techniques by significantly augmenting their capabilities
- Developed novel automated decision-making platforms powered by machine learning, specifically designed for maintaining utility-scale PV plants and optimising end-of-life processes for PV modules
- Innovated a novel PV module specifically designed for agriPV (agriculture and photovoltaic) applications

Impact

- Helping meet the ICCP report target of 8-10 TW peak power of installed PV by 2030, through:
- developing innovative methods to quantify and identify the nature of defects in PV materials
- developing methods for early detection of degradation mechanisms across the entire PV chain
- optimising the decisions regarding end-of-life of PV modules
- developing new applications for PV systems, such as agriculture
- These developments will lead to lower production costs, higher efficiency solar cells, and more reliable PV systems

Successful Applications

- Determination of defect parameters responsible for LeTID in mc-Si wafers
- Determination of defect parameters in n-type float-zone wafers
- Development of photoluminescence imaging systems with spatially inhomogeneous illumination and at uniform excess carrier concentration
- Imaging of installed modules in solar field and on solar cars
- Machine learning applications for PV that significantly enhance existing capabilities
- Automated machine learning based decision-making platforms for maintaining utility-scale PV plants and optimising end-of-life processes for PV modules

Capabilities and Facilities

- Lifetime measurements at a wide temperature range (80 – 680K)
- Lifetime measurements of metallised samples
- Current-voltage measurements at a wide temperature range (80 – 680K)
- Optical and spectral measurements at a wide temperature range (80 – 680K)
- Photoluminescence measurements at uniform excess carrier concentration
- A variety of machine learning algorithms
- Novel design for agriPV modules

Our Collaborators

- Sinton Instruments
- BT Imaging
- Meyer Burger
- Sunrise Solar Solutions
- JinkoSolar
- Neoen
- Spark Renewables
- Gentari
- Caelux
- Halocell
- RayGen Resources
- PV Industries
- Tindo Solar

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Advanced Condition-Monitoring for Optimised Maintenance of Critical Equipment

In the rapidly growing renewable energy market, where fuel is free, maintenance is the major operational cost. In this situation, condition-monitoring provides major economic benefits in terms of plant availability, maintenance optimisation and safety. UNSW's capability in this area includes condition-monitoring and condition-based maintenance for critical equipment in wind, solar-thermal, hydroelectric and traditional thermal plants.

Competitive Advantage

- Ability to integrate wear and vibration analysis to monitor machine condition and predict the remaining life of critical assets
- Cutting-edge diagnostic and prognostic tools to inform maintenance decision makers
- World-renowned research group with expertise in vibration and wear debris analyses

Impact

- Significant cost savings by targeting maintenance where required
- Increased asset availability to deliver energy security
- Amplified maintenance savings on large fleets – e.g., wind farms
- Increased safety for personnel via early detection and failure prediction in rotating machine components

Successful Applications

- Detection of gear faults on planetary and spur gears for wind turbines
- Maintenance optimisation for concentrated solar power plants
- Monitoring of pumps, fans and auxiliary rotating machines
- Development of remotely controlled standalone acquisition systems for monitoring asset fleets

Capabilities and Facilities

- Fault detection, diagnostics and prognostics are supported by:
- Test rigs with diagnostic and prognostic capabilities:
- Multi-stage parallel + planetary gearbox test-rig
- Spur gearbox test-rigs
- Rolling element bearing test-rig
- A large range of vibration and acoustic emission instrumentation
- Portable acquisition systems for onsite measurements
- Oil and wear debris analysers

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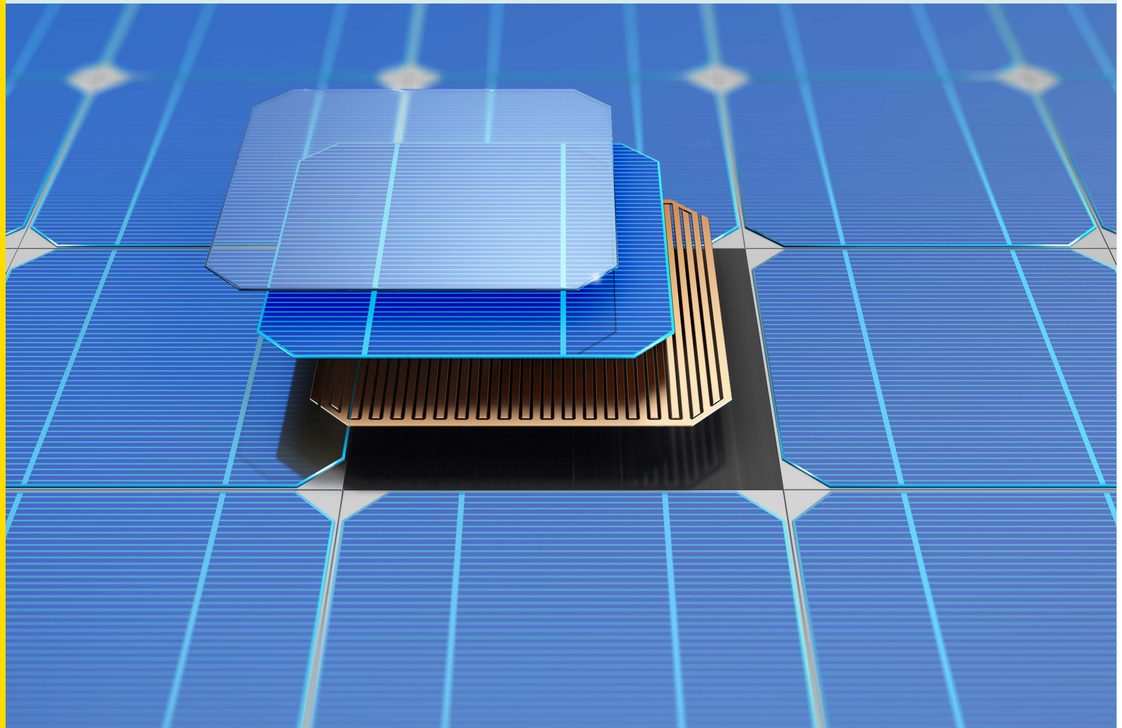
Advanced Surface Passivation of Silicon Solar Cells

Combining in-depth material science know-how with advanced device simulation to optimise the performance of silicon solar cells by applying thin surface passivation layers.



Competitive Advantage

- Deep understanding of device-relevant fundamentals
- In-house capability to synthesise a wide range of surface passivation materials/stacks
- Field-leading characterisation capabilities
- First to develop a method for extracting the quantity of charge in dielectrics on doped silicon surfaces

Impact

- As the surface of a silicon solar cell typically contributes the highest efficiency loss, this optimisation improves their long-term performance

Successful Applications

- A pioneer in the development of aluminium oxide, which is now the de facto standard used in PERC solar cells
- Worked with various non-disclosed equipment suppliers and solar cell manufacturers to optimise surface passivation using their unique technologies
- Developed an intrinsically safer process for the deposition of aluminium oxide surface passivation films
- Currently unravelling the surface passivation fundamentals of complex three-dimensional structures, such as those used for black silicon

Capabilities and Facilities

- Access to state-of-the-art device simulation tools and in-house laboratory
- Pilot-scale thin film fabrication capability with expertise in a wide range of surface passivation films

Our Collaborators

- Leadmicro

More Information

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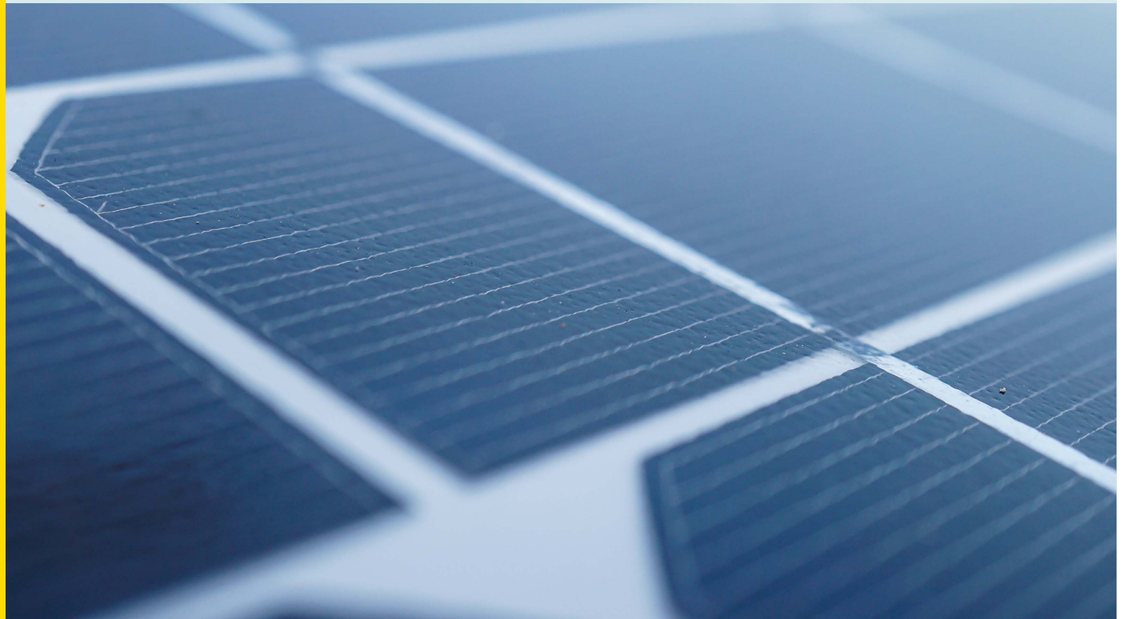
Buffer and Passivation Layers for High-Efficiency Tandem Solar Cells

Tandem solar cells have gained acceptance as the most promising way to achieve a solar cell efficiency exceeding 30 percent. If these are to be silicon-based, they will require both buffer and surface passivation layers to maximise their performance.



Competitive Advantage

- Australian-based laboratory featuring an atomic layer deposition reactor with real-time feedback on synthesised material – offers an unprecedented advantage in terms of process optimisation and device integration
- Utilise an advanced, computational material science approach to identify the most promising materials before synthesising them
- Able to perform atomic-scale engineering using atomic layer deposition
- Real-time insight and control of thin film growth and its correlation to final device performance

Impact

- The application of a buffer and passivation layer has already resulted in creating world-record efficiency in Cd-free CZTS solar cells

Successful Applications

- A wide range of binary and tertiary compound thin films have been developed for integration into thin film solar cells

Capabilities and Facilities

- Both laboratory-scale and pilot-scale atomic layer deposition reactors to explore novel processes from low- to high-technology readiness level
- Access to both lab-scale and pilot-scale thin film deposition equipment for swift transfer from the laboratory to the factory

More Information

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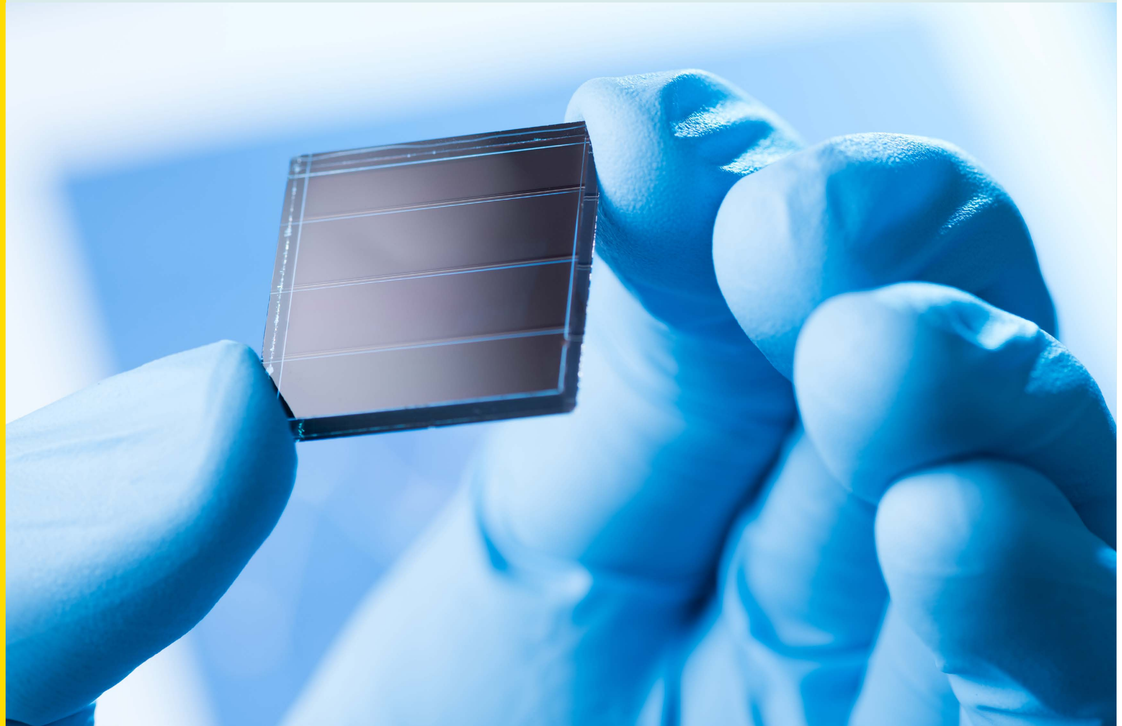
Carrier Selective Contacts for Silicon Solar Cells

Investigating a wide range of passivating contacts that selectively extract holes and electrons, and reduce surface recombination in industrial silicon solar cells, to mitigate contact recombination losses and improve efficiency.



Competitive Advantage

- Australian-based laboratory featuring an atomic layer deposition reactor with real-time feedback on synthesised material – offers an unprecedented advantage in terms of process optimisation and device integration
- Cutting-edge device optimisation informed by a high-level understanding of device fundamentals
- Utilise an advanced, computational material science approach to identify the most promising materials before synthesising them
- Able to perform atomic-scale engineering using atomic layer deposition
- Real-time insight and control of thin film growth and its correlation to final device performance

Impact

- A process to lower the contact resistance of screen-printed contacts was successfully transferred to high-volume manufacturing in less than two years after the first demonstration at a laboratory scale

Successful Applications

- Demonstrated that the contact resistance of screen-printed contacts could be lowered by the application of nanoscale aluminium oxide films
- Showed that the electronic properties of nanoscale nickel oxide could be changed by doping
- Developed a low-cost method for growing tunnelling oxides for poly-silicon contacts, which can easily be integrated into PECVD and PVD equipment

Capabilities and Facilities

- Both laboratory-scale and pilot-scale atomic layer deposition reactors to explore novel processes from low- to high-technology readiness level
- Access to both lab-scale and pilot-scale thin film deposition equipment for swift transfer from the laboratory to the factory

Our Collaborators

- Leadmicro

More Information

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Dams and Pumped-Hydro

The Water Research Laboratory (WRL) provides specialist services to dam engineering at its laboratory facilities in Manly Vale, Sydney. It provides both fundamental research of flow dynamics on spillways, and commercial large-scale physical modelling of hydraulic structures.

Competitive Advantage

- WRL's hydraulic laboratories are the largest and most comprehensive in Australia covering more than 5,000m2 of floor space, and include high flow-rate flumes
- Extensive experience in conducting performance assessment of hydraulic structures, such as dam outlet works, spillways and hydro power stations
- In-depth experience with equipment for accurate measurement of flows and flow patterns
- WRL is ISO 9001 Quality Assurance certified – guarantees that commercial activities are executed in accordance with strict quality requirements, as well as time, budget, and contractual agreements

Impact

- Offers an internationally renowned, integrated approach to hydraulic engineering problems and world-class solutions

Successful Applications

- World-first application of Lidar for the measurement of aerated surfaces to assist in dissipator design
- Development of a miniature, neutrally-buoyant accelerometer and pressure transducer device to assess fish passage
- Increased flow capacity with a 1,000 L/s pump
- Scour assessment of rip-rap using a 3D terrestrial scanner

Capabilities and Facilities

- Four fully-equipped physical laboratories for research and related specialist studies – laboratories contain a variety of innovative facilities used for the construction of large-scale physical models
- 1.5 m3/s flows
- Large spillway flume
- Extensive suite of laboratory sensors, including wave probes, current meters, LIDAR, 3D FARO, submersible load cells, and pressure sensors

More Information

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Fusion energy

Accelerating the development of clean fusion energy by designing novel engineering solutions and materials for the extreme environments of fusion reactors.

Competitive Advantage

- ARC industry fellow and several ARC/industry-backed research groups
- Student-led construction of a fusion reactor onsite, supported by a multidisciplinary team of academics and industry sponsors
- Home of the discovery of hydrogen-boron fusion

Impact

- Enabling faster development of Spherical Tokamak technology
- Advancing the engineering of boron-hydrogen laser-fusion
- Lowering the cost of energy from nuclear fusion

Successful Applications

- Technology Readiness Level (TRL) advancement from 3 to 6 – the ‘shield’ component for our industry partner
- Identified novel materials with enhanced shielding performance for ‘spherical tokamaks’ – this reduces device size, and the cost of electricity from the device
- Prediction of degradation mechanism of materials exposed to a fusion neutron flux
- Optimisation of cooling geometry for central column of compact tokamak reactors

Capabilities and Facilities

- Ion and neutron irradiation and characterisation expertise
- UNSW radioactive material research facilities
- Multiscale materials modelling capability, integrated with experimental characterisation and testing
- In-situ neutron diffraction capability with advanced corrosion testing cell
- Discretionary access to Australian nuclear infrastructure

Our Collaborators

- Tokamak Energy
- HB-11 Energy
- Australian Nuclear Science and Technology Organisation (ANSTO)
- Imperial College London

More Information

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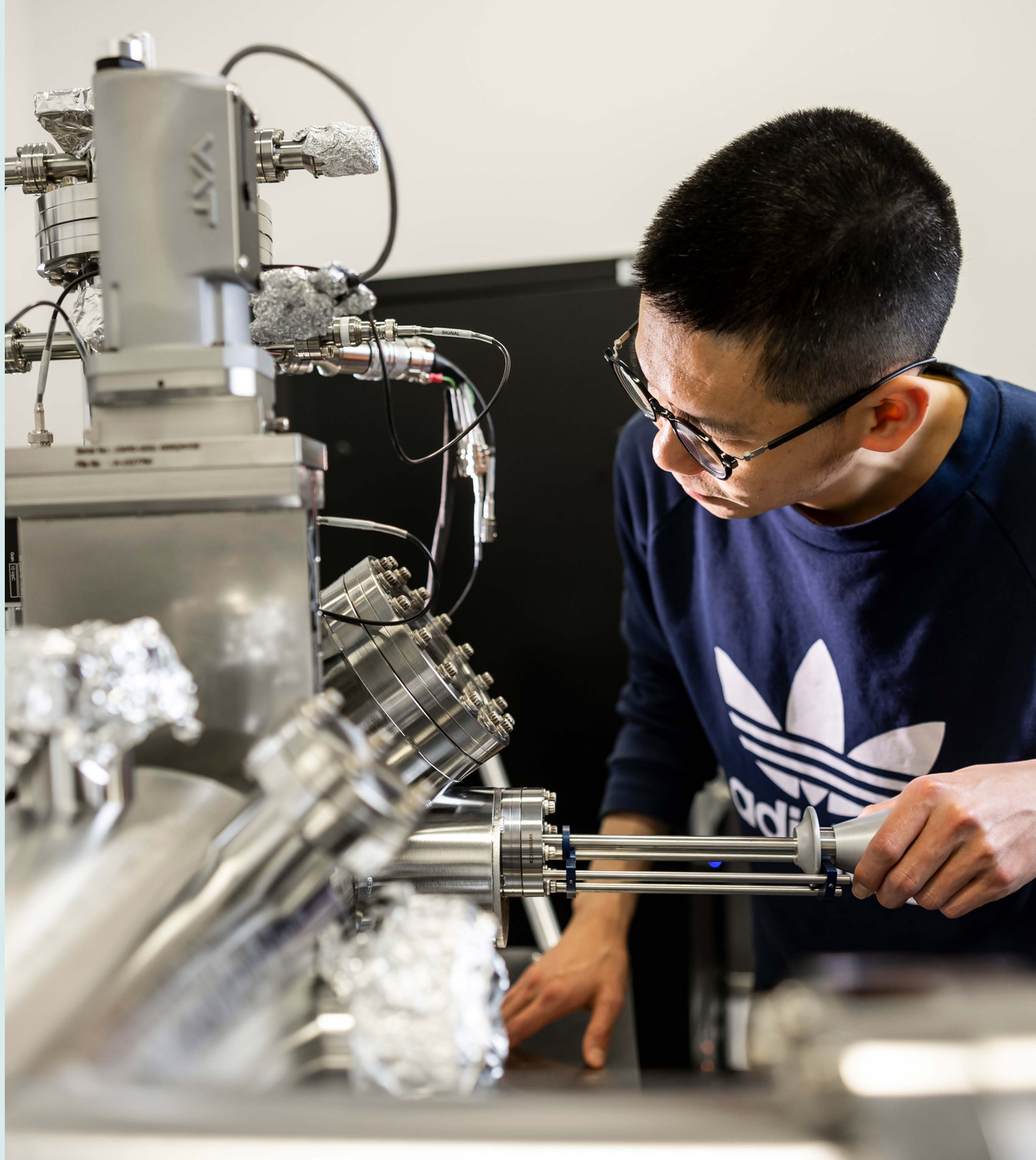
Nanoscale Characterisation of Solar Cells and Functional Materials by Advanced Scanning Probe Microscopy

Various forms of advanced scanning probe microscopy can be used to characterise the properties of grain boundaries and other functional material interfaces with nanometre lateral resolution under light illumination. Capabilities range from the investigation of electronic band bending, surface photovoltage, photocurrent and surface potential, to chemical passivation strategies and quantum efficiency. Possible measurements include nanoscale electrical, mid-infrared spectral and nuclear properties of solid materials, performed in a wide parameter space, such as variable temperature, electric and magnetic fields, different gas environments and controllable humidity.



Competitive Advantage

- UNSW developed scanning probe microscopy platform (not available commercially)
- Material properties can be assessed with nanometre resolution
- Ability to test 6-inch wafers

Impact

- Creating a better understanding of materials properties at the nanoscale level

Successful Applications

- Application of technology to improve grain boundary properties in various halide perovskites, silicon, CZTS, and kesterites, among other solar cell materials

Capabilities and Facilities

- Unique in-house developed characterisation platform for nanoscale PV properties
- Measurement of nanoscale electronic band bending at interfaces, surface photovoltage, photocurrents, surface potential, chemical treatment changes, quantum efficiency of grain boundaries, and other interfaces in solar cells and photovoltaic devices

Our Collaborators

- Lawrence Berkeley National Laboratory

More Information

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Hydrodynamic Testing of Offshore and Coastal Projects

The Water Research Laboratory (WRL) helps solve complex engineering challenges encountered by the offshore wind and renewable sector. WRL provides expertise in offshore renewable energy resource assessment, hydrodynamic modelling and coastal engineering, ensuring safe and successful development of offshore wind in the Australian marine environment.

Competitive Advantage

- WRL's hydraulic laboratories are the largest and most comprehensive in Australia, and include 2D and 3D wave making facilities, as well as high flow-rate flumes – these facilities enable testing of both offshore and nearshore wave conditions
- Our expertise in wave structure interactions, sediment mobility, metocean and scour modelling, helps increase affordability and safety of offshore wind projects
- Expertise in design and physical modelling of coastal and port infrastructure, helping port operators prepare for unique challenges from offshore wind projects
- WRL is ISO 9001 Quality Assurance certified – guarantees that applied research activities are executed in accordance with strict quality requirements, as well as time, budget, and contractual agreements

Impact

- Physical modelling of coastal port infrastructure and offshore structures, such as monopiles
- Model testing conducted at scale, which allows design optimisation, extreme load measurement, and scour modelling along structure foundations or subsea cables
- Highly experienced in wave and current resource assessment through combined expertise in field measurement and numerical environmental modelling

Capabilities and Facilities

- Large 3D Wave Basin with segmented wave making capability, three deep wave flumes, open channel flumes, and propwash testing basin
- Extensive suite of laboratory sensors, including wave probes, current meters, 3D LIDAR, submersible load cells, and pressure sensors
- Large range of offshore and marine field measurement equipment

More Information

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Improved Stability Single Junction and Tandem Solar Cells

Aside from efficiency, long-term stability is critical for achieving the lowest levelized cost of electricity (LCOE). UNSW focuses on developing rapid testing solutions, root cause analysis, and mitigation solutions for a wide range of degradation modes in commercial silicon solar cells.

Competitive Advantage

- Unique rapid testing capabilities for a broad range of failure modes, often orders of magnitude quicker than advanced testing methods
- Patented technologies for mitigating degradation at the solar cell device level

Impact

- Identifying failure modes in existing and emerging technologies that result in lower LCOE

Successful Applications

- Developed a new cell-level for potential induced degradation, which is 100 times quicker than previous solutions
- Developed cell-level testing methods for damp-heat related failure modes that are up to 100 times quicker than standard solutions
- Developed cell-level mitigation solutions for damp-heat and potential induced degradation

Capabilities and Facilities

- Unique testing capabilities for solar cells and modules
- Extensive microscopy and material characterisation techniques for root cause analysis
- Extensive experience in solar cell and module modelling to support root cause analysis

Our Collaborators

- Various Tier-1 solar cell/module manufacturers

More Information

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Mine Internet of Things

Developing various technologies for Mine Internet of Things (IoT) applications, including communication, energy harvesting, and small feature detection using LiDAR point clouds.

Competitive Advantage

- Only research group in Australia that focuses on Mine IoT technologies
- Expertise in LoRa based communication, vibration energy harvesting, AI based small feature detection, and underground robotics
- Proven experience and innovation in Mine IoT applications

Impact

- Ensuring the safety of mine workers and assets
- Improved productivity
- Supports automation

Successful Applications

- Completed a prototype of the LoRa based chain type communication network for the underground mining environment – communication network has the potential for other scenarios, such as river health monitoring
- Completed a prototype of piezoelectric vibration energy harvester design and testing
- Developed an AI-based method to detect rock bolts

Capabilities and Facilities

- Design and develop positioning system for both indoor and underground environments
- Develop LoRa-based communication networks
- Develop Mine IoT systems
- Develop vibration energy harvesting module for sensors

Our Collaborators

- Roobuck
- Roboworks
- DSIU
- 21MT

More Information

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Molecular Light Management for Energy

Utilising a range of different molecules to manipulate light for more efficient energy applications, the research team's laboratories specialise in the characterisation and application of several molecular technologies. This positions the team at the forefront of spectral manipulation and exciton management, through the use of photochemical upconversion and singlet fission, and concentrating light using molecular luminescence.

Competitive Advantage

- World leaders in photochemical upconversion with a decade of experience
- A laboratory utilising photochemical upconversion to convert light from below the silicon bandgap
- Capable of analysing energy flow across full spectrum, on all time-scales
- Access to unique singlet fission materials

Impact

- Upconversion and singlet fission can boost single threshold solar cells above 40% efficiency
- Luminescence solar concentration improves the performance of silicon solar cells in low light

Successful Applications

- Seminal demonstrations of photochemical upconversion applied to solar energy
- Discovery of the molecular spin-quintet in singlet fission
- Luminescence solar concentration used to enable low-light photovoltaic applications

Capabilities and Facilities

- Full range of optical and electrical characterisation facilities – ultrafast optical, THz and Raman, time-resolved electron spin resonance
- Material synthesis and fabrication of oxygen-sensitive devices

Our Collaborators

- HiVis Group
- Through ACEx – CSIRO, RBA and DSTG

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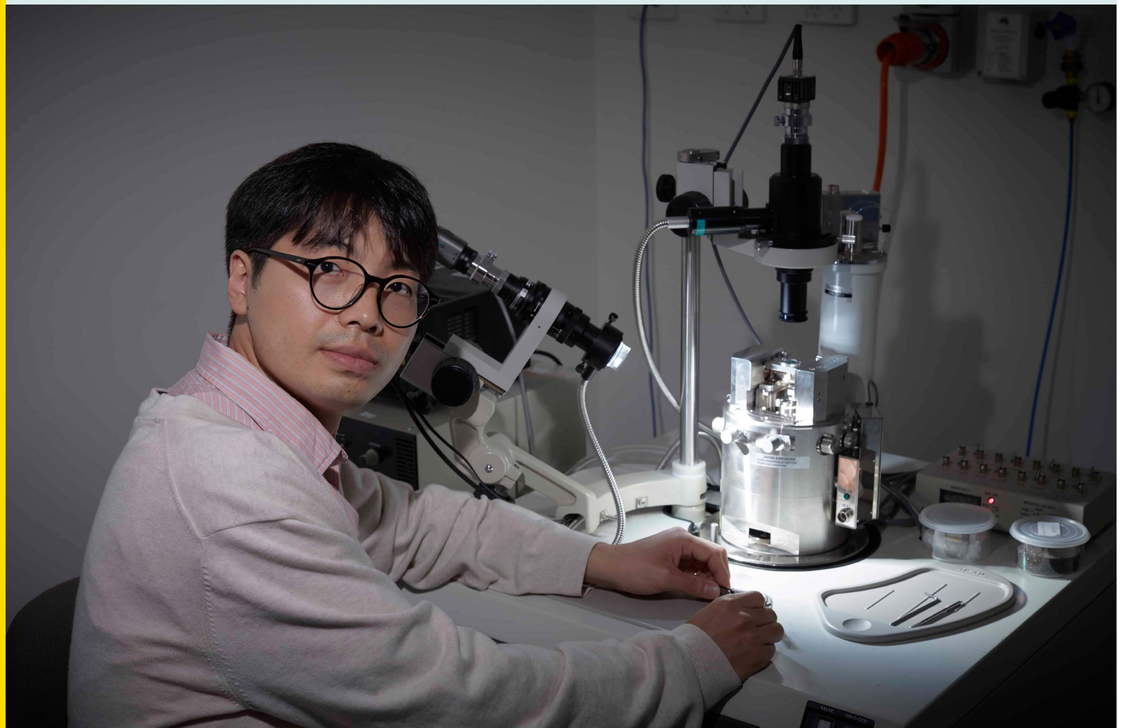
Nanoscale Functional Imaging of Energy Materials

Understanding the nanoscale properties of energy materials is critical in optimising their performance. Nanoscale functional imaging, using the atomic force microscope to measure local electrical and structural behaviour, can help gain deep insight into why photovoltaics materials either achieve, or fail to meet, their performance targets.



Competitive Advantage

- Developed a functional scanning probe microscope technique that can provide nanoscale spatial resolution
- Ability to measure both the nanostructure and functional data, enabling correlations between the structure and performance of photovoltaics materials

Impact

- Improving the fundamental scientific understanding of nanoscale properties and contributing to device performance improvement

Successful Applications

- Spatially resolved measurements of surface photovoltage and photocurrent in nanoscale
- 2D and 3D structured halide perovskite materials
- Revealing properties of nanoscale defects in semiconductors, including perovskites, CZTS, GaAs, and Si
- Investigate nanoscale properties of semiconductors for solar cells

Capabilities and Facilities

- A scanning probe microscopy setup with the following functions:
- Tuneable wavelength laser source (400-850nm)
- Environmental control (vacuum, O2, N2), heating, cooling stage (-80°C to 100°C)
- High sensitive current sensor (1pA to 10μA)
- Voltage resolution up to mV

Our Collaborators

- University of Surrey
- Korea Advanced Institute of Science & Technology (KAIST)
- Korea University
- Korea Research Institute of Chemical Technology (KRICT)

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New Dye Molecules for a Greener Future

The Research Group designs and builds molecules that push the limits and imagination of chemistry. We apply extensive synthetic, theoretical, and spectroscopic experience, with aim to uncover the key principles underpinning the design of molecules for light-harvesting and light-emission.

Competitive Advantage

- Decade of experience designing and building light-harvesting molecules
- Catalogue of dye molecules in under-explored chemical/IP space
- Multidisciplinary centre combining synthesis, theory, and spectroscopy

Impact

- Dye molecules can be used in organic photovoltaics and advanced light-harvesting applications, or for low-energy illumination
- Novel dye molecules can be used to increase the efficiency of existing solar cells in devices

Successful Applications

- Demonstration of long-range electron delocalisation in single molecules
- Fundamental insight into interplay of molecular structure and optoelectronic properties

Capabilities and Facilities

- Fully-equipped synthetic laboratory with sustainability accreditation
- Full spectroscopic facilities, including spectroelectrochemistry, optical spectroscopy, and IR
- Computational facilities and expertise in quantum chemical calculations

More Information

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Organic and Perovskite Solar Cells

The development and fabrication of high-efficiency semi-transparent organic and tandem solar cells for window and commercial applications. This includes device structure design of tandem devices to improve the device efficiency toward a theoretical efficiency of 40 percent.

Competitive Advantage

- Unique expertise in developing semi-transparent organic solar cells of 12% efficiency, with average visible transmittance (AVT) of 25% for window applications
- World-class facilities for characterisation of organic and perovskite semiconductor materials and for the fabrication of OPV and perovskite solar cells

Impact

- Organic and perovskite photovoltaics differ from crystalline solar cells –they can be produced with affordable solution-based manufacturing processes, and designed to be lightweight and mechanically flexible (for vehicle and architectural integration)
- UNSW has developed solution-based processes for tandem fabrication that can significantly reduce the cost of production for semi-transparent organic and tandem solar cells

Successful Applications

- Innovative solution-processed single junction organic and perovskite solar cells with maximum efficiency ~19% and ~23% respectively, under 1-sun illumination
- Recently developed organic–perovskite tandem solar cells with maximum efficiency of ~22%
- Two patents generated on ‘organic-perovskite tandem solar cells’.
- Developed a slot-dye coater for the fabrication of large area organic and perovskite solar cells

Capabilities and Facilities

- Development pipeline of new materials and devices for organic and perovskite materials
- Facilities for organic and perovskite materials and devices fabrication and characterisation (TEM, SEM, AFM, XRD and XPS, and micro-Raman)
- Advanced optical/spectroscopy capability for spectral measurements, including absorption, PL, and FTIR

Our Collaborators

- Huawei – transparent organic photovoltaic devices
- Dyesol
- Future Solar

More Information

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Photo-Piezocatalytic Green Hydrogen Generation

The current research program involves the development of materials, processes, and devices to generate hydrogen from seawater by piezo-photocatalysis without the complications affecting electrolysis. The ceramic catalyst materials are protected by two patent applications describing different materials that can be engineered to prevent chlorine and oxygen generation – only hydrogen, therefore improving safety and economics.

Competitive Advantage

- Capacity to engineer novel materials that suppress Cl2/O2 generation, while efficiently generating H2
- Funding from Vecor Technologies

Impact

- Energy – large-capacity, scalable, mobile H2 generation
- Environment – green H2 generation
- Security – no strategic raw materials
- Simplicity – high-yield generation of H2 using sunlight and ultrasound
- Materials – ceramic catalysts can be synthesised (aqueous-based, non-toxic, non-strategic) or purchased, use of abundant/free seawater
- Economics – low-cost, basic infrastructure and processes for efficient H2 production, 2030 global hydrogen generation market estimated at A$477 billion
- Safety – no production of O2 or Cl2
- Major funding from Vecor Technologies
- Government National Science and Research Priorities – energy, advanced manufacturing, and environmental change
- Contribution to Australian Public Service Net zero 2030

Successful Applications

- Patent 1 – Engineerable-composition catalyst
- Patent 2 – Engineerable-defect catalyst
- Capabilities and Facilities
- Three dedicated laboratories (120 m2)
- Comprehensive facilities for fabrication (School of Materials Science and Engineering), analyses (UNSW Mark Wainwright Analytical Centre), and testing (UNSW-Vecor Laboratories and UNSW School of Chemistry)
- Expertise in processing, analyses, and testing of ceramic catalysts electrochemistry, and hydrogen

Our Collaborators

- Vecor Technologies

More Information

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NEMCAT Group

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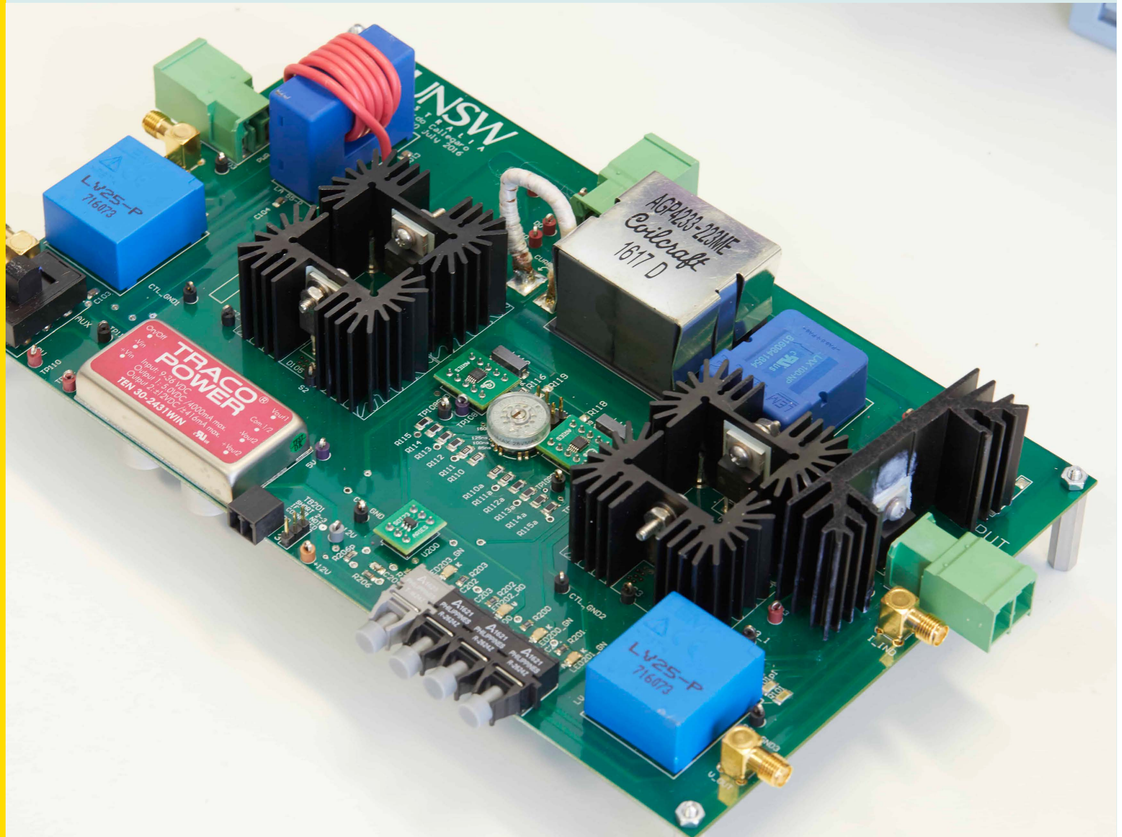
Photovoltaic Module Power Optimiser

A low-cost, universal converter that can act as either a power optimiser or a micro-inverter for photovoltaic (PV) modules. This can maximise the energy output of PV systems by constantly extracting the maximum power from each PV panel separately.



Competitive Advantage

- High frequency and intelligent design that can detect potential faults in PV modules and ancillary equipment, thereby avoiding costly downtime
- Allows flexible installation design with multiple orientations, slopes and PV panel types in the same string
- String voltages can be kept constant, providing greater flexibility with both longer strings and strings of different lengths, to design optimal solar PV systems

Impact

- More efficient PV power systems
- Improved safety functionality
- Improved energy yield and reduced energy loss due to shading effects

Capabilities and Facilities

- State-of-the-art test facilities including accelerated testing
- First-class instrumentation and measurement
- Prototyping and testing solutions
- Real-time simulation

More Information

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Photovoltaic Yield and Techno-Economic Modelling for Large-Scale Solar

Current state-of-the-art yield and financial prediction models are inadequate for large-scale solar, given the use of new technologies, site configurations and business models, as well as uncertain environmental impacts. These tool limitations pose a number of risks, including increased financial and operational costs, and a high level of uncertainty in predicted performance.

Competitive Advantage

- First principle-based modelling of large-scale solar performance for existing and emerging technologies
- In-built techno-economic analysis

Impact

- Unique yield and techno-economic analysis can inform investment decisions
- Analysis can be used to guide development strategy for component suppliers

Successful Applications

- Techno-economic analysis of a wide range of module mounting technologies for giga-scale solar projects in Australia
- Accurate prediction of operating temperatures of various racking/mounting combinations

Capabilities and Facilities

- Unique modelling software tools
- Bespoke climate chambers and accelerated tests for module reliability

Our Collaborators

- Sun Cable
- 5B
- PV Lighthouse

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Piezo-Electric Energy Harvesters: Robust, Performance-Based Design

The surrounding environment is rich with untapped sources of energy – mechanical vibrations. Piezo-electric energy harvesters (PEHs) can convert mechanical vibrations into electric power, enabling local energy generation for the rapid roll out of small electronic devices (e.g., IoT). This capability stems from the development of software for accurate and efficient numerical simulations of PEHs, with the aim of developing fit-for-purpose environmental energy harvesting solutions.

Competitive Advantage

- Computational mechanics and algorithms for shape and topology optimisation that aim to maximise performance of PEHs
- Expertise with simulations based on the mathematical model of thin piezo-electric cantilever plates
- Ability to incorporate uncertainties in material parameters into the model, which enables the analysis of quantities of interests within a confidence interval

Impact

- Virtual simulations can substitute experiments and predict performance of a PEH for any geometry and material parameter. The design can be used for manufacturing high-performing devices.

Successful Applications

- Designing devices of non-conventional shapes for maximum frequency and/or energy/area ratio
- Capabilities and Facilities
- Extensive expertise in modelling CAD coupled with in-house bespoke software development

More Information

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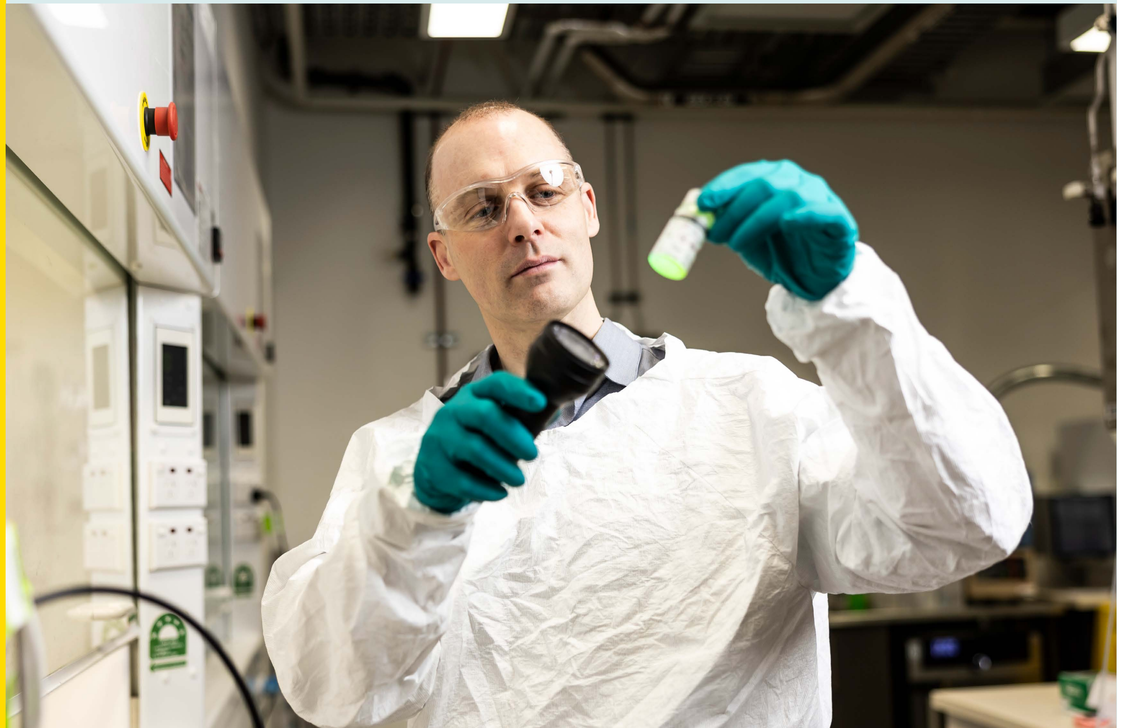
Quantum Dot Optoelectronic Devices

High-performance semiconducting devices are synthesised chemically from nanomaterial and quantum dot colloids. These nanomaterials have energy applications in devices such as colloidal quantum dot solar cells (CQDSCs), solar windows, infrared photodetectors, and gas sensors. They are also highly luminescent materials with tuneable wavelengths/colours for security dyes, high brightness fluorescent coatings, quantum-enabled flat panel displays (QLEDs), and luminescent solar concentrators (LSCs).



Competitive Advantage

- High efficiency semiconducting quantum dot thin film solar cells using PbS and PbSe
- High brightness/luminescence non-toxic nanoparticles, such as Zn:CuInS2

Expertise in developing:

- low-cost, high efficiency chemically synthesised optoelectronic devices
- a variety of oxide nanoparticle coatings with good semiconducting properties
- tuneable surface chemistries in a number of high-performance nanoparticle systems
- inorganic Pb-halide perovskite nanoparticles with tuneable fluorescence across the visible spectrum

Impact

Development of new materials for renewable energy and sensing applications, including:

- Portable power generation for small-load devices (e.g., IoT)
- Photodetection and sensing of infrared light for gas detection
- Substrate independent devices that can be deposited on any surface with best-in-class performance
- Extraction of energy from light in easily implementable/scalable ways, such as building windows

Successful Applications

- High-performance quantum dot solar cells in PbS and PbSe
- Highest recorded photoluminescence quantum yield from PbS quantum dots
- Synthesis of high brightness Pb-halide perovskite nanocrystals for IoT applications
- Lab-scale luminescent solar concentrators with good performance

Capabilities and Facilities

- Chemical synthesis laboratory suitable for the fabrication of high-performance colloidal quantum dot and nanoparticle synthesis by hydrothermal and ligand-based methods
- Fluorometer to measure photoluminescence efficiency across the visible spectrum and into the infrared (approx. 400-1500nm)
- Knowledge across suite of measurement tools relevant to semiconductors and energy

Our Collaborators

- ClearVue
- D3E

More Information

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Solar PV – Manufacturing, Deployment, Performance and Integration

Solar PV technology will be a significant source of future energy generation. From mining and processing critical minerals such as quartzite and silver, to cell and module manufacturing, and the deployment of rooftop and large-scale arrays, solar is set to play a critical role in the Australian economy.

Competitive Advantage

- Record solar cell efficiencies
- Cutting-edge materials and device research
- World-class research in energy markets, policy and deployment
- World-first solar and renewable energy education program

Impact

- Pioneering research on an international level in the areas of cell and module manufacturing, deployment, system performance, data and advocacy

Successful Applications

- Executive Director of the Australian Centre for Advanced Photovoltaics (ACAP, supported by ARENA and founded at UNSW
- Former CEO of UNSW Energy Institute
- Lead technology roles in international module manufacturing with CSG Solar in Germany and Suntech in China
- Co-founder of Solar Analytics, Australia's leading independent energy monitoring provider
- Former Chair and current Secretary of Australian PV Institute (APVI)

Capabilities and Facilities

- UNSW is leading techno-economic analysis activities, and supporting the commercialisation and manufacturing of solar technologies

Our Collaborators

- Australian PV Institute (APVI)
- CSIRO
- Tindo Solar
- 5B
- SunDrive Solar
- SunCable
- Australian National University
- University of Melbourne
- Monash University
- University of Queensland

More Information

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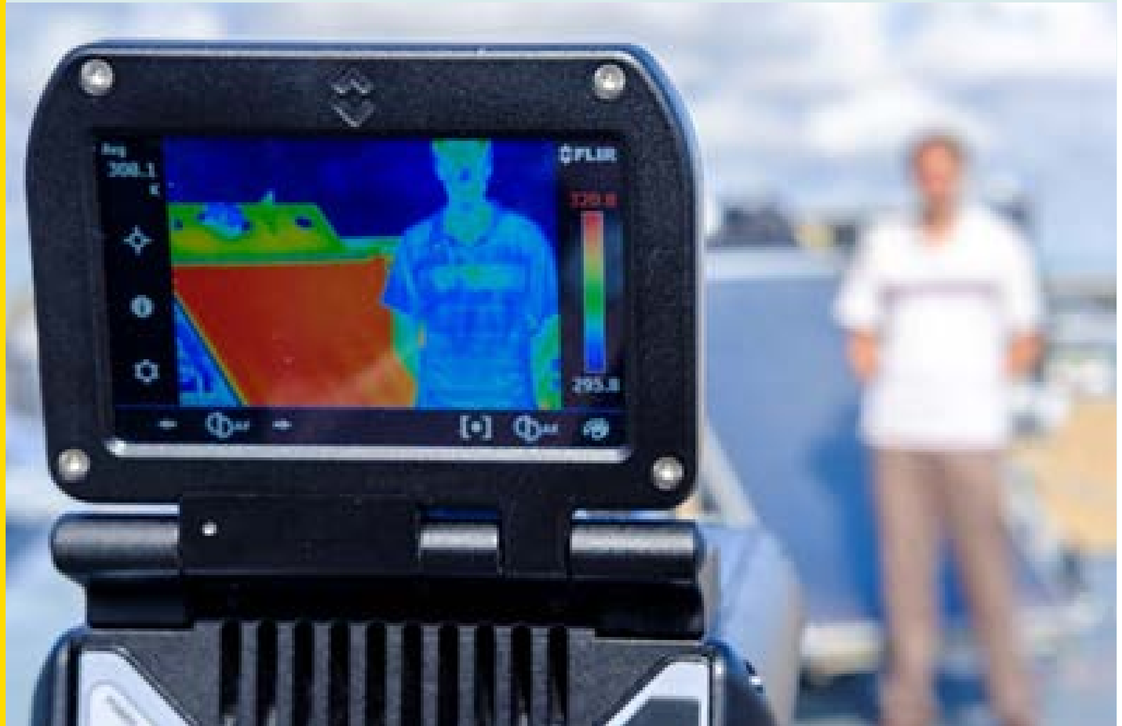
Solar Thermal Energy Harvesting and Storage

Expertise in the development of new solar thermal and thermal energy storage technologies to meet the needs of residential and industrial process heat demand profiles. This includes facilities with fluid and heat transfer characterisation and performance testing capabilities to understand the efficiency and performance in a real-world, 'on-sun' operating environment with simulated loading.



Competitive Advantage

- World-class testing facilities for outdoor testing of prototype solar collectors and thermal storage devices that run on liquid or gaseous working fluids across a range of operating temperatures and pressures

Impact

- Ability to characterise and improve the performance of solar thermal and thermal energy storage components and systems

Successful Applications

ARC/ARENA/CRC projects:

- Superhydrophobic/nanotechnology and micro solar collectors
- Waste heat recycling for desalination in solar thermal power plants
- Aluminium processing with solar energy (current project)
- Hydrogen production via solar thermal/PV systems

Capabilities and Facilities

- Two outdoor solar laboratories
- An indoor lab for fluids and heat transfer measurements (includes a differential scanning calorimeter, IR cameras, and other thermal characterisation equipment

Our Collaborators

- Vast Energy
- Apricus
- Gree
- Coolsheet

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Subsurface Fluid Flows and Dynamics

NMR technology is a versatile approach suitable for the characterisation of partially saturated porous media. It allows the analysis of surface-fluid and fluid-fluid interactions over length-scales stretching from atomic to pore/core centimetre lengths. We combine strong experimental capabilities with numerical simulation based on micro-CT images.

Competitive Advantage

- Characterisation of pore-space and transport in natural porous materials, including multi-phase flow
- Advanced studies of dynamic processes – e.g., capturing kinetics of cement hydration and reactive flow
- Interaction of colloids with solid surfaces – e.g., wettability reversal
- Characterisation of petroleum fluids using a set of industrial standard practices
- Enhanced interpretation of NMR responses using 'Morphy/NMR' pore-scale simulator on tomographic images

Impact

- Technology commercialised through spin-off company Digital Core, which merged with Numerical Rocks AS to form Lithicon – In 2014, Lithicon was acquired by FEI for A$76 million (now part of ThermoFisher)
- Morphy installation at several Fortune 500 companies

Successful Applications

- Two-phase pore-scale wettability alteration studies in sandstones and carbonates
- Cement hydration dynamics for complex cementitious materials

Capabilities and Facilities

- MHz Rock Core Analyser, 13 MHz MOUSE set, high-pressure high-temperature flow cell and high-precision continuous pumps – 1H NMR relaxation, diffusion, correlations (T1-T2, T2-D) and exchange (T2-T2) – 1D spin density, T1 and T2 profiles, flow propagators
- 43 MHz Spinsolve diffusion/carbon with temperature control
- Fifth-generation helical micro-CT in custom led-lined room with high-level environmental controls
- Established collaboration with MWAC NMR facility team (liquid and solid-state NMR spectroscopy and EPR)

Our Collaborators

- BP
- FEI
- OMV
- Petrobras
- RWE
- Santos
- Total
- Wintershall

More Information

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Tandem, Reduced Operating Temperature, High-Efficiency and Vehicle-Integrated Solar Photovoltaics

Research into a range of topics related to improved, low-cost solar photovoltaic energy conversion, including tandem, reduced operating temperature, high-efficiency and vehicle-integrated solar photovoltaics.

Competitive Advantage

- Held the world record of 25%for the highest efficiency passivated emitter and rear (PERC) silicon solar cell, a cell structure invented at UNSW and accounting for most of the presently installed solar globally
- Hold the world record for the most efficient solar module at 40.6% energy conversion efficiency, a multi-cell stack involving four cells, each responding to a different range of solar wavelengths

Impact

- Over USD$1 trillion of UNSW-invented and developed PERC cell systems installed worldwide from 2016 to 2023
- Former team members responsible for successful diversification of manufacturing industry into China, which resulted in a tenfold solar module price reduction between 2008 and 2018

Successful Applications

- BP Solar ‘Saturn’ cell (1992-2006)
- Suntech Power ‘Pluto’ cell (2009-2013)
- PERC cell (2012-present)

Capabilities and Facilities

- Laboratory for fabrication of silicon and thin film solar cells
- Solar Industrial Research Facility for evaluating commercial-sized wafers at pilot production level

Our Collaborators

- AIKO Solar
- Canadian Solar
- Trina Solar
- JinkoSolar
- LONGi Solar
- DAS Solar

More Information

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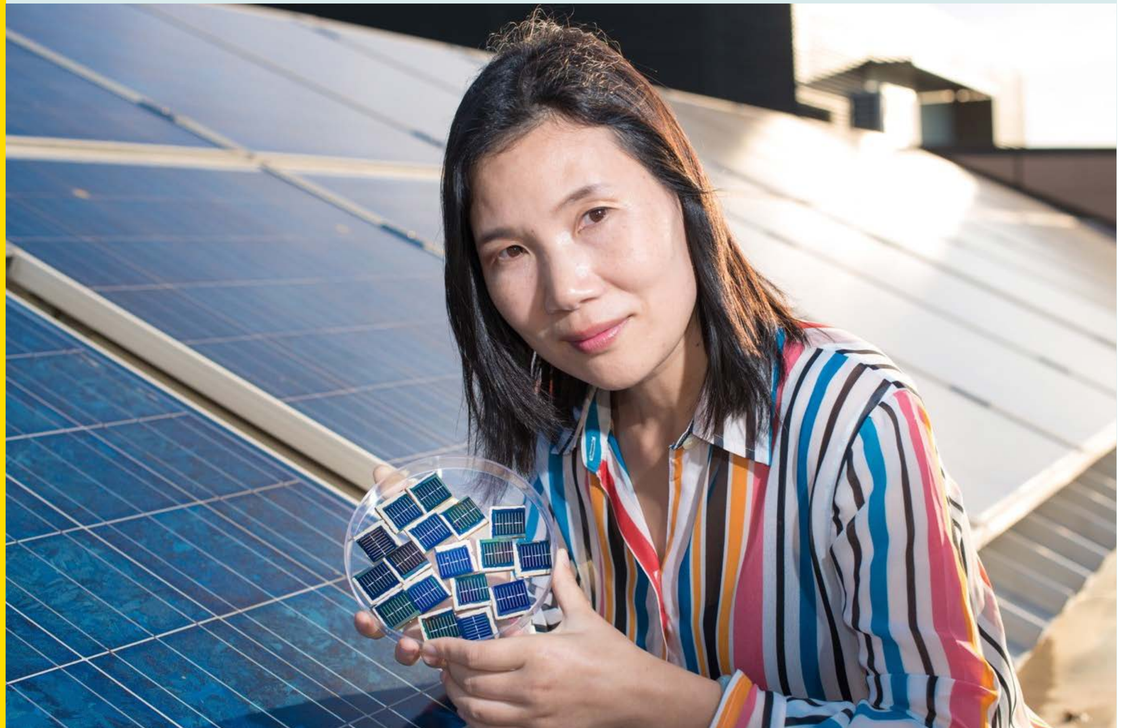
Thin Film Technology for Flexible Solar Photovoltaics

Thin film solar cell technologies offer new solutions for integrating solar electricity generation into the modern economy. These not only enable flexible photovoltaic products, but also lower the cost of silicon PV by increasing solar photovoltaic energy conversion efficiency through the use of high-efficiency tandem cells.



Competitive Advantage

- Hold the world record of 11.4% for highest efficiency high bandgap pure sulphide Kesterite CZTS (Cu2ZnSnS4) solar cells, and have established five world records for this photovoltaic technology
- Developed 24.8% efficient low-temperature (<200 °C) processed planar perovskite solar cells with significantly improved stability without encapsulation
- Developed above 30% efficiency III-V/Si tandem solar cells
- Developed 9.6% efficiency all-inorganic emerging antimony chalcogenide solar cells
- Designing and developing new PV materials made from environmentally-friendly and earth-abundant materials for Silicon-based tandem cells

Impact

- The goal is to make solar photovoltaic more efficient, cost-effective and competitive for the energy market and for their applications in various aspects of our lives, such as building and vehicle-integrated PV and portable power sources
- Kesterite breakthroughs represent a major advancement in the development of flexible, stable, cheap and non-toxic solar cells

Successful Applications

- Working with industry partners for building-integrated PV (2015-present)
- Working with industry partners for III-V/Si tandem solar cells (2011-present)

Capabilities and Facilities

- Laboratory capable of fabricating high-efficiency thin film solar cells (e.g., kesterite, perovskite, Sb2S[Se)3]), and associated function thin films (e.g., transparent electrodes [TCO, Ag NW])
- Upgrading laboratory facility for the pilot production level of tandem cells
- Advanced characterisation tools for thin film PV materials and devices

Our Collaborators

- Trina Solar
- Longi Solar
- Jinko Solar
- Baosteel

More Information

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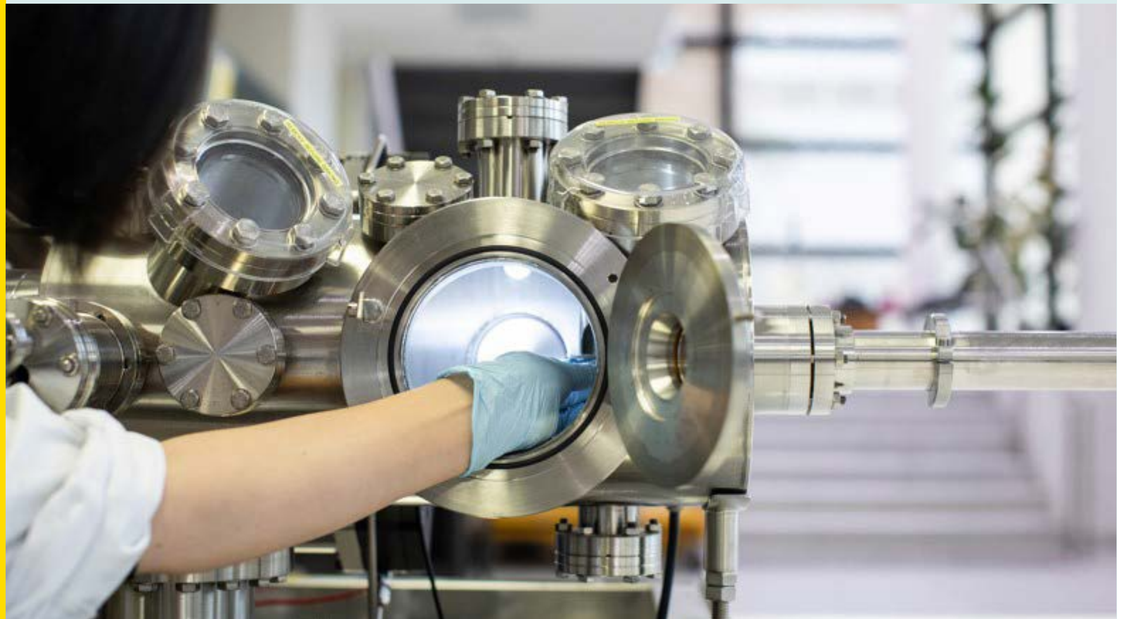
X-Ray Capabilities for Characterisation of Energy Materials and Devices

X-rays are high energy, penetrating light with wavelengths around the length of atomic bonds, which gives them unique properties for exploring energy materials. Our experienced team of twelve instrument scientists can assess chemistry, surfaces, mineralogy and high-resolution 3D images of energy materials and devices for research or industry, often under dynamic conditions during operation.



Competitive Advantage

- Largest combined X-ray laboratory in Australia offering an unparalleled range of instrument capabilities and technical expertise – XRD, TF-XRD, SC-XRD, XPS, XRF, micro-XRF, XPS, micro-CT, EXAFS
- Easy access and support for enquiries, problem solving, multi-technique projects, training, and professional administrative services

Impact

- Deeper understanding cell performance during charge-discharge cycling by monitoring changes in solid electrolyte mineral phases in operando
- Fine-tuning hydrogen-storage in molecular framework materials
- Optimising surface chemistry of graphite-coated electrodes
- Confirming chemistry and structure of thin-film multilayer semiconductors (e.g., thin-film photovoltaics)

Successful Applications

- Quality assessment of new and used electrode surfaces/subsurfaces
- Supporting the development of record-breaking thin-film photovoltaics
- Troubleshooting automotive cells and batteries using 3D imaging

Capabilities and Facilities

- Mineralogy and molecular structure – X-ray diffraction of bulk solids and thin-films and crystals
- Chemistry – X-ray fluorescence of bulk solids from % to ppm
- Surfaces – X-ray photoelectron spectroscopy for chemistry at the top 5 nm, or nanoscale depth profiling
- 2D Imaging – X-ray fluorescence microscopy down to 20mm under inert gas or vacuum
- 3D Imaging – micro-CT with helical and circular scanning mode with pressure and flow cells for various sample sizes and image processing support

More Information

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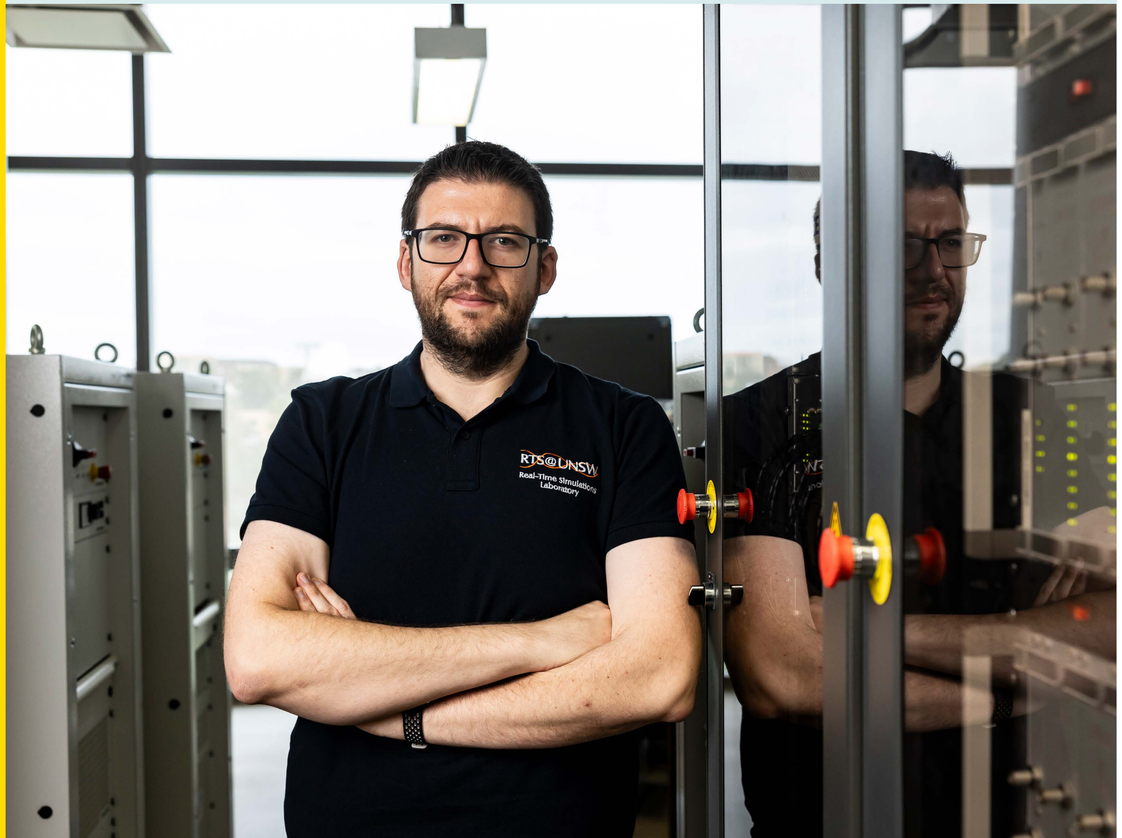
Modular Multilevel Converters

Aiming to extend the use of modular multilevel converters across multiple application areas. The family of modular multilevel converters is the very definition of state-of-the-art in relation to high-power power-electronics conversion, HVDC transmission, and MVDC systems.



Competitive Advantage

- Leading analytical tools and modelling capabilities with more than 10 years of research experience in developing topologies, hardware, and controls for modular multilevel converters

Impact

- Modular multilevel converters deliver greater power capacity, voltage levels and conversion efficiency, than all previous generations

Successful Applications

- Development of tailored solutions for multiple applications, including HVDC systems, energy storage, and renewable energy systems

Capabilities and Facilities

- Reliability focused enhancements, such as active redundancies
- Multiphysics capacity, including electrical, thermal and electromagnetic
- A fully reconfigurable 2/4 full-bridge (Gen2) MMC setup with integrated high-level control
- Small-scale half-bridge (Gen1) MMC with direct access to component level
- Full AC and DC grid emulation
- Advanced monitoring, metering and data logging capacities

Our Collaborators

- Tecnalia (Spain)

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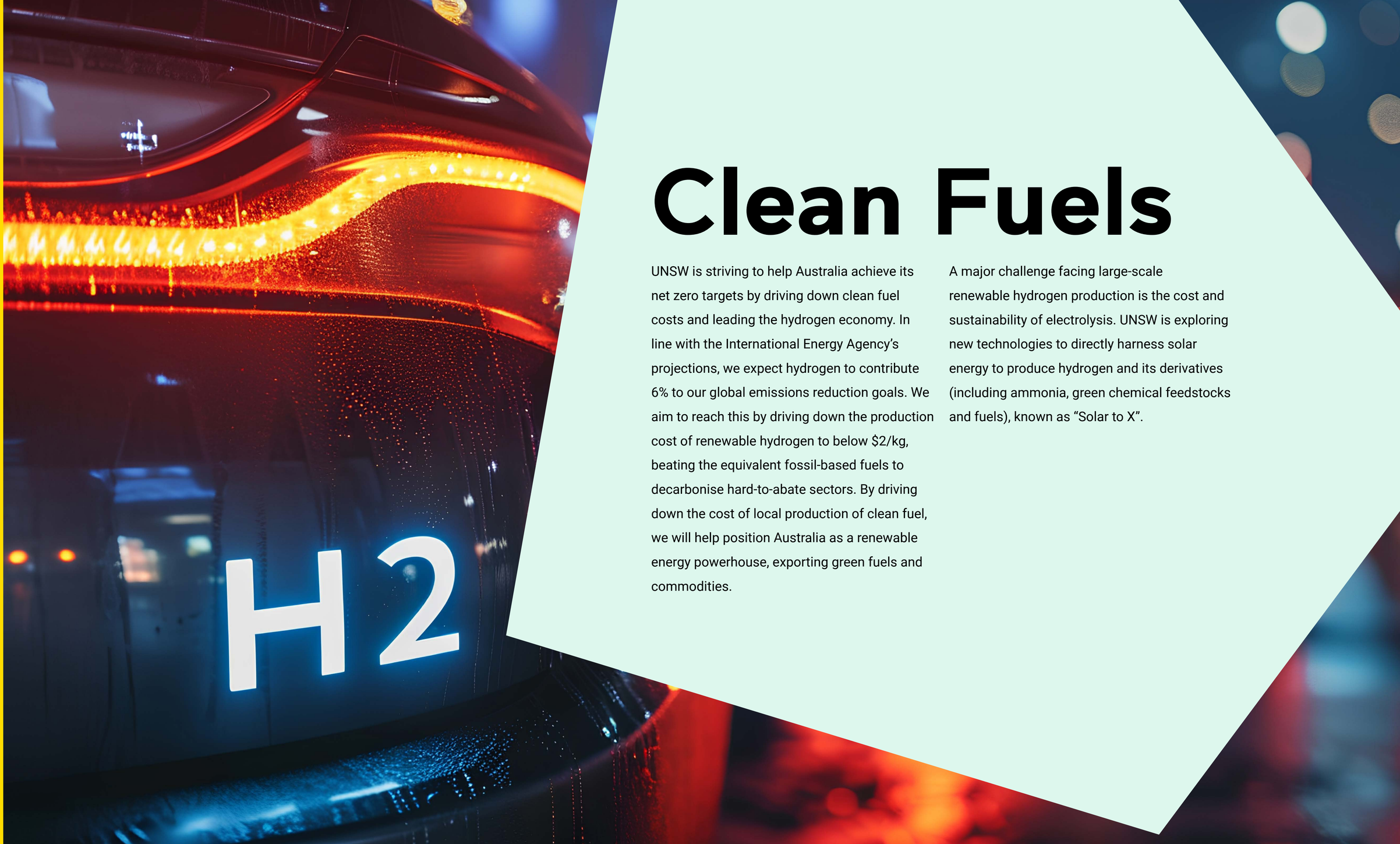


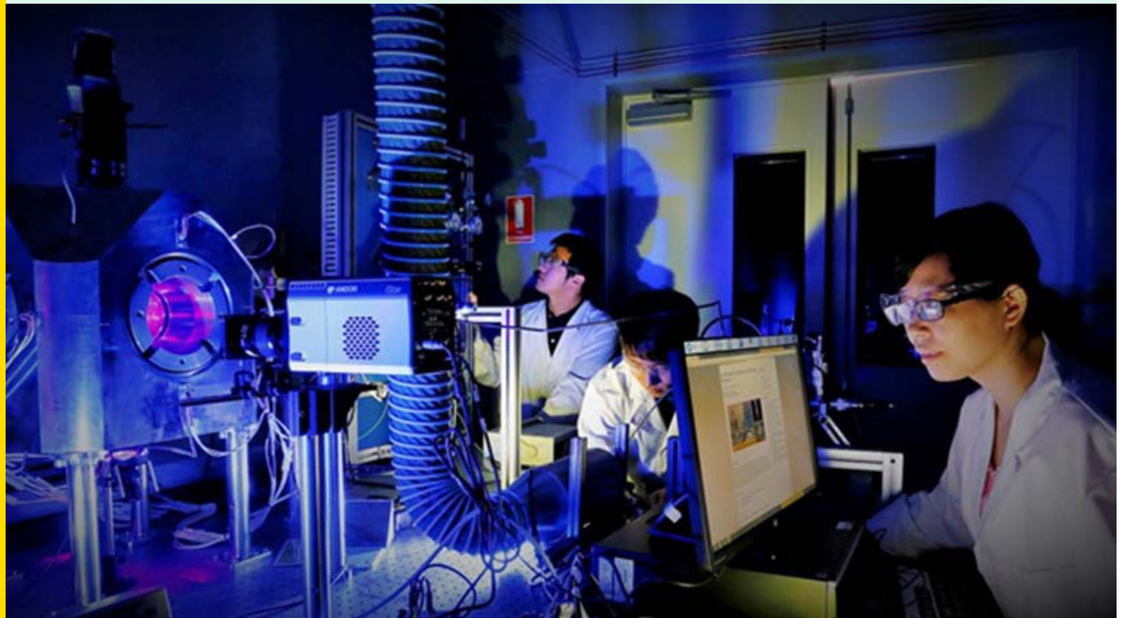
Clean Fuels

UNSW is striving to help Australia achieve its net zero targets by driving down clean fuel costs and leading the hydrogen economy. In line with the International Energy Agency's projections, we expect hydrogen to contribute 6% to our global emissions reduction goals. We aim to reach this by driving down the production cost of renewable hydrogen to below $2/kg, beating the equivalent fossil-based fuels to decarbonise hard-to-abate sectors. By driving down the cost of local production of clean fuel, we will help position Australia as a renewable energy powerhouse, exporting green fuels and commodities.

A major challenge facing large-scale renewable hydrogen production is the cost and sustainability of electrolysis. UNSW is exploring new technologies to directly harness solar energy to produce hydrogen and its derivatives (including ammonia, green chemical feedstocks and fuels), known as "Solar to X".

Advanced Engine Combustion Diagnostics and Clean Energy Innovations

The Advanced Combustion Diagnostics group's research focuses on thermodynamics, fluid dynamics, combustion, and heat/mass transfer. Their work applies directly to practical combustion systems, optimising efficiency and minimising trade-offs in stability, emissions, and cost. Via industry collaboration, the group delivers comprehensive insights and innovative solutions for sustainable energy conversion.



Successful Applications

- Leading technical expertise in the field of hydrogen-fuelled compression ignition engines
- Performed world-first demonstration of a hydrogen-fuelled engine operating on a dual-fuel direct-injection approach (developed by the group)
- Demonstrated exceptional combustion stability, significant substitution of hydrogen energy (up to 90% energy substitution), and a remarkable reduction in pollutant emissions (up to 70% reduction in CO2), all while maintaining comparable or higher engine efficiency compared to diesel-only references

Capabilities and Facilities

- Laboratory facilities that rival the top international research institutes
- Optically accessible, high-pressure, constant-volume combustion chamber (CVCC) capable of replicating the extreme conditions (up to 10 MPa and 1200K) found in existing and future energy systems
- Complementing an advanced chamber are optical and laser-based diagnostics tools, including a high-power pulsed Nd:YAG laser, continuous-wave lasers, photodiodes, spectrometer, high-speed colour camera, and ICCD cameras
- State-of-the-art facilities enable the team to conduct high-fidelity experimental measurements, generating the comprehensive database necessary for assessing and developing innovative solutions for research partners' energy systems
- Proven track record of collaborating with research partners to develop advanced technological solutions, while also conducting thorough techno-economic analyses – ensures proposed solutions can deliver technological advancements and align with partners' specific financial goals

Our Collaborators

- MAN-Energy Solution
- Wuhan Shuanglian-Xingxin Machinery & Equipment

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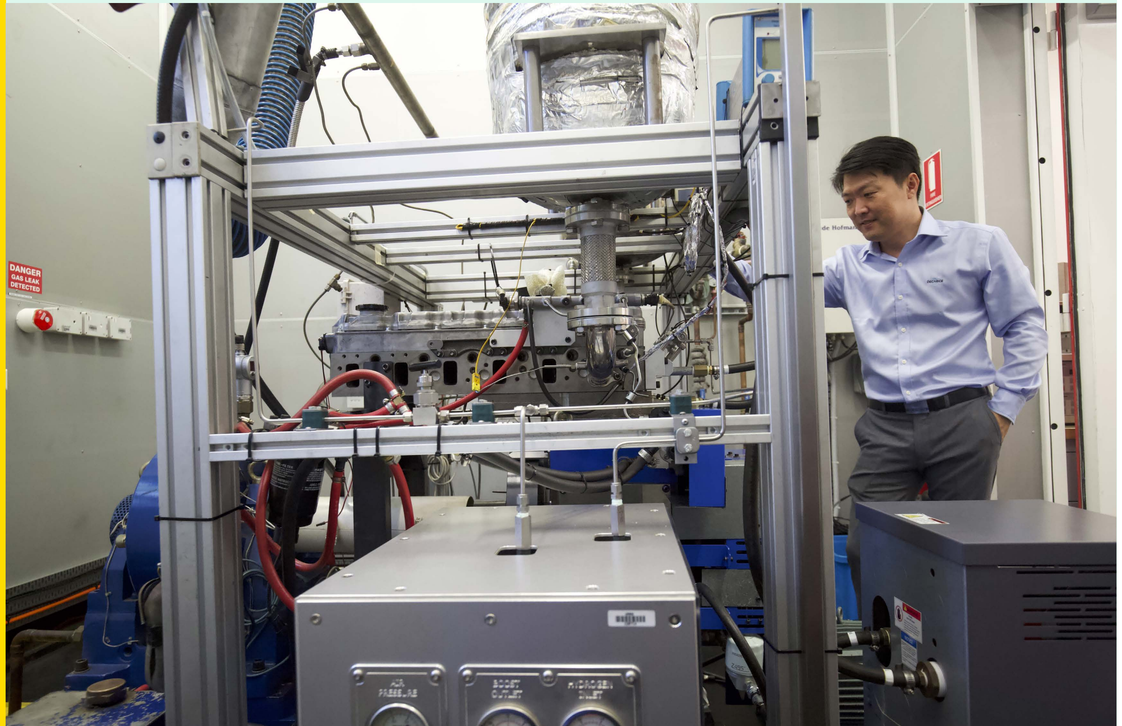
Alternatively Fuelled and Low-Emission Engines

Technologies for low-emission, high-efficiency power machines that enhance the use of renewable carbon-neutral fuels.



Competitive Advantage

- Combining optical diagnostics and engine design/testing for the development of multi-fuel capable and low-emission combustion engine technologies
- Laser-based imaging in optically accessible engines to visualise complex and transient motion of in-cylinder flows, development of fuel sprays, flames, and formation of pollutants
- Direct industry collaboration for technology development

Impact

- Combustion technology enables the extended use of renewable fuels, such as hydrogen, methanol, ammonia, ethanol and biodiesel

Successful Applications

- Fuel injection technologies for ethanol-diesel dual-fuel engines
- Biodiesel combustion technologies for reduced pollutants formation
- Ethanol and petrol combustion in a high-efficiency compression-ignition engine
- Hydrogen-diesel dual direct injection engines

Capabilities and Facilities

- Optical engines and advanced imaging systems
- Engine-performance/emission-testing facility
- Design of key engine components and retrofitting applications

Our Collaborators

- SCANIA
- Hyundai Motor Company
- US Army Research Laboratory
- MAN Energy Solutions

More Information

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Ammonia Production from Renewable Hydrogen

Development of a highly efficient single-stage electrocatalytic ammonia synthesis reactor to produce ammonia at lower cost than via the traditional Haber-Bosch process.

Competitive Advantage

Ammonia is produced using PV electrolysed hydrogen from photovoltaic-electrolysis (PVE) and atmospheric nitrogen – a number of innovations are used to increase efficiency:

- nitrogen activity is increased by ionising the molecule
- nitrogen selectivity over oxygen is achieved using tailored ionic liquids as electrolytes and the nitrogen reaction is catalysed using tailored electrodes
- In-house expertise exists across all engineering requirements to solve problems and design and test a working prototype

Impact

- A cheaper and more energy-efficient process for ammonia production

Successful Applications

- PVE of water to produce renewable hydrogen
- Demonstration of selective transport in ionic liquids

Capabilities and Facilities

- Extensive laboratory facilities for PVE and characterisation
- Expertise and analysis facilities for studying the application of ionic liquids, and the ability to assess the increased nitrogen activity

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Anaerobic Digestion for Biogas Production

Energy in the form of methane in biogas can be harvested through anaerobic digestion of organic solids derived from wastewater, food or agriculture. Microorganisms are self-replicating catalysts responsible for initial organic matter decay in transit and storage, and for hydrolysis, acidification, acetogenesis and methanogenesis in the anaerobic digestion process. Control over the activity of microorganisms in anaerobic digestion provides gains in organic feedstock throughput, and therefore, revenue.

Competitive Advantage

- Microbiology expertise in anaerobic processes with experience in manipulating the microbiology of anaerobic organic waste decomposition to enhance biogas production

Impact

- Enhanced biogas production from anaerobic digestion facilities operated by water and waste utilities and agriculture

Successful Applications

- Laboratory scale demonstration of enhanced biogas production from food waste (Earthpower)
- Field demonstration of enhanced biogas production from coal (Biogas Energy)

Capabilities and Facilities

- In-house PC1 and PC2 laboratories for manipulating and analysing complex communities of microorganisms in biogas production
- Access to high-end DNA, RNA and protein (omics) analysis
- Methane potential testing

Our Collaborators

- Biogas Energy
- Earthpower

More Information

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Catalyst and System Design for Photocatalytic Hydrogen Production and Organic Reforming

Particle and Catalysis Research Group (PartCat) engineer photocatalytic processes and materials to efficiently produce hydrogen, while simultaneously reforming organic molecules such as furfuryl alcohol into value-added products such as jet fuel precursors. The catalyst and systems have low capital and operational costs with direct solar energy inputs, creating a low-cost alternative for decentralised hydrogen production in the agriculture, mining, and chemical sectors.

Competitive Advantage

- Fully-equipped laboratory and research experts in catalyst and reactor design
- Efficient photocatalytic systems for simultaneous or decoupled hydrogen production and biomass reforming
- Low-cost hydrogen production with minimal energy input

Impact

- Energy security by using diffusive solar energy to produce energy carriers
- Off-grid hydrogen generation for remote sites
- Economical catalyst and reactor design to minimise capital costs
- Hydrogen production by reforming organic waste to produce value-added chemicals such as jet fuel precursors

Successful Applications

- A fully-functional demonstration scale reactor system that can generate 1.6 Litres of hydrogen per hour, while reforming benzyl alcohol into hydrogen and benzaldehyde using a visible-light-active photocatalyst
- Lab-scale reforming of biomass feedstocks such as lignocellulosic waste-derived furfuryl alcohol to produce hydrogen, and value-added products (hydrofuroin) or photoreforming ethanol to produce hydrogen and acetaldehyde

Capabilities and Facilities

- Nanoparticle synthesis and characterisation techniques
- Custom-designed photocatalytic reactor and light sources for measuring catalyst performance
- Demonstration-scale reactor system with reactor size of 0.5 m2 irradiation area and 5 Litre slurry capacity for scale-up and testing
- Product detection capabilities (NMR, GC/MS, UV-Vis)

More Information

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Coal Mine Methane Capture and Conversion to Energy

Coal mine methane released from coal extraction activities accounts for six percent of global greenhouse gas emissions. The development of a next-generation methane capture and conversion system provides a high-efficiency solution for the multi-trillion dollar mining industry to improve health and safety, reduce greenhouse gas emissions, and capture clean energy.

Competitive Advantage

- Interdisciplinary research expertise in coal mine methane, mining geomechanics, and seismology
- Experience collaborating with local and international mining companies
- Computational resources, numerical software packages, and laboratory facilities

Impact

- Improve mine health and safety
- Reduce greenhouse gas emissions and address climate change
- Convert fugitive emissions from coal mines to usable energy

Successful Applications

- Extended gas drainage production time in Queensland mines from 20 to over 100 days, and increased total gas production volume by one order of magnitude
- Characterisation of gas content in coal seams and coal measures based on geophysical logs
- Optimisation of gas drainage designs in European and Chinese coal mines to increase methane purity by 30%
- Mining induced fracture characterisation to significantly reduce drilling costs

Capabilities and Facilities

- Numerical simulation strengths in rock mechanics, reservoir evaluation, production planning and prediction
- Lab testing facilities for rock strength and petrophysics properties in field conditions
- Advanced lab testing for multiphysics rock behaviour (permeability, acoustic emissions, and ultrasonic) in high-pressure-high temperature triaxial cell

Our Collaborators

- Anglo American Steelmaking Coal
- Australian Coal Association Research Program (ACARP)
- Australian Research Council (ARC)
- BMA
- Coal Services
- Glencore
- South32

More Information

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Coal Simulation Technology – Solutions for Natural Gas Production

The development of technology that provides a fast, efficient and accurate means to predict properties of coal seams in deep earth, that are necessary for producing coal seam gas (CSG) and predicting gas and water production.

Competitive Advantage

- Fast, efficient, and accurate prediction of coal properties
- Innovation in coal characterisation at reservoir pressure and temperature
- Expertise in history matching of CSG reservoirs
- Ability to optimise methane gas production
- Skills to determine water production

Impact

- CSG is the natural gas extracted from underground coal seams and its emissions are significantly lower than those of other fossil fuels. It will play an important role in Australia becoming a significant global exporter of natural gas.

Successful Applications

- Petrophysical analysis of coal permeability, porosity and relative permeability for Australia's Queensland Gas Company
- In-situ analysis of coal permeability and swelling/ shrinkage effect for Shell Global Solutions
- Cleat-scale to core-scale analysis of coal for Australian Research Council
- Validation of coal geo-mechanical models for Australian basins
- Quantification of permeability rebound
- Permeability, porosity, and relative permeability analysis of complex coal cores
- Ash content and well log analyses for coal seam wellbores

Capabilities and Facilities

- Tyree imaging facility with X-ray computed micro-tomography for 3D images of coal internal structure
- ITRAX XRF imaging of coal cores for ASH and rank analysis
- High-pressure setups for in-situ experiments and imaging
- Core flooding equipment for permeability and relative permeability
- Gas adsorption units for Langmuir isotherm curves
- High performance computing for flow simulations and history machine
- Our Collaborators

Queensland Gas Company

- Shell Global Solutions

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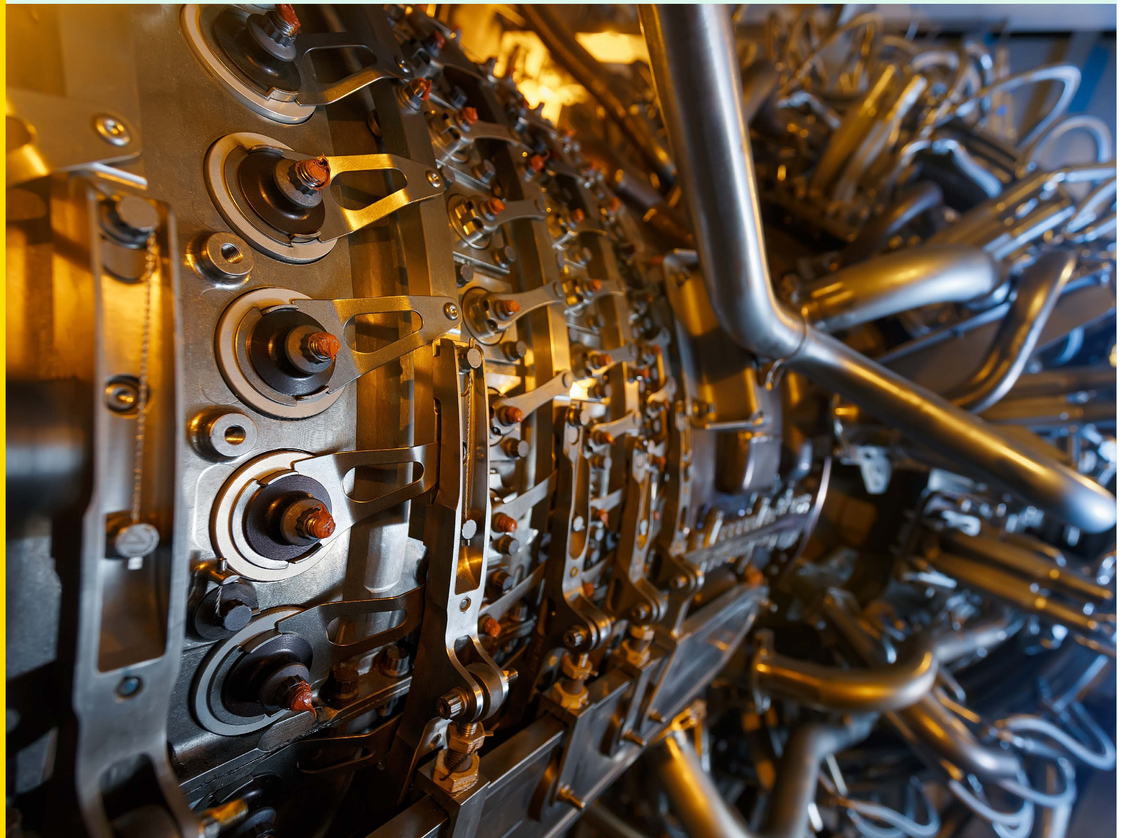
Combustion Modelling for Gas Turbines

New approaches for combustion in gas turbines, industrial burners, and reciprocating engines adapted to hydrogen and/or ammonia fuels. Work includes early-stage concept development, improving understanding, and improving engineering modelling for these challenging fuels.



Competitive Advantage

- Experimental facilities, including multiple engines, optical and metal, high-pressure combustion chambers, and optical diagnostics
- In-house direct numerical simulation (DNS) codes that scale to millions of CPU-cores, complemented by large eddy simulation (LES)
- Deep understanding of hydrogen and ammonia combustion characteristics specific to issues associated with gas turbines, burners and diesel engines

Impact

- Proof of concept for new combustion approaches adapted to hydrogen and ammonia combustion
- Greater understanding of combustion phenomena for improved performance outcomes
- Improved confidence in engineering models, which reduce design and testing costs, and optimise solutions

Successful Applications

- Successful development of dual-fuel hydrogen-diesel engine up to 90% hydrogen substitution
- Successful development of gasoline compression ignition engines exceeding efficiency of diesel baseline
- Many successful applications of DNS to improve understanding of combustion phenomena, and in developing and validating engineering models

Capabilities and Facilities

- Multiple engine test beds complemented by high-pressure combustion chambers
- Extensive optical measurement capabilities
- Highly scaling DNS and LES codes and access to significant CPU time allocations

More Information

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Coupling of Energy Systems (Solar or Hydrogen) with Desalination Technologies

Developing new materials and design tools to overcome the technical challenges that have previously limited membrane distillation technology, to reveal an innovative method for the co-production of water and electricity capable of handling transient solar and water quality inputs.

Competitive Advantage

- Broad expertise from membrane materials development through to CST plant optimisation
- Innovators in the design of modules and materials, such as hydrophobic coatings and 3D printed parts, with a skillset in determining how to best incorporate them into solar thermal systems

Impact

- Remote locations in Australia, Middle East and North Africa are blessed with abundant solar resources and increasing levels of development. However, they are burdened by access to reliable drinking water and electricity generation facilities. Enabling the co-production of water and electricity will unearth significant possibilities for these regions. Prototype, multi-effect membrane distillation systems have achieved record low specific energy consumption in laboratory tests.

Successful Applications

- Production of prototype membrane distillation modules that can utilise the exhaust from thermal power plants
- Geo-techno-economic analysis of many configurations for the energy-water nexus

Capabilities and Facilities

- Experimental facilities to produce and test new modules and materials at laboratory and pilot scale

Our Collaborators

- Vast Energy
- Origin Water

More Information

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Dry CO2 Reforming of Methane

Advanced expertise in the design, development and testing of cost-effective dry reforming catalysts for the conversion of common greenhouse gases (carbon dioxide and methane) into syngas.

Competitive Advantage

- Highly active methane dry reforming catalyst based on cheap active metals (Ni and Co) that can be rapidly synthesised in a single-step method, and readily scalable
- High conversion of methane (up to 90%) is achievable at a relatively low operating temperature of 700 °C
- Catalyst support (using SiO2 and Al2O3) modification to enhance catalyst stability

Impact

- Alleviate global warming by converting CO2 and methane into synthetic fuels
- Large-scale production of active and stable catalyst

Successful Applications

- The transformation of two greenhouse gases into a feedstock suitable for synthetic fuel manufacture

Capabilities and Facilities

- Access to expertise and state-of-the-art facilities to enable catalyst synthesis for large-scale production
- Characterisation and testing of catalyst performance
- In-situ testing to understand conversion mechanisms

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Electrolysis of CO2 into Fuels and Chemicals

Developing electrochemical processes for the conversion of CO2 into value-added chemicals and fuels, is an attractive solution to realise a carbon-neutral energy circulation, while simultaneously storing electricity generated from intermittent renewable sources.

Competitive Advantage

- Expertise in electrocatalyst design and synthesis
- Prototype flow cell for scaling-up CO2 reduction
- Deep understanding of the reaction mechanism for electrochemical CO2 reduction

Impact

- Sustainable electrochemistry approach to producing valuable fuels that mitigate energy issues
- Alleviate global warming by converting CO2 into valuable products

Successful Applications

- Nanoporous alloy catalysts for bifunctional CO2 reduction to CO and formate
- Single-atom catalysts with an ultrahigh Faradaic efficiency (>98%) for converting CO2 into CO

Capabilities and Facilities

- Extensive lab facilities for electrocatalyst fabrication, characterisation and testing
- Access to comprehensive analytical techniques, such as diffractions, surface analysis, and electron microscopy
- Expertise and access to nuclear magnetic resonance spectroscopy (NMR) and solid-state NMR facilities

More Information

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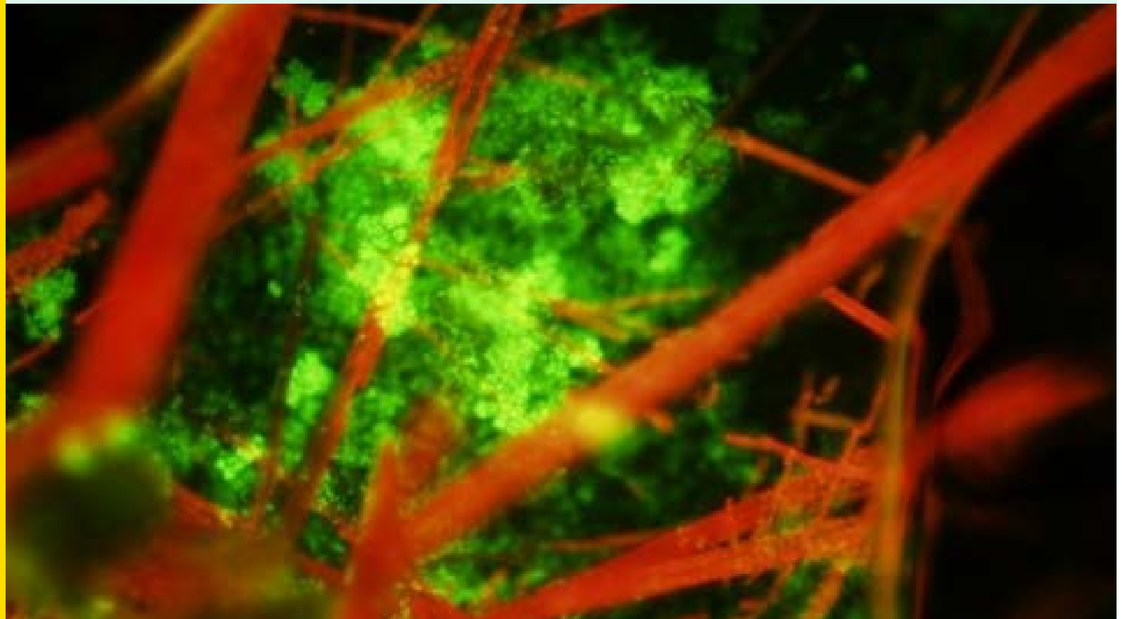
Enhanced Gas Production from Coal Seams by Methanogens

NSW and Queensland host an estimated 235 trillion cubic feet of coal seam gas resources (an emerging global low carbon emission energy), the majority of these resources being biological in origin. Direct electron transfer to methanogenic archaea, native to major coal seams has been shown to boost biological methane production. Other abundant organic feedstocks like biosolids from wastewater, agricultural waste and food waste, can also be digested to produce biogas.



Competitive Advantage

- Synthetic phenazine crystals have been found to facilitate direct electron transfer to methanogenic archaea to enhance methane production by an order of magnitude representing a positive shift in increasing methane production. Leveraging a deep understanding of the microbiology and biochemistry of biogas production, we can develop enhancement strategies and troubleshoot underperformance of anaerobic digestion systems.

Impact

- Enhancing biogas production in-situ in real-time helps sustain coal seam gas production at its current level. It represents a solution to reduce the environmental impact of the industry and increase profit margins by reducing infrastructure expenditure. Anaerobic digestion converts waste-to-energy, thereby lowering operational costs.

Successful Applications

- Lithgow coal seam (NSW)
- Jahria Coal Seam (Jharkhand, India)
- Earthpower food waste digestion facility (NSW)

Capabilities and Facilities

- Microbial community analysis of biogas producing biomass
- Anaerobic cultivation of methanogenic archaea producing biogas
- Culture collection of methane producing microorganisms
- Biomethane potential testing expertise and equipment
- Expertise in feedstock pretreatment for anaerobic digestion
- Expertise in electron shuttle-based biogas enhancement

Our Collaborators

- Biogas Energy
- Earthpower
- ONGC India

More Information

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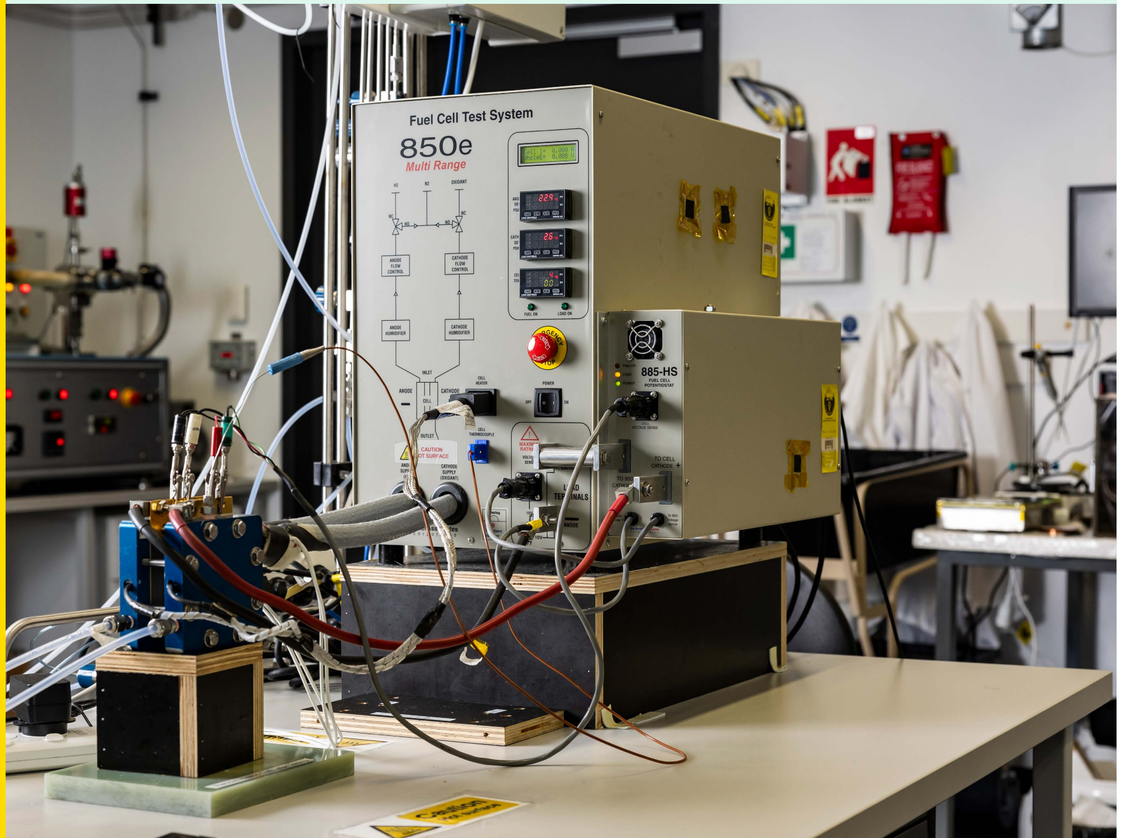
Hydrogen Fuel Cells

Hydrogen fuel cells consume hydrogen and air to produce electricity and water, which are the cornerstone for a greener and more sustainable future. The key issue in achieving large-scale commercialisation of this technology is cost reduction.



Competitive Advantage

- Zero CO2 emission technology
- In-house expertise across all scientific and engineering requirements to design and test a stack
- Low-cost, earth-abundant non-precious metal electrodes

Impact

- Accelerating the commercialisation of low-cost hydrogen fuel cells
- Enhancing the performance of hydrogen fuel cells improves durability and efficiency

Successful Applications

- Combining novel electrodes and membranes in hydrogen fuel cells
- Assessing the electrochemical performance of novel catalysts in electrochemical devices

Capabilities and Facilities

- Expertise in fuel cell catalyst development and diagnostic techniques
- Hydrogen laboratory
- In-house, custom-made manufacturing of membrane electrode assembly
- Testing of hydrogen fuel cells with several commercial fuel cell testers
- In-situ and operando testing capabilities

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Materials for Clean Fuel Generation Using Solar Energy

Design and development of novel semiconducting materials systems for efficient, direct conversion of solar energy to chemical fuels, which allows solar energy to be stored and transported for on-demand use.

Competitive Advantage

- The research team specialises in using computational analysis and materials design to accelerate material discovery and deepen fundamental understanding. By collaborating with experimental researchers and integrating this computational analysis with multidisciplinary expertise across materials fabrication techniques, advanced characterisation and device testing, a holistic approach covering all stages from design to testing can be achieved.

Impact

- New materials that can absorb energy from sunlight and convert it to energy stored in chemical fuels
- Atomic-level understanding (derived from computational studies) of the light absorption and surface catalytic properties of novel materials

Successful Applications

- Prediction and confirmation of a new materials system with photoactivity extending to longer wavelengths than most existing materials
- Provision of evidence that explains the underlying mechanism and experimental results support for a range of catalyst systems

Capabilities and Facilities

- High-performance computing capabilities
- Expertise in applying computational materials science to accelerate the development of new materials and understand materials performance across a range of energy applications – including photocatalysis, photoelectrochemistry, and catalysis, as well as photovoltaics and batteries

More Information

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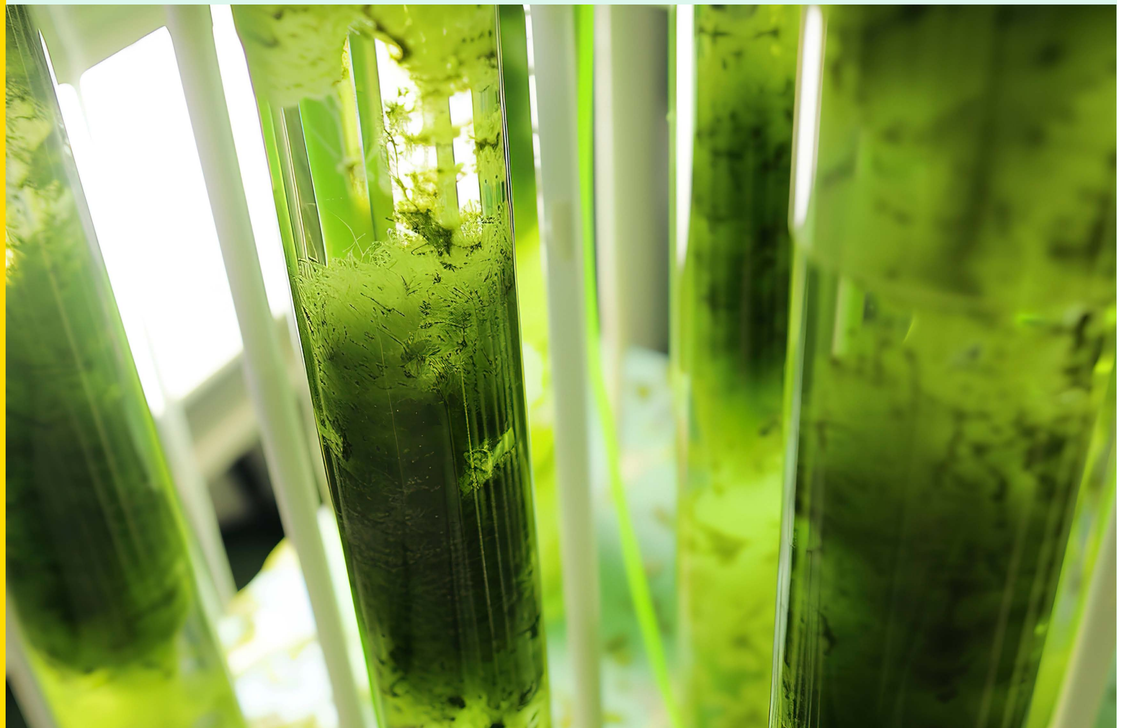
Net-Negative CO2 and Methane Producing Bioreactor

A bioreactor that uses sunlight and CO2 dissolved in seawater to simultaneously generate methane from the decomposition of algae and sequester CO2 in the coccoliths of growing algaesynthesis reactor to produce ammonia at lower cost than via the traditional Haber-Bosch process.



Competitive Advantage

- CO2 dissolved in seawater is at 20 times the concentration atmospheric CO2. Algae growing in seawater use sunlight and this CO2 to produce energy rich lipids and calcium carbonate rich coccolith skeletons. The bioreactor provides the appropriate conditions for good algae growth in an aerobic environment on its surface and at the base of the reactor, the right condition for anaerobic archaea to breakdown the algal lipids to produce methane that is removed as a fuel. The remaining coccoliths are removed in a batch process and stored as sequestration of CO2 (the precursors of limestone). The bioreactor provides methane as a renewable fuel, and bequests CO2 as calcium carbonate or limestone.
- A bespoke bioreactor
- Expertise to leverage existing technology in a combined approach to achieve net-negative CO2 production, and produce a renewable energy source (methane) from solar energy

Impact

- Renewable fuel production
- CO2 capture to reduce atmospheric concentration of greenhouse gases

Successful Applications

- Design and commissioning of a bespoke bioreactor for net-negative CO2 and algal methane production
- Proven methane generation from methanogenic archaea decomposing algae and of CO2 incorporation in algal coccoliths

Capabilities and Facilities

- Lab facilities for biogas experiments
- A bioreactor for algal growth and methanogenic archaea decomposition

More Information

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Nuclear Energy

Developing nuclear materials and nuclear engineering systems for carbon-free energy generation that is economical, reliable, dispatchable and integrated with renewable sources.

Competitive Advantage

- Expertise in nuclear fuels research
- Established partnerships with international industry bodies and government agencies

Impact

- Qualification of advanced nuclear fuels
- Integration of small modular reactors in grids with a high penetration of renewable generation, through increased load-following capability
- Power sources for deep space missions
- Reduced waste volume and fuel cost of fission reactors

Successful Applications

- Composition of advanced nuclear fuels with slower oxidation in off-normal reactor operating conditions
- Low-corrosion Zr-Sb alloys for nuclear fuel cladding, developed with Westinghouse Electric
- The highest melting-point refractory high-entropy alloy, containing chromium for oxidation protection
- Nuclear engineering of components and systems in the OPAL reactor
- Block-chain solution to nuclear materials safeguards – SLUMBAT/SLAFKA
- In-reactor irradiation of nuclear materials, in conjunction with Rolls-Royce and Imperial College London

Capabilities and Facilities

- UNSW radioactive material research facilities
- Corrosion testing with in-situ neutron characterisation
- Discretionary access to Australian nuclear infrastructure
- Materials modelling capability and grid simulators
- Experience in accessing international facilities with successfully demonstrated outcomes

Our Collaborators

- Westinghouse Electric
- Australian Nuclear Science and Technology Organisation (ANSTO)
- Los Alamos National Laboratory
- Stimson Center
- Radiation and Nuclear Safety Authority (STUK)
- Australian Safeguards and Non-Proliferation Office (ASNO)
- International industry consortia (MUZIC, PACE, MIDAS, CARAT)

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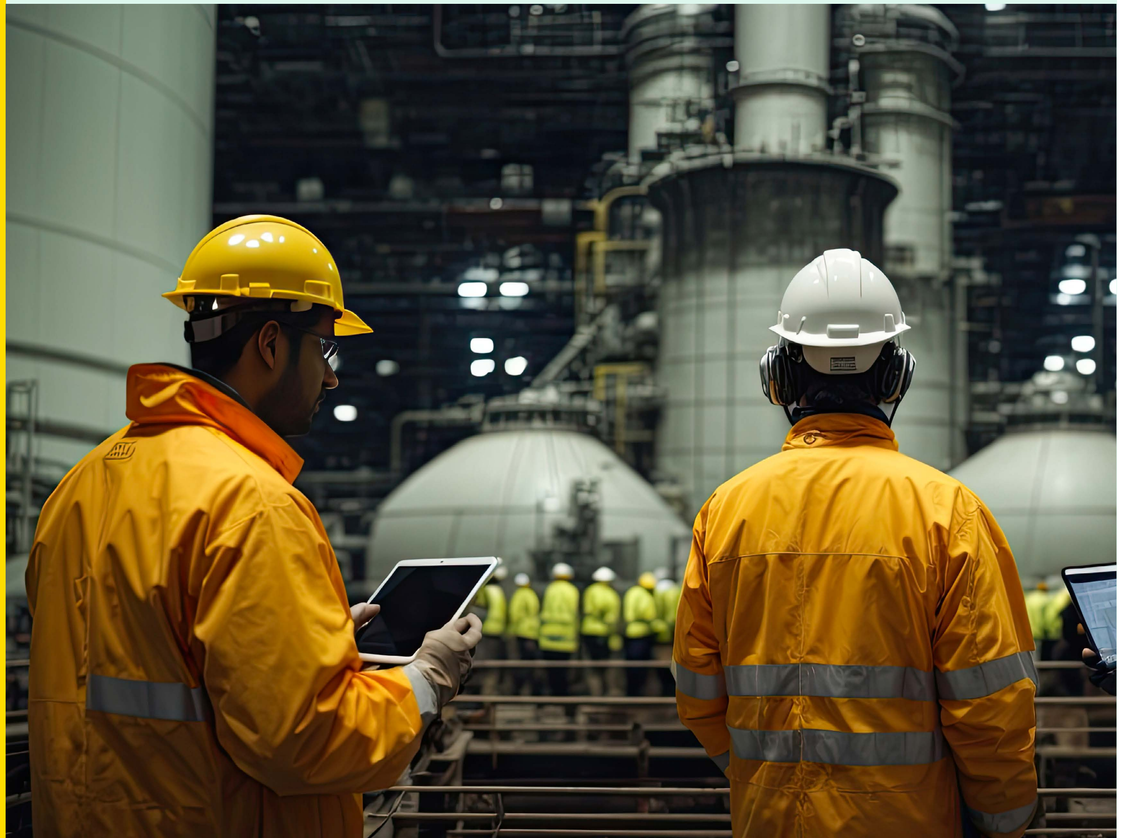
Nuclear Engineering

Nuclear energy is a scalable low carbon energy source that is available on demand. The researchers team focus on nuclear fuel, nuclear reactor structural materials, and nuclear waste technology.



Competitive Advantage

- Integration of materials modelling
- Access to nuclear material test facilities

Impact

- Accident-tolerant nuclear fuels and new technologies for nuclear safeguards
- Improving the efficiency and safety of the nuclear materials supply chain

Our Collaborators

- Australian Nuclear Science and Technology Organisation (ANSTO)
- Westinghouse
- Los Alamos National Laboratory
- KTH Royal Institute of Technology
- Imperial College London

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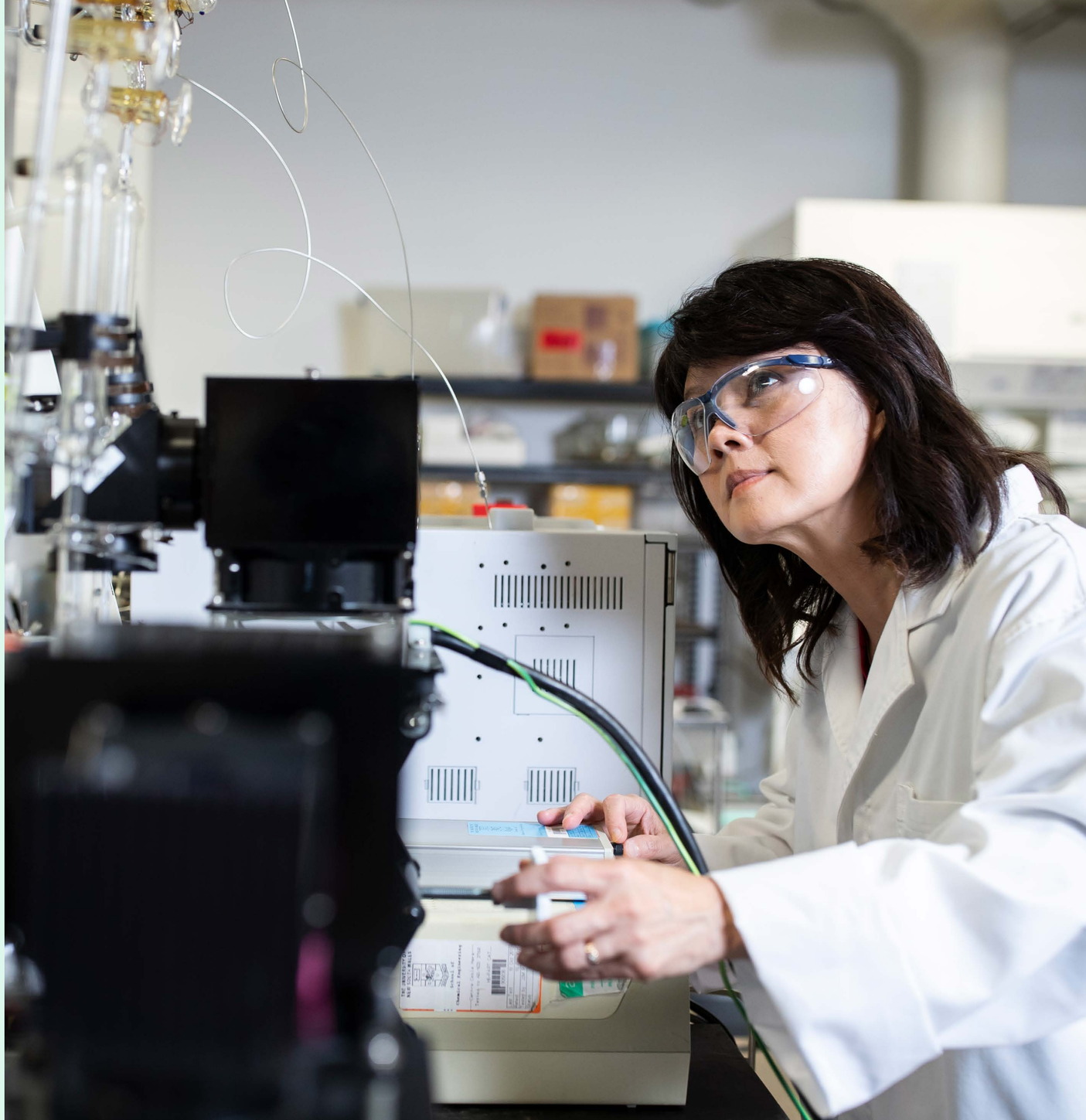
Photoelectrocatalytic Systems for Energy Conversion

Particle and Catalysis Research Group (PartCat) lead the development of photoelectrocatalytic systems for a range of energy conversion reactions including CO2 reduction into (oxy)hydrocarbons and urea, hydrogen production, hydrogen peroxide production, and biomass conversion. PartCat focus on nanoscale material design, scale-up engineering, membrane electrode assembly design, and implementation of demonstration scale electrolyser systems.



Competitive Advantage

- Fully-equipped laboratory and research experts in catalyst and reactor design
- Nanoscale design and scale-up of electrocatalytic materials and integration into demonstration-scale (1.5 kW) electrolyser systems
- Expertise in electrocatalytic energy conversion reactions including CO2 reduction, hydrogen production, biomass reforming, and hydrogen peroxide production
- Combined expertise from photocatalysis and electrocatalysis, to the design of photoelectrocatalytic systems

Impact

- Using the electrolyser systems and nanoscale catalyst design, PartCat have demonstrated:
- efficient syngas, liquid hydrocarbon, and urea production using waste CO3 and NO3- streams
- hydrogen production competitive with the highest reported production rates at minimal electrical energy input
- decentralised hydrogen peroxide production using renewable energy inputs
- biomass conversion reactions that enable the production of value-added organic products
- Development of photoelectrocatalytic electrolyser systems that enable direct harnessing of solar energy and hydrogen production with solar-to-hydrogen efficiency of >20% for a 1 kW pilot system

Successful Applications

- Onsite industry project on highly efficient and low-cost photovoltaic-electrolysis system to generate hydrogen
- CO2 and NO3- conversion to carbon monoxide, syngas, formic acid, and urea with current densities up to 500 mA cm-2 as well as other liquid products
- Onsite production of hydrogen peroxide solutions with a wide range of concentrations (~0.05 wt% to 5 wt%) using water and air inputs
- A stand-alone system incorporating solar-thermal and photovoltaic-powered electrocatalytic technologies to generate renewable hydrogen and FDCA (a platform chemical) from waste biomass

Capabilities and Facilities

- Nanoparticle synthesis and characterisation techniques
- Electrolyser systems for electrode testing (from 3-electrode cells to 1.5 kW system) with light enhancement capabilities
- Prototype system capable of generating ~100L renewable H2/day and >80% clean water reclamation from 25 L/day of waste sugar-containing feedstock (~5 g/L initial sugar concentration)
- Demonstration-scale reactor electrolyser system (1.5 kW 10-stack system)
- Product detection capabilities (NMR, GC/MS, UV-Vis) and a range of electrocatalytic reactions

Our Collaborators

- RayGen Resources
- Shenzhen Shengshi Liye Industrial Development Co. Ltd

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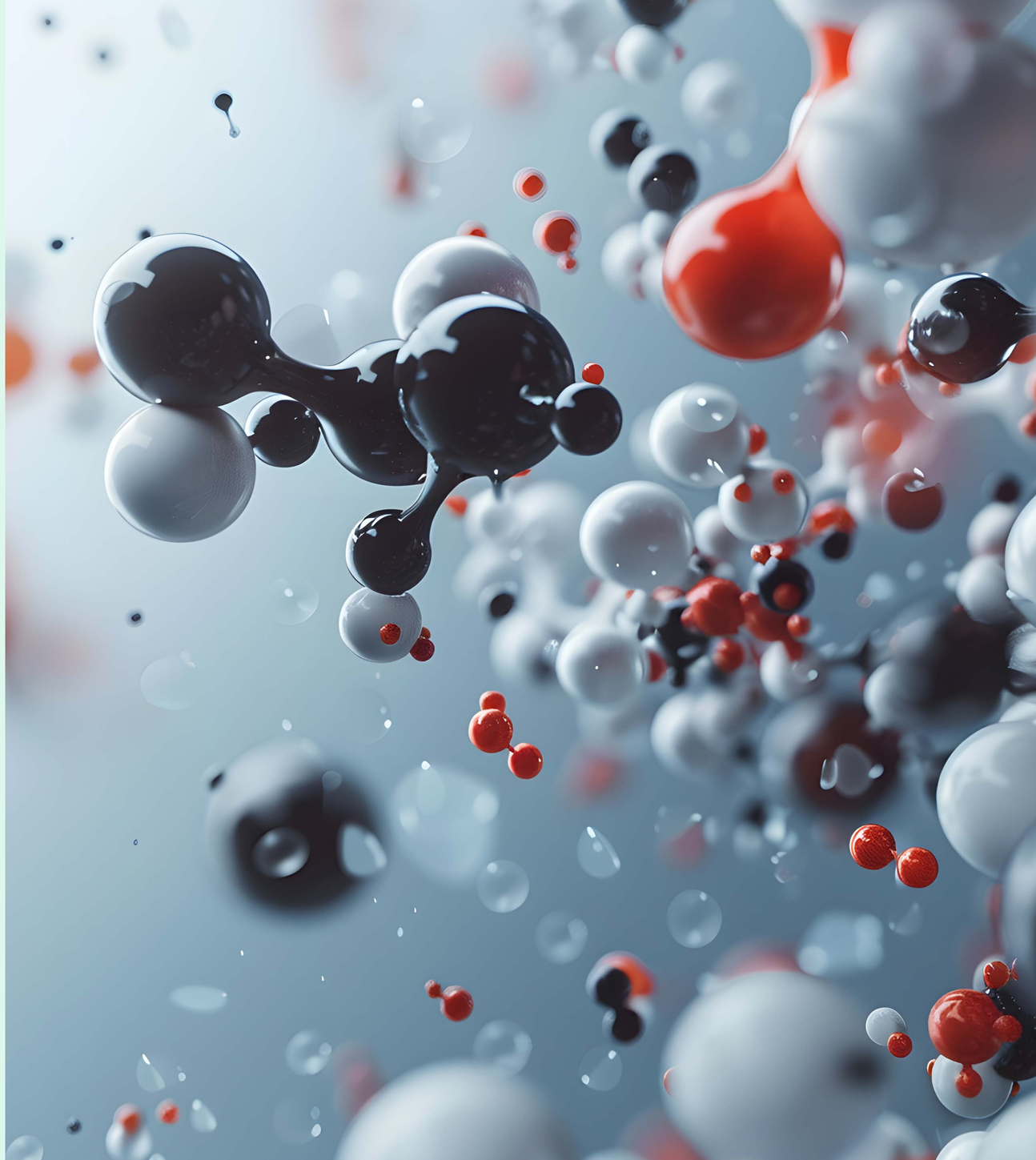
Plasma-Enhanced Catalytic Reactions

To improve the energy efficiency of catalytic energy conversion reactions, Particle and Catalysis Research Group (PartCat) have developed expertise in plasma integration in electrochemical ammonia production and thermal CO2 methanation. Through integration of plasma, the reaction catalytic intermediates are altered, changing the overall reaction pathway, therefore reducing the required energy inputs to generate sustainable energy carriers.



Competitive Advantage

- PartCat combines expertise in nanoscale catalyst synthesis, reaction process design, and plasma technology for two key reactions – ammonia production and CO2 conversion
- Ammonia production – utilisation of non-thermal plasma can generate NO3-, which is then electrocatalytically reduced to ammonia, a novel pathway for ammonia production only utilising water, air, and electricity
- CO2 methanation – utilisation of non-thermal plasma can enhance the dissociation of CO2 into reaction intermediates, which are then reduced to methane at lower temperatures compared to conventional thermal catalysis

Impact

- Ammonia production can occur without the energy intensive Haber-Bosch process, while utilising renewable energy inputs, where the ammonia produced can be used as a hydrogen carrier, chemical feedstock, or directly as a fertiliser
- Conversion of waste CO2 (e.g., contained in flue gas) into methane can be used as a carbon up-cycling process, which can occur at lower temperatures due to the incorporation of plasma

Successful Applications

- Ammonia production utilising hybrid-plasma-electrolyser technology uses a low pressure (~10 bar) operation, and could reduce the energy input by >25% and carbon footprint by >90% compared with the conventional Haber–Bosch process
- ammonia yields can be increased by ~3,000 times when compared to the highest yields obtained by electrochemical nitrogen reduction
- CO2 methanation with an integrated plasma resulted in a CO2 conversion of 60% with a CH4 selectivity of >97% at 150°C, compared to a required temperature of 320 - 330°C in conventional thermal catalysis

Capabilities and Facilities

- A range of non-thermal plasma generating devices to generate plasma, including dielectric barrier discharge plasma
- Custom-designed electrochemical and thermal catalytic reactors that integrate plasma
- Nanoparticle synthesis and characterisation techniques
- Product detection capabilities (NMR, GC/MS, UV-Vis) and a wide range of electrocatalytic reactions

Our Collaborators

- PlasmaLeap technologies
- CSIRO

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Thermal Catalytic Energy Conversion and Waste Treatment Reactions

Particle and Catalysis Research Group (PartCat) have developed a wide range of capabilities in thermal catalysis ranging from carbon dioxide conversion into methane and methanol, dry reforming of methane and Fischer-Tropsch synthesis, to carbon monoxide oxidation and waste pyrolysis. PartCat combines expertise in photocatalysis to develop photothermal systems with enhanced product selectivity and reduced operating temperatures.

Competitive Advantage

- Amongst the highest reported catalytic rates for CO2 conversion into methanol or methane
- Thermal systems can be integrated with photothermal technology to alter reaction selectivity and improve conversion
- Direct harnessing of solar energy can be used as the main energy input for CO2 conversion reactions

Impact

- Enabling technology for CO2 conversion into value-added chemicals to support industry decarbonisation
- conversion of waste CO2 (e.g., from flue gas) into value-added chemicals and fuels such as methane and methanol, as well as longer chain hydrocarbons through Fischer-Tropsch synthesis
- Treatment of carbon monoxide (CO) and other polymer waste products associated with solar panels
- CO2 capture and storage in hydrocarbon form
- Reduced energy input for CO2 conversion reactions by utilising solar energy to provide heating and catalyst activation

Successful Applications

- Demonstration scale integrated photo-thermal CO2 reduction system producing methane at a rate of up to 30 L/hour (SHINE 2.0 system)
- Multiple lab-scale reactor systems enabling light integration for high-rate methane and methanol production, Fischer-Tropsch synthesis, carbon monoxide oxidation, waste plastic pyrolysis/ gasification, and methane reforming

Capabilities and Facilities

- Pressurised reactor and product detection systems for CO2 reduction into methane, CO, and methanol
- Photothermal reactor systems for integrating light into traditional thermal catalytic systems
- Nanoparticle synthesis and characterisation facilities
- Prototype-scale reactor array for scaled-up performance testing

Our Collaborators

- CSIRO Energy

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Waste Biomass to Renewable Hydrogen

The production of renewable hydrogen from pre-conditioned biomass is an important source of energy, and a key component of Australia's future hydrogen generation and export. It is an economically viable and environmentally conscious energy solution with net zero carbon dioxide (CO_2) emissions.

Competitive Advantage

- Pre-conditioned biomass (from raw biomass stream) can be obtained at a very low cost
- Electrocatalytic hydrogen extraction from pre-conditioned biomass is generally easier than water electrolysis
- It is selective, delivers net zero CO_2 emissions, and can produce value-added organic products

Impact

- Competitive energy production by utilising waste to produce renewable hydrogen
- Alleviate global warming via carbon footprint reduction
- Improved resource recovery and utilisation of new materials

Successful Applications

- A zero-emission tandem array for transforming biomass into renewable hydrogen

Capabilities and Facilities

- Access to technical expertise and facilities that are dedicated to sustainable technology development

More Information

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Hydrogen Production from Water Electrolysis

Hydrogen is regarded as the fuel of the future as it possesses the highest mass-energy density of any fuel. Hydrogen production from electrochemical water electrolysis is considered as the simplest and cleanest approach to producing highly pure H2.

Competitive Advantage

- High-efficiency and low-energy consumption in the production of hydrogen
- Free-standing, low-cost transition-metal-based catalyst electrodes
- Innovative and environmentally-friendly, highly integrated water electrolyser design suitable for installation and reassembly
- Easy to integrate with renewable electricity from solar and wind

Impact

- High-profile research and development that has received international recognition
- New generation electrodes greatly reduce water electrolysis energy consumption
- Accelerated commercialisation of hydrogen technologies

Successful Applications

- Research utilised by regulators around the world
- Locally, the team has worked with the ACCC, ACMA, ASIC and the Treasury at a Federal level, as well as many NSW agencies
- Globally, the team has worked with regional regulators, including Cambodia, China, Laos, Malaysia, Thailand, Singapore and New Zealand

Capabilities and Facilities

- Industrial application of electrodes for highly-efficient, large-scale hydrogen production
- Advanced flow water electrolyser cell to produce hydrogen

Capabilities and Facilities

- Expertise in design and fabrication of binder-free 3D water electrolysis electrodes with desirable structures and functions
- In-operando spectroscopy techniques for understanding mechanisms
- Laboratory and industrial facilities for electrode fabrication, characterisation, and real-time durability testing in harsh conditions

More Information

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Power-to-X (P2X) Techno-Economic Analysis

Particle and Catalysis Research Group (PartCat) and ARC Training Centre for the Global Hydrogen Economy researchers have developed expertise in techno-economic analysis. Researchers have created a series of open-source costing tools and road mapping frameworks, applied to various industry and government projects for exploring and evaluating viability of hydrogen and Power-to-X (P2X) projects in Australia and Asia-Pacific.

Competitive Advantage

- Open-source techno-economic tools developed in collaboration with industry partners and government agencies
- Established set of costing tools and roadmap frameworks that can be applied to a variety of sustainable energy technologies across the P2X value chain
- Previous economic analyses have been applied to hydrogen hubs, hydrogen production and transportation, ammonia production and transportation, hydrogen refuelling networks

Impact

- Techno-economic analysis enables governments to allocate resources efficiently to facilitate net zero goals
- Investors/investment managers can use the analyses to evaluate the unit economics of projects and corporations
- The private sector can use the techno-economic analysis to map pathways to net zero and support informed investment decisions
- Applied researchers can use techno-economic analysis to guide research efforts towards implementation bottlenecks

Successful Applications

- Development of the Powerfuel Value Chain Tool for NSW Government
- Pacific Regional Hydrogen Strategy with International Renewable Energy Agency and Pacific Community
- Feasibility Study of Hydrogen Decentralised System in Indonesia (Hasnur Group)
- Pre-FEED for Remote P2X Microhub for NSW Government
- State of Play: The Case for an Australian Hydrogen Value Chain to Germany (DFAT and DISER)
- NSW P2X Pre-feasibility Study (NSW OCSE)
- Assessment of CCUS in developing blue ammonia value chain from Indonesia to Japan
- Mapping of the hydrogen refuelling network in Australia's eastern states

Capabilities and Facilities

- Economic analysis, costing tools, roadmaps, cash flow modelling, and project finance
- Open-source hydrogen cost tool, including HySupply Cost Analysis Tool (farm gate costing tool), Shipping Cost Analysis Tool, and Green Ammonia Tool

Our Collaborators

- Siemens
- CSIRO
- Department of Climate Change, Energy, the Environment and Water
- Office of the NSW Chief Scientist & Engineer (OCSE)
- Department of Regional NSW
- Department of Industry, Science and Resources (DISER)
- Department of Foreign Affairs and Trade (DFAT)
- Arup
- GHD
- Hasnur Group
- ATCO
- Iberdrola
- H2UTM
- Origin Energy
- Macquarie Bank
- FPCU
- GPA Engineering
- MAN Energy
- Deloitte
- WSP

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Storage Technologies

UNSW is striving towards 1,000 GWh of beneficial energy storage in Australia by 2050. We believe this level of storage will underpin a healthy society by promoting a resilient and sustainable energy system. Resilience means providing electrical energy more reliably, by accommodating variable generators and unplanned damage to grid infrastructure. Sustainable means a system that requires less or cleaner materials and promotes resource stewardship.

UNSW holds world class expertise and facilities in Vanadium Redox Flow Batteries, which were invented by UNSW Emeritus Professor Maria Skyllas Kazacos and co-workers in 1985. Flow batteries are likely to be the most commercially viable technology for long-term energy storage in Australia. The technology is proven and is ready to scale. We need to build a 10-20 MWh demonstration plant, coupled with a neighbouring research facility. With this in place, we will be on track able to deliver a suite of 110 GWh plants by 2030 that can support our major cities, future industry and regional and remote communities.

Advanced Battery Management Systems

Battery Management Systems (BMS) are critical components in a wide range of applications, including electric vehicles and renewable energy storage systems. Their primary role is to monitor and manage operational parameters of the battery, such as its state of charge, state of health, current, voltage and temperature. These preserve battery longevity, optimise its performance, and prevent damage or safety hazards like overcharging or deep discharging. A well-implemented BMS can improve energy efficiency by regulating the charging and discharging processes, subsequently maximising the usable capacity of the battery.

Competitive Advantage

- A range of technologies from low-cost cell balancing technologies to complex management systems that utilise ultra-low power IoT/wireless technologies – simplify the collection of cell parameters and control the cell charge (e.g., using novel DC-DC converter technologies)
- A high-power density DC-DC converter technology that decreases the size and volume of the battery management system
- An IoT/wireless interface that decreases the complexity of the system, improving reliability and security
- Ability to provide lab-scale development with interface capability up to 50 kVA

Impact

- Development of advanced BMS technologies that improve safety, reliability and lifetime, while ensuring cell performance at optimum levels

Successful Applications

- Solar car battery management systems
- Pipeline pigging applications
- BMS systems for traction drives
- Prototypes of active and passive balancing systems for various battery chemistries
- Distributed cooperative balancing system for reconfigurable battery systems
- Modular multilevel battery storage system with second order harmonic current reduction
- Direct AC linked hybrid (battery/ultracapacitor) energy storage system with second order harmonic current reduction
- Temperature monitoring system for ultracapacitor strings using a limited number of temperature sensors

Capabilities and Facilities

- Hardware-in-loop simulation for rapid assessment of control techniques
- Hardware testing capability up to 50kVA, 1kV, 400A
- Arbin Instruments battery tester, Cadex C8000 battery testing system with a load capture unit, Hioki battery simulator, GAMRY Model REF3000 potentiostat, LiBa WorkStation, TempEvent temperature chamber with the EUCAR 5 level capability
- Prototypes of active and passive balancers, hybrid (battery/ultracapacitor) energy storage system, and reconfigurable power converter

Our Collaborators

- RST Projects
- Taipei Locomotives
- BenAn Energy
- Dovetail Electric Aviation
- Dante Aeronautical
- LAVO/Providence
- Master Instruments

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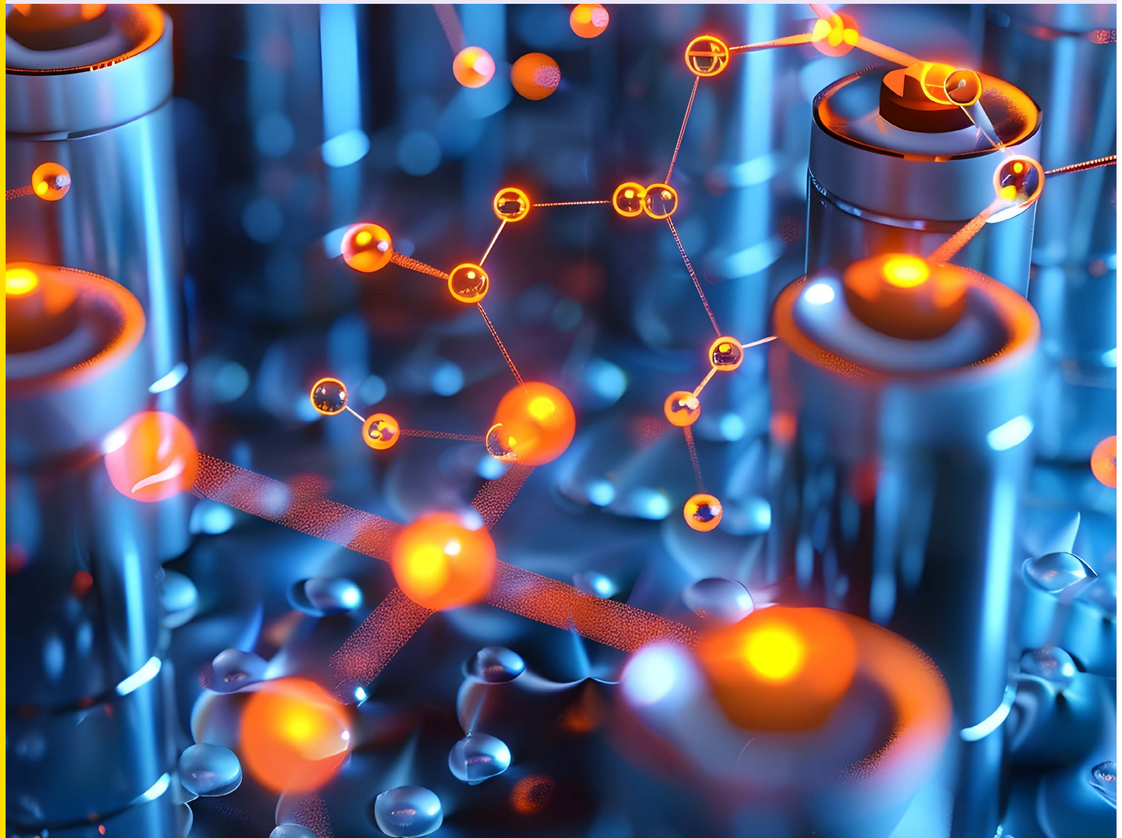
Advanced electrolytes for lithium-ion batteries

Lithium-ion batteries are currently the leading energy storage chemistry for electric vehicles and grid-scale storage. New electrolyte solutions with enhanced stability are required to enable next-generation batteries with high-energy, lower cost, and improved sustainability.



Competitive Advantage

- Experience in understanding degradation in full cells and developing rational strategies to mitigate the issues
- Expertise in electrolyte development with tailored functionality

Impact

- Novel electrolyte solutions for the development of advanced battery chemistry
- Innovative electrolyte as ‘drop-in’ enabler for cell manufacturing

Successful Applications

- New electrolytes with enhanced stability and improved performance

Capabilities and Facilities

- Materials synthesis and characterisation using a full suite of analytical techniques
- Battery cycling and electrochemical testing

More Information

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Advanced Energy Storage Materials

Lithium-ion battery technology has undergone remarkable transformation, finding utility across a broad spectrum of applications, from portable electronic devices to electric vehicles. The development of energy storage solutions for renewable resources will assume growing significance in the future.

Competitive Advantage

- A unique interdisciplinary background with valuable research experience in battery engineering and synthetic chemistry, which facilitates an approach to energy storage systems from multiple perspectives
- A strong foundation in materials science with extensive experience in the exploration of design and fabrication of lithium metal anode and anode-free rechargeable batteries

Impact

- New and novel battery technologies for better and more efficient energy storage

Successful Applications

- Developed specifically tailored graphene quantum dots and implemented in lithium metal batteries, enabling a greater leap in energy density
- Bottom-up synthesis of redox-active compounds and fundamental understanding of the reaction mechanism in rechargeable batteries
- Pioneering work to demonstrate rechargeable aluminium-ion batteries using a redox-active organic compound as the active material

Capabilities and Facilities

- Synthetic organic chemistry laboratory setup
- Advanced electrochemical and battery analysis equipment

More Information

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Advanced Monitoring and Control Strategies for Industrial-Scale Energy Storage Systems in Demand-Side Power Management

Developments of advanced monitoring and control systems for energy storage systems including the vanadium redox flow batteries (VFB). The technologies are developed to maximise the performance, efficiency and longevity of the batteries systems. The expertise extends across energy systems to maximise renewable energy power plant performance to improve electricity quality and demand and supply.

Competitive Advantage

- Novel scalable distributed control approach (using advanced control theory integrated with advanced flow battery designs) to control and coordinate distributed energy storage systems and load management for enhanced reliability and flexibility
- An integrated approach to the design and control of flow batteries based on the dynamic mechanisms of the electrochemical reactions to achieve optimal efficiency and flexibility of battery operation
- Advanced monitoring systems to monitor the state of charge, flow channel blockage, capacity loss monitoring and imbalance of electrolyte, with online fault detection techniques based on dynamic battery models
- Advanced battery management and control systems to operate batteries with improved efficiency and economy
- Use of flow batteries as a multi-functional energy storage system for voltage stability and power quality improvement without complementary energy storage devices to reduce system costs and improve reliability
- Technologies for virtual energy storage and industrial scale demand side power management – power modulation of aluminium smelters, including advanced smelting cell monitoring and thermal control of aluminium smelters under flexible production rate and power consumption

Impact

- Significant improvements in flow battery systems
- Greater flexibility in battery operation for optimised charging and discharging with time-varying input/output power for integration with renewable power sources
- Improved voltage stability and power

Successful Applications

- Vanadium flow battery developed at UNSW now manufactured commercially
- Installation of a 200 MW/800 MWh VRB in Dalian, China

Capabilities and Facilities

- 30 kW/130 kWh commercial VRB system and battery stack for laboratory research
- Extensive state-of-the-art electrochemical and mechanical laboratories
- Climate-controlled chambers for evaluating effects of environmental parameters on energy storage system performance
- Programmable power source and bidirectional load

Our Collaborators

- North Harbour Clean Energy

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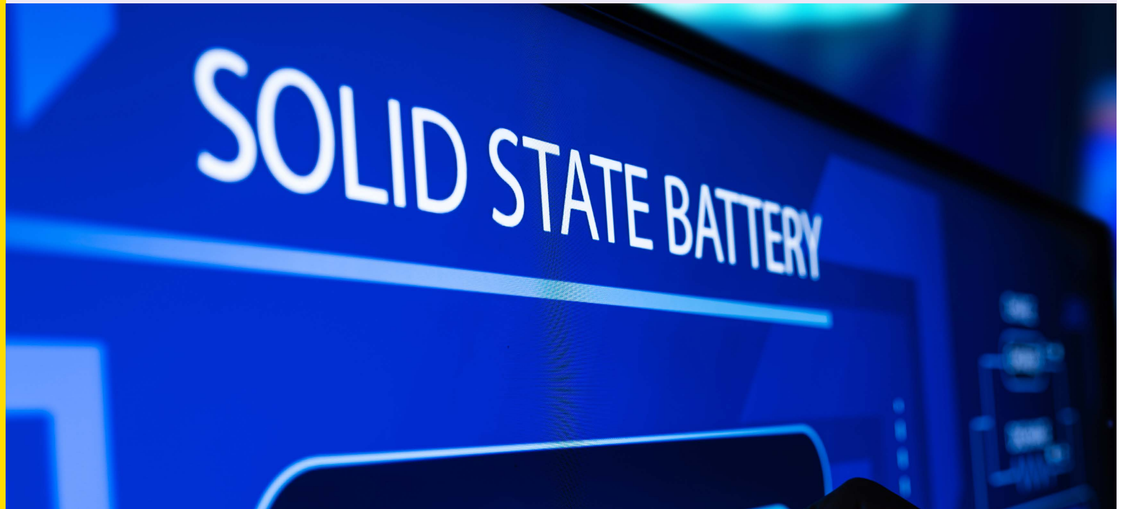
Development of All-Solid-State Lithium Batteries for High-Energy Applications

As the electric vehicle revolution gains pace, the demand for high-energy, safer batteries becomes paramount. The emergence of all-solid-state lithium batteries (ASSLB) with higher energy density, enhanced safety with reduced leakage and thermal risks, and potentially longer lifespan, has garnered attention from over 50 startups backed by major automakers. Aside from enabling energy-dense Li-metal anode, the competitive development of ASSLB technology hinges on achieving optimal cathode performance in terms of high capacity, rate capability, and durability at and beyond ambient temperatures.



Competitive Advantage

- Expertise in battery materials development
- Expertise in all-solid-state lithium battery (ASSLB) research – one of few research groups in Australia in this field
- Expertise in developing prototype devices for solid-state battery research
- Experience in beyond-lab-scale development of battery technologies

Impact

- Understanding and development of innovative materials solutions and strategies for the practical development of ASSLB technology

Successful Applications

- Developed surface-engineered conductive additives for enhanced and stable cathode performance, including at elevated temperatures, for ASSLB applications
- Developed rational fundamental understanding of cathode interface design for high-energy and durable cathode performance in ASSLB
- Invention disclosure filed with UNSW Knowledge Exchange for patent filing

Capabilities and Facilities

- Battery materials synthesis and cell-level battery performance evaluation
- Range of prototype devices for diverse electrochemical performance assessment
- A suite of characterisation tools for fundamental investigation and post-mortem analysis
- Translational development of battery chemistries

More Information

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Aqueous Zinc Battery Development for Stationary Storage

Aqueous zinc batteries are safe, environmentally benign, low-cost, and potentially fully recyclable, which are highly desired attributes of stationary storage systems for mass-scale implementation. Numerous novel solutions and approaches have been reported claiming to address zinc anode rechargeability concerns, and deliver exemplary cathode performance, however most are inaccurate under practically desirable cell parameters and cycling conditions. Some solutions sacrifice the core virtues like the technology's safety and affordability. The UNSW research team is striving to develop scalable solutions that can bridge the gap between lab-scale demonstration and commercial development, while upholding the critical benefits of the battery technology.

Competitive Advantage

- Expertise in fundamental electrochemical research, zinc metal anode development, and materials design
- Expertise in aqueous zinc battery research – one of the early developers of the technology
- Expertise in fundamental investigations toward understanding the origin of performance bottlenecks
- Experience in beyond-lab-scale development of aqueous zinc battery technologies

Impact

- Beyond-lab-scale development of the aqueous zinc battery technology
- Development of scalable solutions to prolong battery performance under practically viable conditions
- Materials development for stable high-energy aqueous zinc battery anode and cathode

Successful Applications

- Developed proprietary electrolyte formulation for stable cycling of the zinc anode in aqueous zinc batteries
- PCT applications filed
- Secured Australia's Economic Accelerator (AEA) seed grant for commercial development of the technology
- Developed a patented high-capacity cathode chemistry, leading to a startup in Canada (Salient Energy)

Capabilities and Facilities

- In-depth fundamental and applied electrochemical research
- Translational development of battery chemistries
- Range of prototype devices for diverse electrochemical performance assessment
- A suite of characterisation tools for fundamental investigation and post-mortem analysis

Our Collaborators

- RACE for 2030
- Australia's Economic Accelerator (AEA)

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Cryogenic Testing of Advanced Fibre Composite

Lightweight storage of liquid hydrogen is important for the sustainable energy and decarbonisation of heavy industries, such as electric aircraft, spacecraft, and ships. Existing carbon-fibre reinforced composites suffer matrix cracking that leads to leakage and lower strength. The UNSW team led by Scientia Professor Chun Wang has developed groundbreaking techniques that can eliminate matrix cracking in carbon fibre composites by toughening the polymer matrix at cryogenic temperatures using nano-fabrication technologies.

Competitive Advantage

- Lightweight and strong fibre composites that can safely operate at cryogenic temperatures without microcracking are urgently required to reduce the weight of future aerospace craft, launch vehicles, fuel storage, and other space missions. This need is being addressed with extensive expertise in:
- Nano-engineering of fibre reinforced composites to simultaneously improve mechanical, electrical and other functionalities, such as gas permeability
- Design and manufacturing of carbon fibre composites for extreme operating conditions, such as high mechanical stress and super cold temperatures
- Automated manufacturing processes, such as fibre placement and filament winding to reduce the cost of production

Impact

- Significant improvement of mechanical properties and permeation leakage in cryogenic tanks
- Lighter fibre-composite tanks for transporting and storing liquid hydrogen as a fuel source

Successful Applications

- Prototype development of carbon fibre composite tank for storing liquid hydrogen (Lockheed Martin)

Our Collaborators

- Omni Tanker
- Lockheed Martin Space

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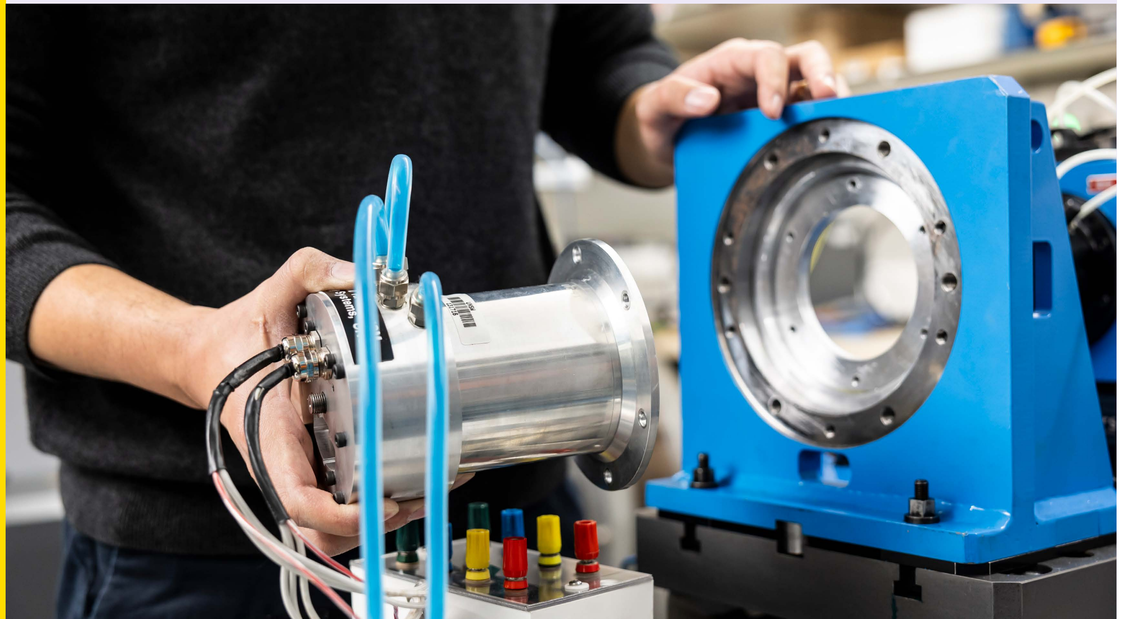
Design and Control of Permanent-Magnet Synchronous Machines for Flywheel-storage

Specialists in permanent magnet (PM) type electric machines and drive systems. Strong capabilities in designing and optimising high-speed PM machine geometries and developing advanced control techniques to further improve performance for emerging applications, such as flywheel storage.



Competitive Advantage

- Expertise in PM machine design and control
- Mechanical sensorless control for PM machine
- Expertise in designing very-high-speed PM machine drives suitable for applications, such as the flywheel storage
- Developing advanced on-line parameter identification techniques
- Advanced control techniques for the generator-side converters of Wind Energy Conversion
- Advanced techniques for on-line parameter identification with potential use in remote condition monitoring for offshore generators

Impact

- PM motor-generators with a rated speed in excess of 50,000 rpm
- Advanced control schemes and drivers for smooth energy conversion

Successful Applications

- Sensorless control techniques for PM motor drive
- Development of novel interior-type PM motors with speed capability >50,000 rpm
- Advanced control techniques for the direct-drive PM generators
- Patented fractional-slot concentrate wound PM machine technology
- Pending patent application—design optimisation package for PM machine

Capabilities and Facilities

- Finite-element packages, including Magsoft and ANSYS, with optimisation tools developed in-house
- Simulation platforms (Matlab–Simulink, PSIM), FPGA and DSP systems with high-performance signal acquisition, estimation and switch gate-drive interfaces
- Two and three-level inverters
- Several machine drive set-ups complete with shaft position sensors, torque sensors and highly dynamic loads
- Four-quadrant dynamometer for testing direct-drive wind generators
- High-speed (>50,000 rpm) PM machine test bed

Our Collaborators

- Conry Tech
- CSIRO
- Wisconsin Electric Machines and Power Electronics (WEMPEC)

More Information

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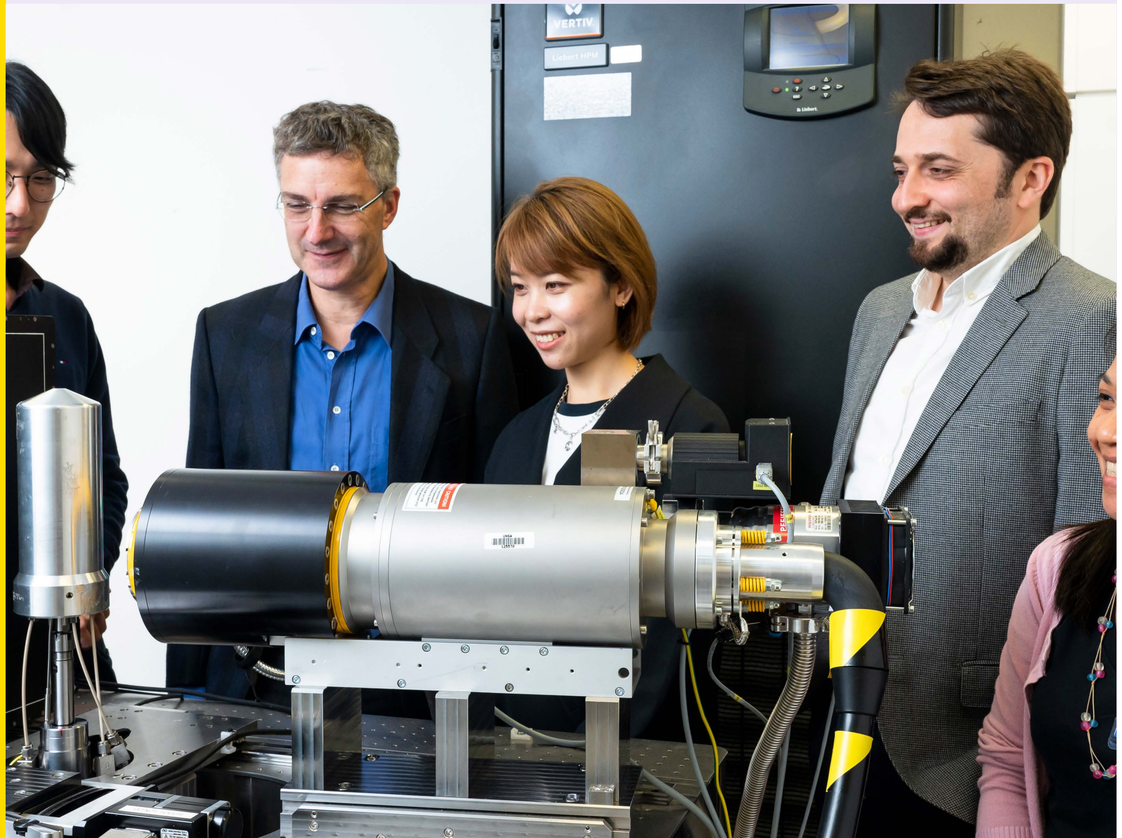
Digital Rock Physics and Characterisation

Porous media are a ubiquitous class of materials important in many industrial applications. The behaviour of such systems is controlled largely by their microstructure. Based on micro-computed X-ray tomography, digital rock physics delivers enhanced system analysis capabilities for heterogeneous material characterisation.



Competitive Advantage

- Morphological, topological and spatial analysis of porous materials
- Innovative, massively parallel physical property calculations (electrical conductivity, elastic properties, fluid flow, NMR responses) for complex porous micro-structures
- Embedded classification structures for upscaling of physical properties
- Ability to integrate experiment and simulation

Impact

- Digital Rock Physics (DRP) is a key technology to uncover the mechanisms controlling reservoir performance at the pore scale
- Regional classification and characterisation of microstructural features allows the integration of these measures into industry workflows to optimise the long-term geostorage of CO2 or seasonal storage of hydrogen

Successful Applications

- Technology commercialised through spin-off company Digital Core, which merged with Numerical Rocks AS to form Lithicon – In 2014, Lithicon was acquired by FEI for A$76 million (now part of ThermoFisher)
- Morphy installation at several Fortune 500 companies

Capabilities and Facilities

- Tyree X-ray micro-CT facility
- High-pressure, high-temperature NMR low-field laboratory
- ‘Morphy’ – MPI parallel Morphology and Petrophysical Software Suite – implementation on National Computing Infrastructure gadi (NCI)

Our Collaborators

- BP
- OMV
- Petrobras
- PETRONAS
- Saudi Aramco
- Shell
- Total
- Wintershall

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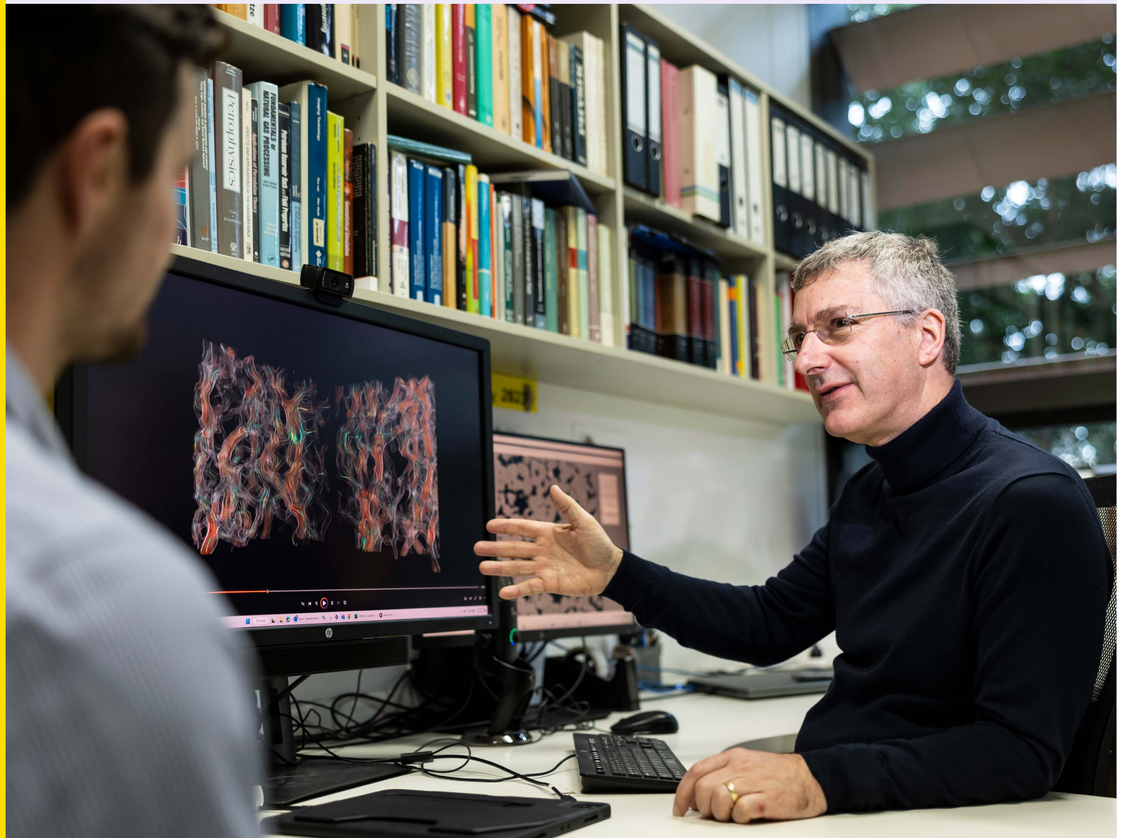
Direct Porous Media Flow Simulations

Innovations in fluid dynamic simulators that utilise porous media images to design, test and study the flow of fluids through porous media, on which various energy resources and storage technologies are dependent.



Competitive Advantage

- A team experienced in running the world's largest direct 3D simulations of fluid flow in porous media
- Innovative imaging technology allows the explicit definition of the wetting nature of porous systems that are important for transport of immiscible phases
- Coupling of imaging technologies with flow simulations that provide unprecedented information for the design of porous systems and/or recovery of resources from porous rocks
- Representative models that are unmatched by computational power and efficiency

Impact

- Multiscale reservoir models for the recovery of natural gas or mineralogical resources
- Optimisation of porous systems for the design of structures that provide efficient transport
- Innovations that facilitate the design and optimisation of a broad range of porous media technologies, including fuel cells, natural gas reservoirs, and in-situ mineral recovery, packed-bed reactors and membranes

Successful Applications

- Validation and comparison studies against large simulations conducted on the world's largest super computers
- Testing on sandstone and carbonate reservoir rocks and validation with experimental studies

Capabilities and Facilities

- Access to advanced computational facilities for large simulations on representative rock and porous systems
- Development of workflows for permeability and relative permeability simulations
- Advanced wettability characterisation of surface properties for multiphase flow simulation

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Electrically Conductive Nanocomposite Films

An industrially scalable method has been developed for synthesising polymer nanoparticles decorated with graphene oxide sheets via miniemulsion polymerisation. This enables preparation of electrically-conductive films using a simple method at ambient temperature. The resulting nanocomposite films exhibit high electrical conductivity and have a wide range of potential applications as conductive coatings.

Competitive Advantage

- Technology represents the first example of an approach for synthesis of electrically-conductive graphene/polymer films that form at ambient temperature
- Environmentally-friendly process
- Amenable to industrial-scale applications

Impact

- Potential for advanced coatings, sensors and nanomedicines

Capabilities and Facilities

- Synthesis of polymer/graphene thin films with specified level of electrical conductivity
- Synthesis of hybrid polymer/graphene nanoparticles as hybrid materials
- Synthesis of polymer nanoparticles of various size, shape and internal morphology

More Information

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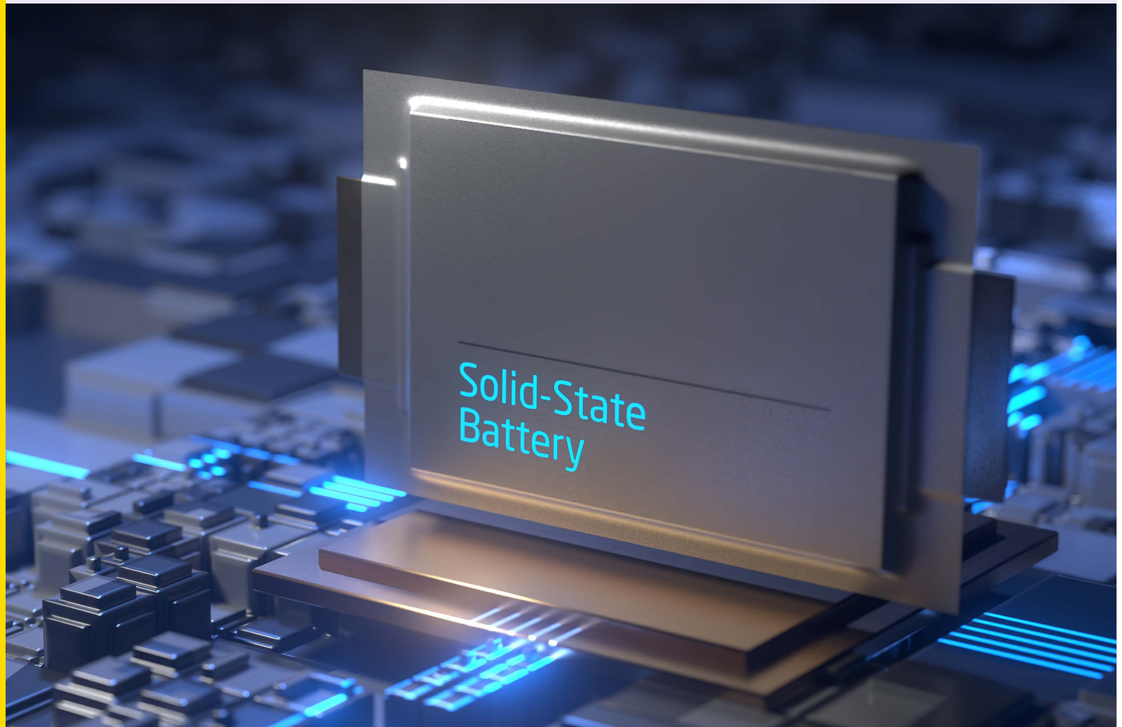
Electrolytes and Thin Films for Solid State Batteries

Battery safety is a key challenge, as is the practical implementation of batteries over a wide range of temperatures without additional heating or cooling. Solid-state batteries overcome these challenges by providing inherently safe batteries that are stable over applicable temperature ranges.



Competitive Advantage

- Expertise in materials development
- Analysis of conductivity and diffusion at bulk and atomic scales
- Spectroscopic and crystallographic methods for characterising materials
- Working towards the development of all-solid-state thin film batteries

Impact

- Understanding the role of grains and grain boundaries on bulk diffusion
- Evaluating the type of atomic-scale diffusion
- Linking structure to local and long-range diffusion
- Using in situ methods to elucidate phase evolution

Successful Applications

- Developed a testing apparatus for the operando study of thin film batteries using synchrotron X-ray diffraction during operation
- Built and tested electrode-electrolyte combinations

Capabilities and Facilities

- Materials synthesis
- Pulsed laser deposition growth of specific electrodes
- Lithium deposition procedures and apparatus under evaluation
- Access to key analytical techniques, solid-state NMR, surface analysis and electron microscopy
- Surface characterisation with scanning probe microscopy methods
- Use of unconventional techniques, such as quasi-elastic and inelastic neutron scattering

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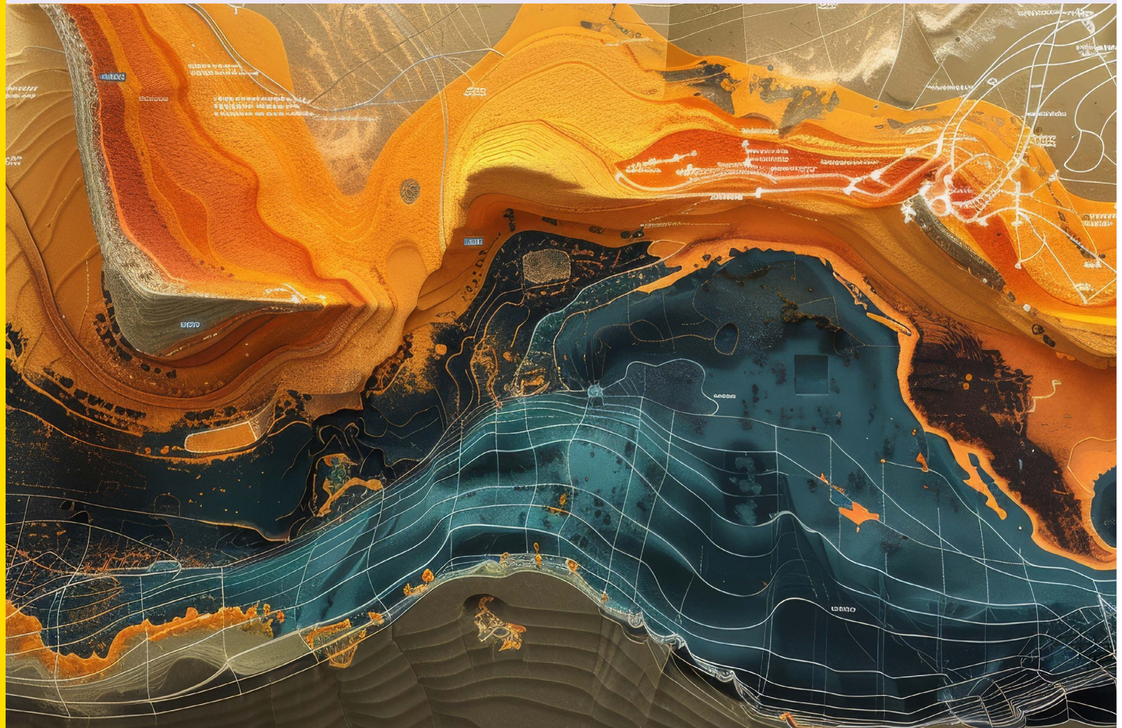
Energy and Mineral Exploration

Machine learning can help unlock the secrets contained in vast amounts of geoscientific data about the subsurface for resources extraction, civil and environmental engineering, and the application of emerging technologies, such as underground hydrogen storage and CO2 geosequestration.



Competitive Advantage

- Machine learning techniques can build subsurface models in minutes, rather than weeks
- Greater accuracy in analysis using all available data to create models
- Expertise in the optimisation of infrastructure placement

Impact

- Reduced expenses and environmental impact in the collection of data, extraction or storage of energy resources, and the placement of facilities and infrastructure
- More accurate mapping of subsurface geology
- Reducing the labour-intensity required in the interpretation process

Successful Applications

- Automated interpretation of complex seismic datasets from the environmentally sensitive Barents Sea region in the Arctic
- Constraining the timing of major basin evolutionary processes in several basins, including the North West Shelf and South Nicholson Basin, Australia, Siberia, East Africa, the Caribbean, and the Scotia Sea

Capabilities and Facilities

- Evaluation of frontier basin properties and energy or storage potential, especially where little data currently exists
- Software for automated interpretation of seismic data

Our Collaborators

- Lundin Norway
- SoluForce
- Department of Climate Change, Energy, Environment and Water (DCEEW)
- Geoscience Australia
- CO2CRC
- EXIGE
- Santos
- Kumul Petroleum
- CSIRO Mineral Resources

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Energy Storage for Integrated Energy Systems

UNSW's world-first developments in energy storage and flow battery technology, including the vanadium redox flow battery, provide opportunities for maximising renewable energy power plant performance and improvements in electricity quality and supply. Advancements made on flow battery technology have been utilised globally in large-scale demonstration and commercial projects.

Competitive Advantage

- Redox flow batteries offer lower cost and longer cycle life than conventional battery systems without thermal issues
- Up to 200,000 cycles for a vanadium flow battery demonstrated in commercial wind system
- Lower risk than Li-ion technology – no emissions or fire hazards
- Advanced battery control approaches based on mechanisms of electrochemical reactions to improve efficiency and flexibility of battery operation

Impact

- Use of vanadium batteries for simultaneous electricity quality control and power demand/supply balance (without supercapacitors) to reduce the capital and maintenance costs of systems

Successful Applications

- Vanadium flow battery developed at UNSW now manufactured commercially by companies in Japan, China, USA, UK and Germany
- Installation of a 200 MW/800 MWh VRB in Dalian, China
- Licensing of vanadium battery technology to international sponsors
- Development of a vanadium oxygen laboratory scale fuel cell system
- Scale-up of an iron slurry flow battery system

Capabilities and Facilities

- 30 kW/130 kWh commercial VRB system
- Dedicated computation laboratories for advanced simulation modelling and associated facilities for validation studies
- Extensive state-of-the-art electrochemical and mechanical laboratories
- Advanced additive and automated manufacturing facilities

Our Collaborators

- North Harbour Clean Energy
- Fraunhofer ICT

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Energy Storage Temperature Monitoring Systems

In an energy storage string or module consisting of a number of cells, a significant variation in temperature distribution can exist. However, monitoring the whole module's temperature is often hindered by hardware and cost limitations, and typically only a limited number of temperature sensors are employed.

Competitive Advantage

- An innovative model-based temperature monitoring and diagnostic system has been developed for a forced-cooled electrochemical energy storage string using a limited number of sensors
- A unique, multiple-model estimator is used to monitor the temperature of all cells, as well as detect and localise an abnormally overheating cell, with the limited number of temperature sensors – the optimal location of temperature sensors is determined by analysis of the Observability Gramian

Impact

- Cost reduction due to a reduced number of temperature sensors
- Increased safety due to the detection of abnormal overheating of cells within a string

Successful Applications

- An experimental prototype consisting of eight supercapacitors capable of detecting overheating using three thermocouples

Capabilities and Facilities

- Power electronics laboratory
- Arbin Instruments batteries and supercapacitors tester

More Information

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Enhancing Battery Energy Storage Systems (BESS) Management through Open-Source Deep Reinforcement Learning Tool

The open-source tool presented in this project embodies a significant advancement in Battery Energy Storage Systems (BESS) management. With an innovative application of Deep Reinforcement Learning (DRL) algorithms and agents – such as Soft Actor Critic (SAC), Deep Deterministic Policy Gradient (DDPG), and Hierarchy reinforcement learning (HRL) – the tool enables robust, data-driven decisions, and optimises energy storage efficiency, cost savings and sustainability.

Competitive Advantage

- Innovative open-source tool applies DRL algorithms to manage BESS
- Enables robust decision-making in uncertain conditions like shifting demand and dynamic prices
- Advanced DRL agents optimise energy costs, while preserving battery health

Impact

- The open-source tool simplifies the integration of DRL algorithms into BESS management, enhancing energy storage system efficiency
- By optimising BESS control, the tool can drive substantial cost savings and reduce environmental impact through more strategic energy usage
- The innovative application of DRL in BESS control can stimulate fresh strategies and techniques to potentially revolutionise the energy storage landscape

Successful Applications

- The open-source tool will be made available on GitHub under the MIT license, providing global accessibility and encouraging further development by the wider community
- The tool is utilised on the existing database of the National Electricity Market (NEM) to showcase its practical applications, providing tangible examples of potential impacts

Capabilities and Facilities

- Suite of pre-built DRL algorithms and benchmark environments for diverse BESS scenarios
- Hands-on training at IEEE ACT SMC Chapter and UNSW research groups
- Outcomes shared in top academic journals and IEEE PES conferences

Our Collaborators

- Industrial – Zepben, Essential Energy
- Community – Hepburn Wind Farm
- Government Agencies – ARENA, CEFC
- Energy Consulting Firms – Aurecon, GHD, WSP

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Fire and Explosion Suppression for Newly Developed Electrochemical Storage Materials

MXenes are a newly discovered class of two-dimensional transition metal carbides, nitrides and carbonitrides. These emerging materials for electrochemical storage have potential usage in lithium-ion battery applications such as cell phones and electric vehicles. However, their practical applications are currently limited by challenges with manufacturing, as well as fire and explosion safety.
situ stress estimation and mapping, AI applications in geotechnical-geological context and near borehole geomechanics.

Competitive Advantage

- MXene-based materials have outstanding electronic properties and large surface areas, which ensure the inherent advantages as electrode materials for electrochemical energy storage

Impact

- Improved safety of next generation electrochemical materials
- Rechargeable batteries with higher energy density

Successful Applications

- Development of a highly thermally-insulated three-dimensional composite architectures comprising epoxy, graphene and hydroxylated boron nitrides nanosheets
- Reinforcing the fire resistant properties of glass fibre using phosphorous-containing silane coupling agent

Capabilities and Facilities

- Collective fire testing facilities including cone calorimeter, horizontal and vertical fire spread (UL94), and oxygen index
- Access to neutron beam diffraction facilities at ANSTO to study the molecular morphological structure of MXenes
- Application of novel computation codes to predict the structural, mechanical, electrical, magnetic and thermoelectric properties of MXenes

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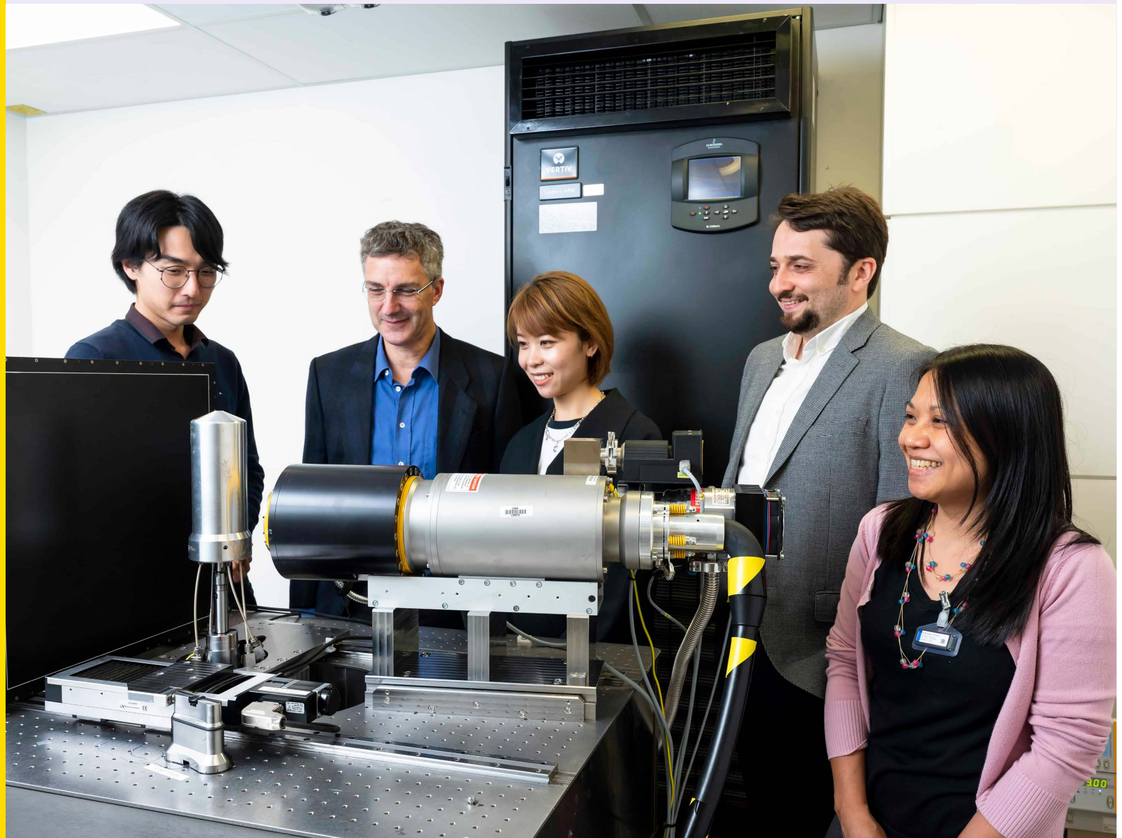
Helical Micro-CT – Imaging and Insights

High-resolution imaging combined with image analysis and dynamic experiments. A rare combination of instrument capacity and people skills provide unparalleled insights into microstructural behaviour.



Competitive Advantage

- Award-winning analysis outperforms conventional X-ray computed tomography
- Very-high-resolution allows imaging at submicron scale
- High-speed method allows dynamic imaging – e.g., tracking of multicomponent fluid flows

Impact

- Imaging of battery materials for degradation studies
- Imaging of flow in three-dimensional electrode materials
- More efficient oil and gas recovery
- High-resolution biomedical imaging

Successful Applications

- Technology commercialised through spin-off company Digital Core, which merged with Numerical Rocks AS to form Lithicon. In 2014, Lithicon was acquired by FEI for A$76 million.

Capabilities and Facilities

- Facility housed in a dedicated, temperature-stabilised, lead-lined room
- X-ray source (180 kV/20 W) with diamond windows
- High quality flatbed detector (3072 × 3072 pixels, 3.75 fps readout rate)
- Helical and circular scanning mode
- Pressure and flow cells for various sample sizes

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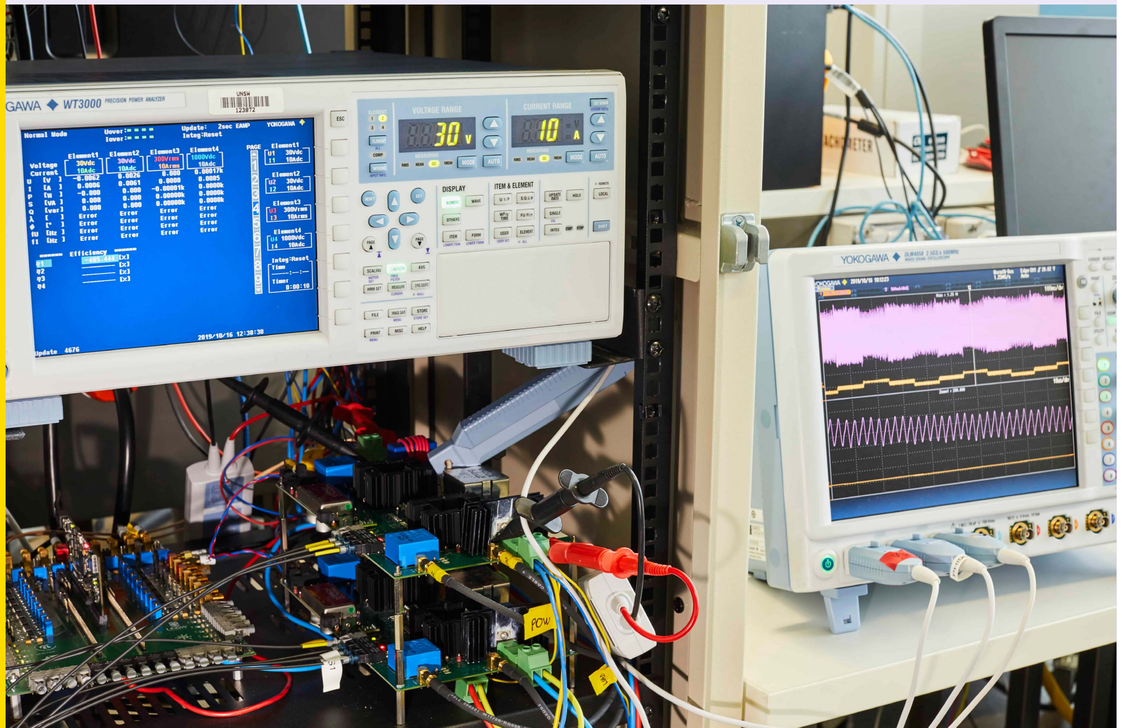
High-Current, High-Conversion-Ratio DC-DC Converter for Super-Capacitors

The design of an optimised bi-directional DC-DC converter capable of charging and discharging super-capacitor banks.



Competitive Advantage

- A class-leading, unique converter in a cost-effective design, with both digital and analogue control, that provides high-efficiency and high-reliability

Impact

- Improves the efficiency of energy management systems
- Makes energy recovery economically viable in CDI water treatment systems

Successful Applications

- A customised high-current DC-DC converter for capacitive deionisation technology to treat underground brackish water

Capabilities and Facilities

- High-bandwidth, high-current probes
- High-bandwidth, high-resolution oscilloscope
- Real-time hardware-in-the-loop simulation platform
- Power device analyser

Our Collaborators

- Instrument Works
- Goldwind

More Information

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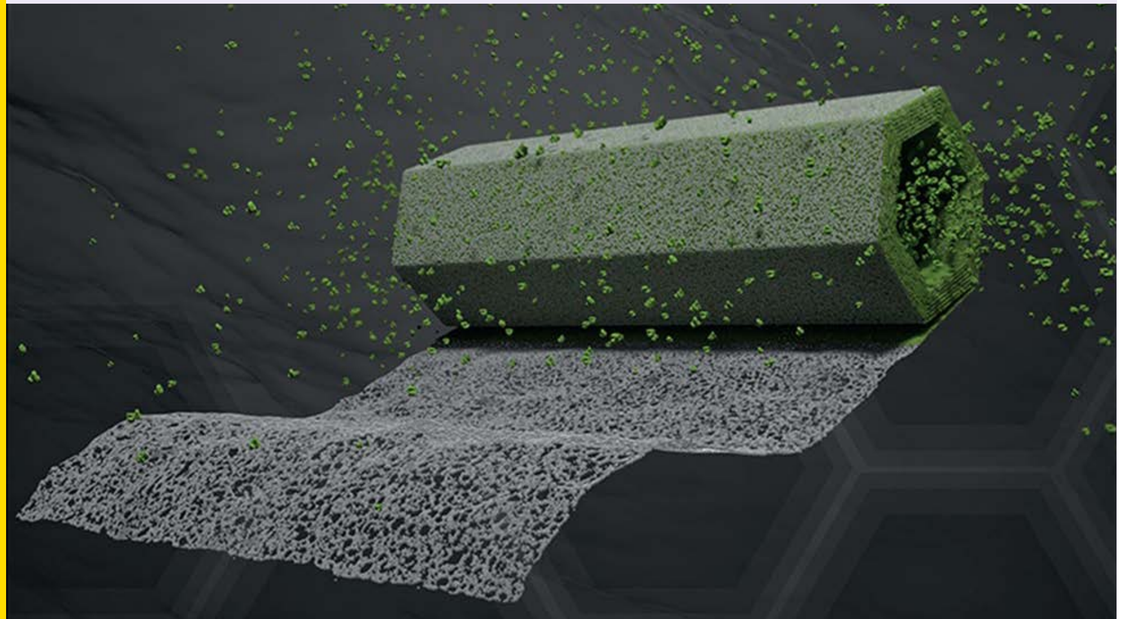
High-Performance Sodium-Ion Rechargeable Batteries

The development of sodium-ion rechargeable batteries using complementary technologies that are protected by two patent applications. The advantages of environmentally-friendly, room-temperature, single-step, and controllable processing, result in the high-yield and cost-effective production of battery electrodes. These are high-capacity with rapid charge/discharge, without the use of strategic materials.



Competitive Advantage

- Outstanding energy density (capacity) for sodium-ion batteries
- Successful outcomes facilitated by continuous research funding from Vecor Technologies

Impact

- Energy – high-performance batteries, low-cost, and readily available raw materials
- Environment – Aqueous-based and low-power-demand processing using non-toxic materials
- Security – no strategic raw materials
- Economics – 2030 global market revenue is estimated to be A$526 billion
- Major funding from Vecor Technologies
- Government – National Science and Research Priority: Advanced Manufacturing
- Industry – contribution to Australian Public Service Net zero 2030

Successful Applications

- Patent 1 – new generation of metastable polymers that can be engineered as inorganic compounds for energy storage
- Patent 2 – direct and non-toxic fabrication of high-performance, flexible, and robust electrodes
- Both patents leverage unconventional strategies based on simplified electrochemistry

Capabilities and Facilities

- Three dedicated laboratories (120 m2)
- Comprehensive facilities for fabrication (School of Materials Science and Engineering), analyses (UNSW Mark Wainwright Analytical Centre), and testing (UNSW-Vecor Laboratories and UNSW School of Chemistry)
- Expertise in processing, analyses, and testing of ceramics, polymers, electrochemistry, and coin-cell battery materials

Our Collaborators

- Vecor Technologies
- RMIT University STEM College
- Deakin University Battery Research and Innovation Hub (BatTRI-Hub)

More Information

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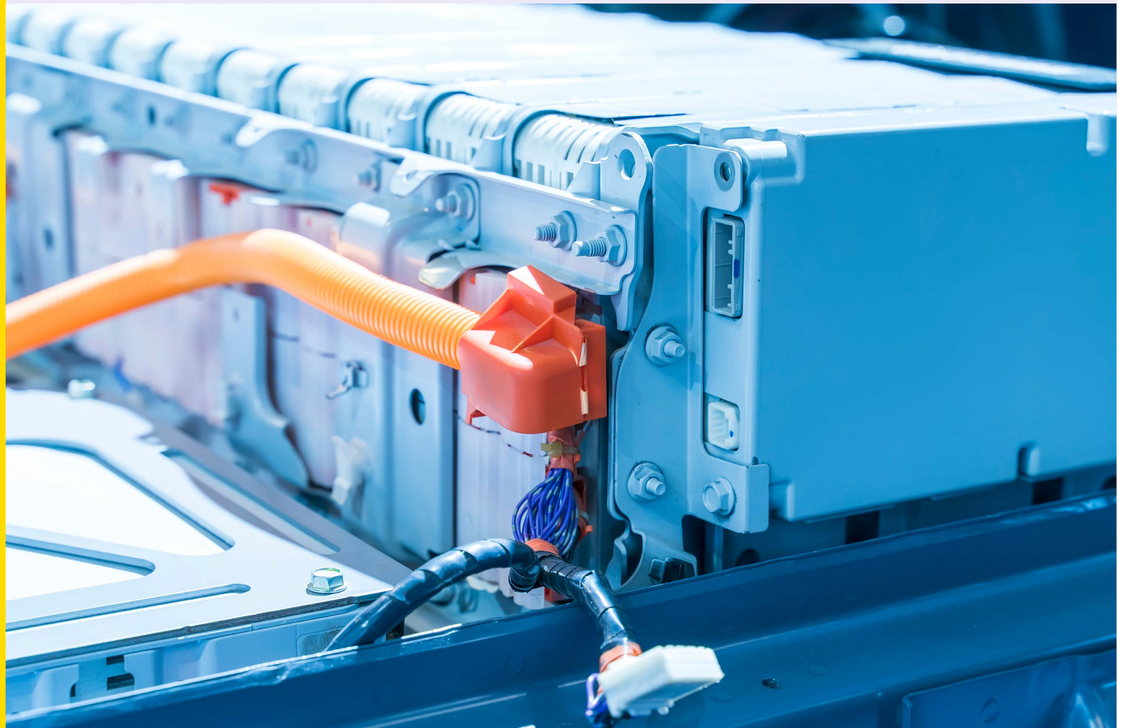
Hybrid Energy Storage Systems

Hybrid energy storage systems (ESS) combine the individual advantages of different storage types to realise a single ESS with enhanced power and energy capabilities. A battery-supercapacitor based hybrid ESS can reduce a battery's power rating and extend its lifespan by minimising variations in battery current.



Competitive Advantage

- Novel energy storage technologies that can be customised based on industry/customer specifications, allowing rapid introduction into the market
- Ability to conduct rapid prototyping and real-time verification of advanced power electronic concepts using Opal RT/RTDS – provides fast verification and quick adoption by industry for mass production
- Power hardware-in-the-loop capabilities to enable testing at full power

Impact

- Improving reliability, efficiency and flexibility in grid energy storage, rail systems, residential energy storage, and electric vehicles

Successful Applications

- Developed novel DC linked and direct AC linked hybrid (battery/ultracapacitor) ESS – primary advantages are increased lifespan, improved efficiency, increased reliability and flexibility
- Reconfigurable hybrid ESS that can be adapted online to fulfil different operating modes – feeding load from the battery system or from a backup power source, regenerative mode, intra-module balancing mode and charging mode. Unlike conventional systems, they share components among different operating modes, which makes them more compact

Capabilities and Facilities

- Hybrid ESS prototypes
- Hardware-in-the-loop simulation for rapid assessment of control techniques
- Hardware testing capability up to 50kVA, 1kV, 400A
- Arbin Instruments battery tester
- Cadex C8000 battery testing system with a load capture unit
- Hioki battery simulator
- GAMRY Model REF3000 potentiostat
- LiBa WorkStation
- TempEvent temperature chamber with EUCAR 5 level capability

Our Collaborators

- ABB Corporate Research Centre (Sweden)
- Dovetail Electric Aviation

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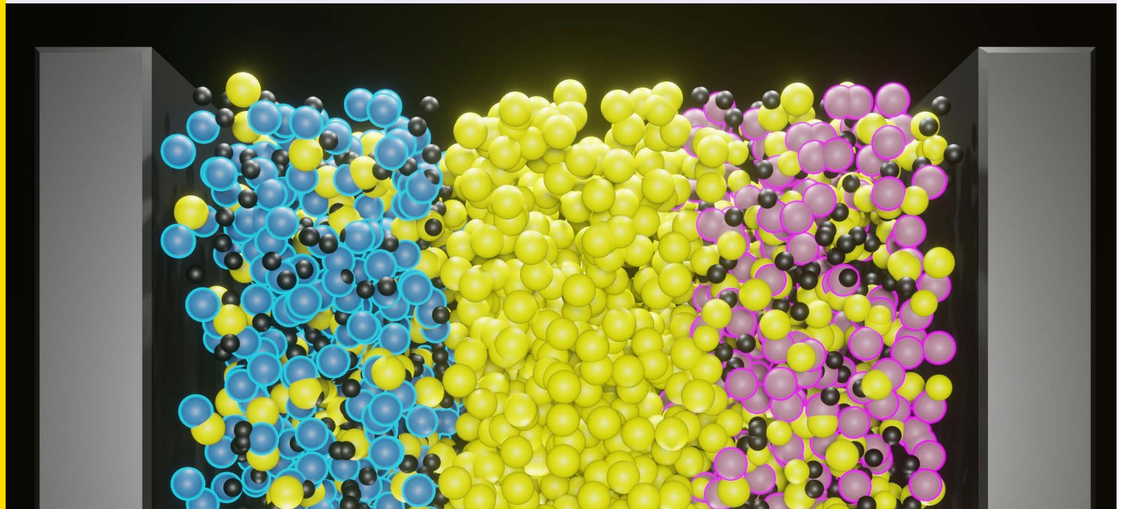
Development of Inorganic Solid Electrolytes for All-Solid-State Lithium Batteries

The notable advantages of all-solid-state lithium batteries (ASSLB), such as improved safety and high energy density potential, stem from the impressive attributes exhibited by solid electrolytes. These include their high single Li-ion conductivity and mechanical and thermal stability. The design and engineering of functional electrolytes and their scalable development are crucial for the practical advancement of the ASSLB technology.



Competitive Advantage

- Expertise in inorganic materials development, including inorganic solid electrolytes
- Expertise in all-solid-state lithium battery (ASSLB) research – one of few research groups in Australia in this field
- Expertise in developing prototype devices for solid-state battery research
- Experience in beyond-lab-scale development of battery technologies

Impact

- Design and development of functional inorganic solid electrolytes for ASSLB applications

Successful Applications

- Developed a scalable solution route for halide-type solid electrolyte synthesis with record-high ionic conductivity for ASSLB applications
- Developed electrolyte engineering strategies to achieve enhanced stability with battery anode and cathode

Capabilities and Facilities

- Inorganic solid electrolyte synthesis by applying a range of synthetic techniques and cell-level ASSLB performance evaluation
- A range of prototype devices for diverse electrochemical performance assessment
- A suite of characterisation tools for fundamental investigation and post-mortem analysis
- Translational development of battery chemistries

More Information

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LiFePO4 Battery Management System

A wireless battery management system for LiFePO4 batteries capable of surviving cold-soaking at -80oC, with proven performance in Antarctica.

Competitive Advantage

- An innovative battery management system that:
- Has zero wiring
- Uses infrared for communication
- Allows hundreds of cells to be queried in seconds
- Contains one node per cell with infrared programmable firmware
- Can program multiple nodes in parallel, from any single node
- Completely separates digital and analogue sections for redundancy
- Has a large current capacity for charge balancing
- Is proven to survive altitudes of 4,100 metres in Antarctica in -80oC conditions

Impact

- Developed for use in Antarctica where reliability and low-temperature survivability are critical, and where untrained operators need to be able to replace cells easily
- Eliminating wiring and connectors, which are the major cause of failures

Successful Applications

- Used by China's astronomical observatories at Kunlun Station – Dome A, Antarctica
- Capabilities and Facilities
- -80oC fridge for environmental testing
- Fault-tolerant software using low-power AVR microcontrollers

Our Collaborators

- Polar Research Institute of China
- Purple Mountain Observatory (China)

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Liquid organic hydrogen storage system design

Liquid organic hydrogen storage (LOHS) has a number of advantages over other energy storage and transport systems. We have the capability to design optimal LOHS systems using a 'synergistic catalysis concept' to select carrier molecule mixtures, hydrogenation and dehydrogenation catalysts.

Competitive Advantage

- Patented catalyst technology
- Intersection of computational materials design, lab-based materials development, and industrial-scale materials systems testing
- Supported by globally-significant computational resources

Impact

- More efficient and effective energy storage

Successful Applications

- Pilot plant at the Canberra Hydrogen Refuelling Facility in Fyshwick

Capabilities and Facilities

- Access to national supercomputing resources and state-of-the-art quantum chemistry software
- Access to synthesis team at the Australian National University
- Access to industrial pilot plant

Our Collaborators

- Global Power Generation Australia
- Hydrogenia
- Evoenergy
- Illuminact
- Australian National University

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Lithium-Ion Batteries – From Ore to Cells, Degradation and Recycling

Lithium-ion batteries are currently used extensively across a range of applications. Their uptake in larger-scale applications requires the development of new materials, quantification of battery degradation, and looking into the future – end-of-life and recycling innovations. At the forefront of research and development in this space, the research team designs new materials and electrode manufacturing processes, while investigating degradation mechanisms and developing methods to observe these. It is also working towards re-use and recycling concepts, attempting to undertake these processes in an environmentally-friendly manner.

Competitive Advantage

- Development of new, high-performance environmentally-friendly electrode materials
- Directed materials design for optimised performance
- Ability to develop materials, characterise, examine electrochemical performance, and understand the chemical reasons behind performance
- Access to non-destructive methods to assess battery degradation and failure modes for research and large-scale batteries
- Variety of analytical tools to determine degradation, in particular in situ or operando neutron and synchrotron X-ray diffraction, X-ray tomography and solid-state NMR
- Know-how for analysing data from a range of analytical techniques to illustrate degradation
- Development of new recycling approaches to minimise environmental impact

Impact

- Development of next generation materials for higher performing or specialised lithium-ion batteries
- Ability to non-destructively assess battery degradation
- Design and development of recycling methods
- Understanding failure and degradation modes to help design next generation batteries
- Developing new recycling scenarios

Successful Applications

- New anode materials developed and protected
- Materials from industry partners examined in cells
- Non-destructively examined the state-of-health of cells used in testing
- Non-destructively examined the role cathode chemical composition plays in cycling and high voltage stability
- Investigated new chemical doping regimes and their influence on electrochemical performance
- Investigated batteries in different form factors – e.g., thin film and all-solid-state
- Characterised various options for re-use of black-mass

Capabilities and Facilities

- Synthetic capabilities for electrode development, formulation and recycling studies
- Access to in situ/operando neutron diffraction
- Access to in situ/operando synchrotron X-ray diffraction and X-ray absorption spectroscopy
- Solid state NMR
- X-ray photoelectron spectroscopy, Raman, XRD, electron microscopy
- X-ray tomography
- Battery materials development to research-scale cell development

Our Collaborators

- Orica
- Sicona
- Mint Innovation

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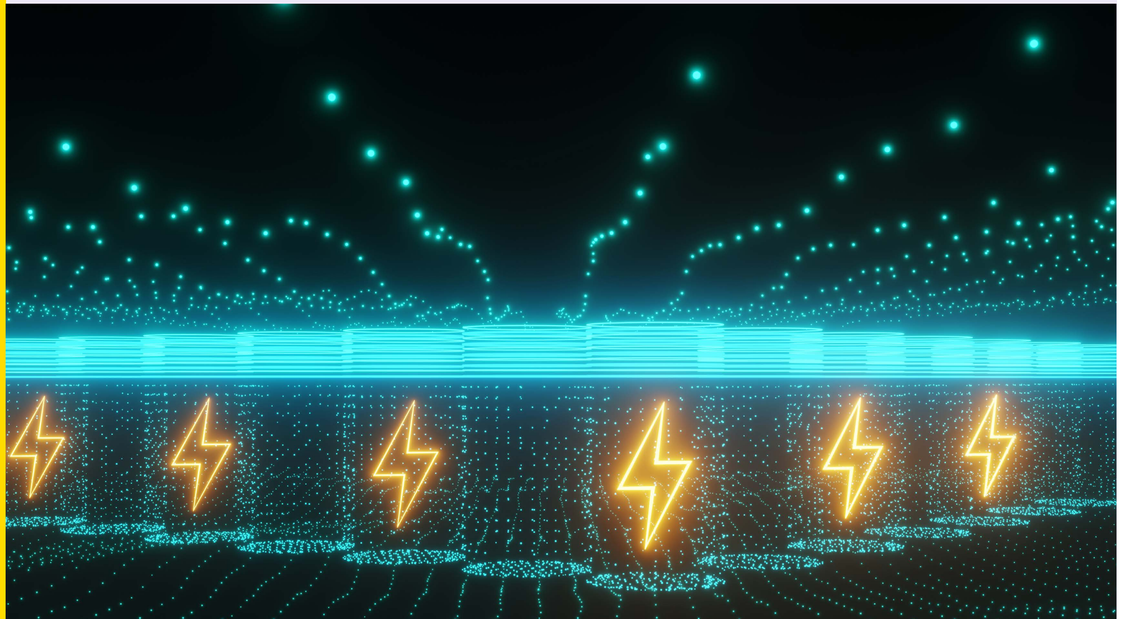
Materials Development for Next Generation Batteries

Future batteries will need to supply more energy. In order to achieve this, new materials and new concepts are required for alternative battery chemistries, such as lithium-sulfur and potassium-ion. Lithium-sulfur batteries are capable of storing as much as ten times the energy as current generation lithium-ion batteries, whereas potassium-ion batteries provide a significantly cheaper option to lithium-ion batteries. The development of these battery technologies will allow a mix of chemistries to be deployed and tailored to unique applications based on cost, performance and lifetime.



Competitive Advantage

- Flexible materials development capacity
- Ability to work with and examine a range of battery chemistries
- Full structural, spectroscopic and electrochemical characterisation

Impact

- The next generation of batteries, providing a step change to current technology

Successful Applications

- Development of new cathodes for lithium-sulfur and potassium-ion batteries
- Overcoming challenges in both battery systems

Capabilities and Facilities

- Materials synthesis
- Access to key analytical techniques, such as solid-state NMR, operando X-ray and neutron diffraction, surface analysis, and electron microscopy

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Micro-Supercapacitors for IoT

Micro-supercapacitors offer energy densities comparable to micro-lithium-ion batteries, but with one hundred times more power density and an ability to be recharged in three seconds. These devices have a range of potential applications, including electric vehicles and wearable electronics.

Competitive Advantage

- Bulk intercalative charge storage allows high energy density and low self-discharge
- Dual-carrier transfer renders high power capability
- Based on neutral aqueous electrolyte with high environmental compatibility

Impact

- Improved lifetime, stability and power density for electric vehicle applications
- Facilitating maintenance-free biosensors, mobile environmental sensors, wearable electronics and nanorobotics

Successful Applications

- Lab-demo coin-type cell developed

Capabilities and Facilities

- High-end electrochemical materials and device evaluation system
- In-situ electrochemical cell diagnosis (structural, chemical, and thermal)
- Advanced materials fabrication platform
- Versatile printing technologies for cell development (roll-to-roll, spraying, bar coating, doctor blade, etc.)

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Mineral Exploration for a Sustainable Future

Research utilising an in-situ laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) analytical technique to investigate the trace element chemistry of pyrite in sediment hosted Zn-Pb and Cu deposits. The pyrite geochemical database can be used to devise mineralisation vectors and assist with critical minerals exploration in Australia.

Competitive Advantage

- Robust and extensive in-situ pyrite geochemical database and its multiple applications in mineral exploration

Impact

- Robust databases are an integral part of the mineral exploration process and valuable to the broader mining industry
- The pyrite database supports ore deposit characterisation and critical mineral exploration

Successful Applications

- 2024-2023 – $30,000 – Geological Survey of South Australia
- 2023 – $30,000 – Science Faculty Research Grant (UNSW)
- 2019-2021 – $125,000 – Ian Potter Foundation Fellowship (UTAS)
- 2019-2021 – $480,000 – Industry (7 mining companies and 2 state geological surveys)
- 2019 – $50,000 – Ivanhoe
- 2018 – $110,000 – DGO Gold
- 2015 – $5,000 – Society of Economic Geologists Fellowship

Capabilities and Facilities

- Extensive research capability coupled with access to cutting-edge facilities

Our Collaborators

- University of Toronto
- Central Michigan University
- University of Tasmania
- Geological Survey of South Australia
- Queensland Geological Survey
- Mineral Resources Tasmania
- Glencore
- First Quantum
- Teck Resources
- Red Metal
- Sandfire Resources
- DGO Gold
- Anglo American
- Ivanhoe
- South 32
- MMG
- Ian Potter Foundation

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Multiscale Analysis for Underground Hydrogen Storage

The research group uses innovative technology to model and design safe storage of hydrogen underground in depleted gas reservoirs or aquifers, providing a large-scale energy storage solution. By converting excess renewable energy into hydrogen, fluctuations in supply can be mitigated. The team's extensive research and advanced capabilities enable accurate prediction and optimisation of Underground Hydrogen Storage (UHS) systems.

Competitive Advantage

- A groundbreaking solution for energy storage through modelling UHS –involves storing hydrogen in subsurface aquifers or depleted gas reservoirs, providing a viable long-term energy storage option
- UHS taps into the potential of renewable energy sources like wind and solar power – these sources often face fluctuations in energy supply on a daily or seasonal basis, so UHS mitigates these fluctuations by converting excess electrical energy from renewables into hydrogen energy and storing it in large volumes
- Extensive research into the interaction between rock, water, and hydrogen in subsurface environments – facilitates the design of effective UHS systems
- Cutting-edge multiphase laboratory setup and X-ray scanning facilities enables monitoring and imaging of hydrogen transport phenomena and its interaction with the host rock at microscale – capability to upscale the outcome to larger scales, which allows accurate prediction of hydrogen's behaviour in the subsurface, aiding the design and optimisation of UHS systems

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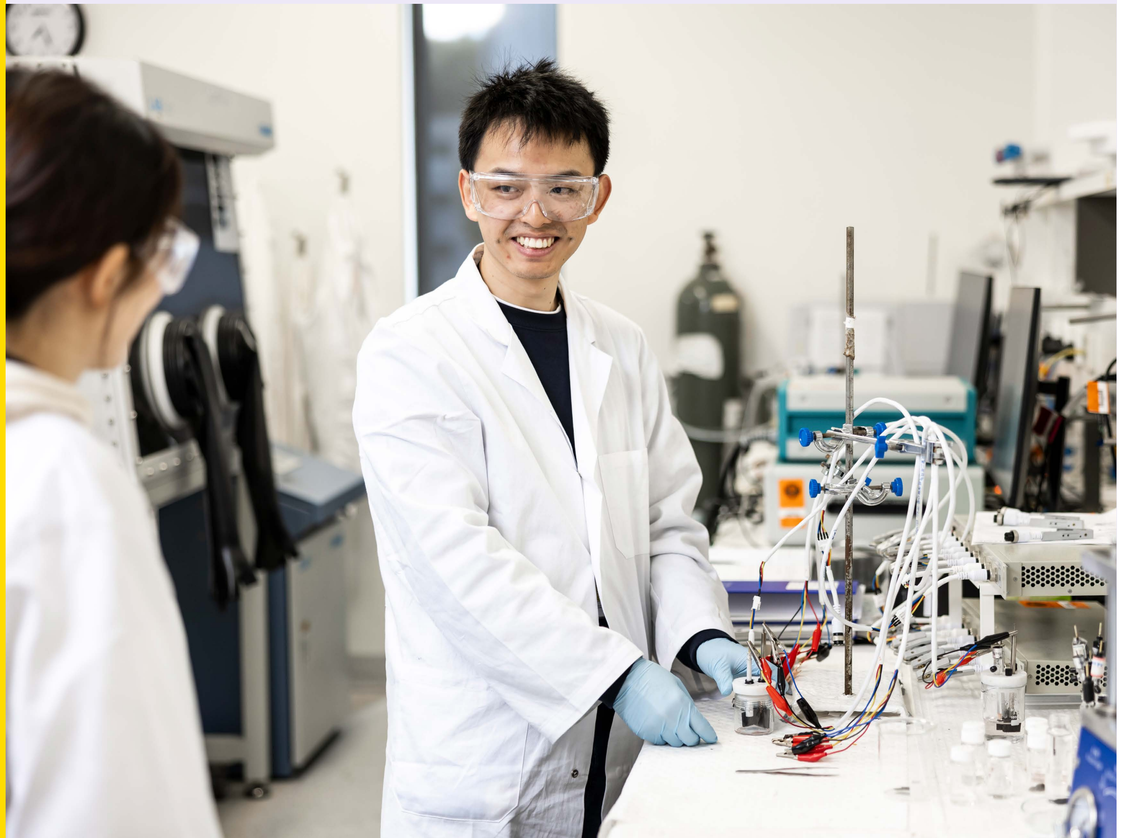
Proton Batteries

Developing energy storage systems featuring the energy density of batteries, and the power density of supercapacitors, is an exciting target for energy storage. New-concept proton batteries that utilise highly mobile protons as the carrier charge, have the potential to revolutionise energy storage in the near future.



Competitive Advantage

- Interdisciplinary experiences in battery research
- Expertise in materials research and developments in synthesis, modification, and characterisation
- Leaders in comprehensive electrochemical methods in probing the fundamentals of electrode-materials for batteries
- Development of new materials accessible for proton storage

Impact

- Pioneering research on understanding the fundamentals of battery materials for proton batteries
- A novel concept combining high capacity with high-rate capability

Successful Applications

- Development of a prototype proton battery that achieves both high capacity and high voltage in aqueous media

Capabilities and Facilities

- In-operando techniques to monitor mass changes and structure evolutions during battery charge/discharge processes
- Laboratory materials synthesis setup
- Scaled synthesis of battery materials
- Battery fabrication and analysis equipment
- Access to comprehensive analytical techniques, such as diffractions, surface analysis, and electron microscopy

More Information

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Safety of Lithium-Ion Batteries

With the rapidly increasing number of lithium-ion batteries in society, there is also a growing concern surrounding their safety. An in-depth understanding of how batteries may fail, and what can be done to mitigate the risks, is paramount to further reduce the risks associated with this critical technology.

Competitive Advantage

- Expertise in lithium-ion battery operation and safety
- Experience investigating the mechanisms that lead to failure

Impact

- Increased safety and reliability of lithium-ion batteries
- Improved understanding of potential issues and mitigation strategies
- Inform best practice and provide knowledge to various stakeholders

Successful Applications

- Identified battery degradation mechanisms
- Identified important factors causing battery safety incidents

Capabilities and Facilities

- Battery fabrication and testing under standard and harsh conditions
- Access to X-ray computed tomography for non-destructive imaging and analysis of cells
- Comprehensive post-mortem analysis of battery materials

More Information

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Sodium-Ion Batteries for Large Scale Storage

Sodium-ion batteries are a potential candidate that can either supplement or replace lithium-ion batteries for specialised applications, such as renewable energy storage. These batteries typically store slightly less energy density than lithium-ion batteries. Although not the best solution for portable electronics or electric vehicles, they are ideal for stationary energy storage. Sodium-ion batteries are new to the market and commercially attractive to further develop and optimise components, and understand their structure-property relationships.

Competitive Advantage

- Development of environmentally-friendly, cost-effective electrode materials
- Use of a range of analytical techniques, particularly operando synchrotron X-ray diffraction, to elucidate structure-property relationships
- Utilising waste as a source for sodium-ion battery electrodes, potentially making them even more environmentally-friendly and cheaper
- Rationale design of new materials

Impact

- The development and understanding of materials for potential commercial sodium-ion batteries
- Understanding structure-property relationships to design better materials

Successful Applications

- Evaluating the chemical compositions of electrodes and their performance
- Combining a range of analytical methods to understand material properties in devices
- Development of new environmentally-friendly and cost-effective materials

Capabilities and Facilities

- Battery materials development to research-scale cell development
- Access to key analytical techniques, such as operando synchrotron X-ray diffraction, solid-state NMR, surface analysis and electron microscopy
- X-ray tomography of devices

Our Collaborators

- Vecor Technologies

More Information

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Structural Supercapacitors and Batteries

Lightweight energy storage is vital to environmentally-friendly transport, including electric vehicles, drones, and wearable devices. Structures that can simultaneously carry load and store electrical energy, while simultaneously providing an energy density equivalent to the current state-of-the-art supercapacitors or batteries, are critical enablers for these new technologies.

Competitive Advantage

- The current bottleneck preventing the production of structural energy storage devices is the development of a stiff and strong material – one that also exhibits the high ionic conductivity required to facilitate the electrochemical processes inherent in common energy storage devices, such as batteries and supercapacitors
- Development of structurally strong batteries and supercapacitors
- Ability to integrate energy storage into the load bearing capability of a transport structure, eliminating or reducing the need for a traditional energy storage device and its weight from the platform
- Significant weight savings in autonomous vehicles resulting in improved energy efficiency for direct energy requirements, and embedded communications and sensing technologies that allow energy to serve other applications for greater overall capability

Impact

- Lightweight energy storage devices for Defence applications where high-energy storage density is required, and can be directly integrated into applications

Successful Applications

- Demonstration of the first generation of structural batteries by embedding flexible lithium-ion batteries into laminated fibre composites. The resulting structure can simultaneously store electricity and carry load.

Our Collaborators

- Defence Science and Technology Group (DSTG)

More Information

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GeoEngineering Research Laboratory

Using multiphysics theoretical, numerical and experimental modelling, to address geoengineering challenges related to geostorage and unconventional reservoir engineering. Additionally, the development of methods, software and tools for formation characterisation, in-situ stress estimation and mapping, AI applications in geotechnical-geological context and near borehole geomechanics.

Competitive Advantage

- Geophysical-driven formation characterisation
- Near borehole geomechanics
- In-situ stress estimation and mapping
- AI applications in geotechnical/geology field
- THMC experimental and computational modelling with applications in geostorage and unconventional reservoir engineering
- Rock mechanics/geomechanics testing

Impact

- Advanced multiphysics geomechanics techniques and tools for complex geotechnical problems in mining, petroleum, as well as civil engineering and infrastructure

Successful Applications

- Develop multiphysics geomechanics software for coupled gas flow – geomechanics modelling (e.g., NetCoal, NetShale)
- Geomechanical investigation of CO2 geological storage
- In-situ stress characterisation using developed tools and software, such as DilaStress, BLASE, iStress and 3DiStress
- Advanced geotechnical laboratory testing
- Data-driven rock mass characterisation using downhole geophysical logs

Capabilities and Facilities

Well-equipped geomechanics laboratory with advanced equipment such as:

- Servo-controlled systems
- X-ray transparent high-pressure-high temperature triaxial systems with ultrasonic and permeability enabled capabilities
- High-pressure-high temperature ultrasonic system with mid-to-high sinusoidal and square wave frequency input
- Micro-shear cell interferometry-optometry and gas adsorption systems
- High-speed infrared cameras and nanoindentation tester

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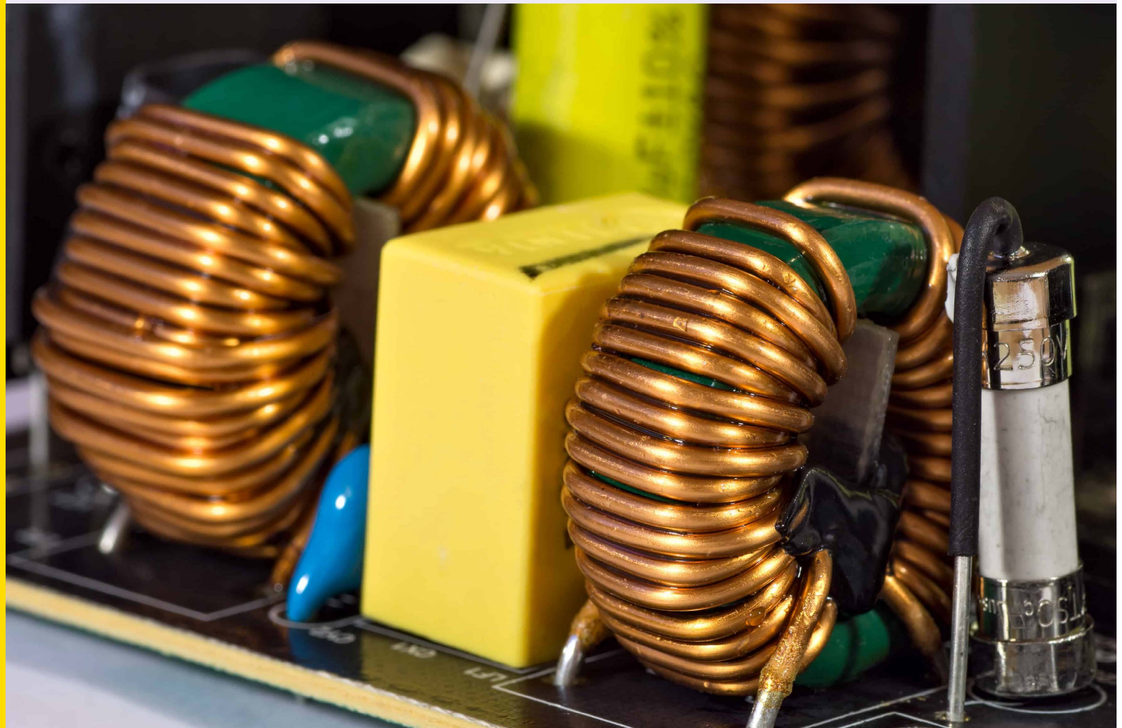
Coupled-Coil Inductor Inverters

Producing multilevel output voltage from just two fast-switching semiconductors by using a coupled inductor. This frees the inverter from dead-time and greatly reduces low-order harmonics.



Competitive Advantage

- More reliable – coupled inductor lowers the risk of DC-link shoot-through
- Cost-effective – fewer semiconductors are employed for three-level output
- Simpler control – no need to balance DC-link capacitor voltage under any condition

Impact

- Improves efficiency and reliability

Successful Applications

- Inverter-based five-phase permanent-magnet synchronous machine-drive system

Capabilities and Facilities

- Advanced control platform with DSP and FPGA
- High-bandwidth oscilloscope
- Multi-function test rig
- Four-quadrant 20 kW programmable power supply

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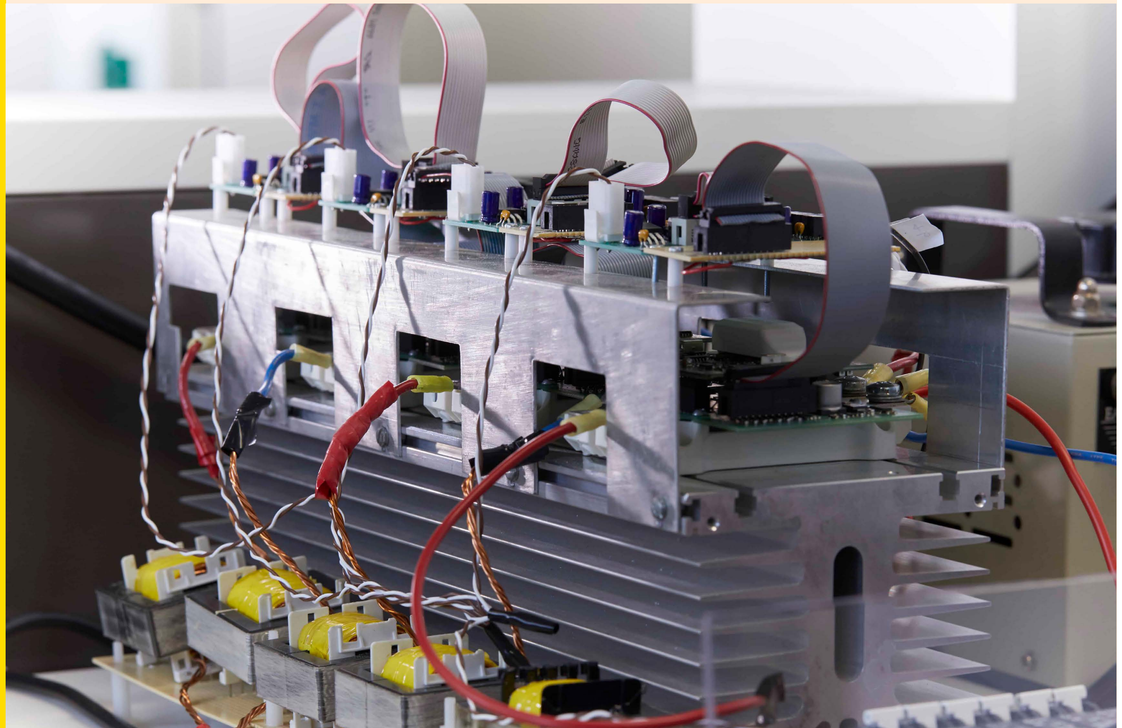
Grid Transformation

UNSW is striving to deliver a future power system that can support 100% renewable generation and the electrification of almost everything by 2050. Our focus is on decarbonising energy systems and industry through technology, people and infrastructure. We are developing and commercialising the technology required to displace centralised fossil-fuel generators with energy equity in mind. We are approaching a situation where 40% of total power generated will be from inverter-based generators. This scale of inverter penetration is globally untested and the ability of inverters to sustain load across large electricity grid is unclear, particularly in the case of anomalous or fault conditions.

UNSW hosts the largest Real-time Digital Simulation (RTDS) Laboratory in Australia. Real-time digital power system simulation provides an accurate, reliable and cost-effective method to simulate, verify and experiment with multiple technologies, functions, operations and control from individual components to large-scale power systems.

Advanced Energy Storage Interfaces for the Digital Grid

Advanced energy storage techniques require advanced grid interfaces. Such advanced interfaces ensure that bidirectional inverter or converter technologies are capable of harnessing the benefits of the storage technique, helping unlock the advantages of new storage technologies.



Competitive Advantage

- Capabilities across all energy storage related areas
- Novel interfaces for single-and three-phase AC systems reduce costs and improve energy storage utilisation
- Unique research and demonstration of hybrid and reconfigurable energy storage systems that can be adapted online to fulfil different operating modes
- Lab-scale development with grid simulation up to 50 kVA

Impact

- Extending the lifetime of energy storage systems

Successful Applications

- Application of technology at laboratory-scale to include both DC and AC microgrid systems
- Supported development of energy storage solutions for NSW rail networks

Capabilities and Facilities

- Real-time digital simulation with power hardware-in-the-loop capability up to 50 kVA
- Best-in-class laboratory equipment including PV simulation, three-and single-phase grid simulation, and load emulation
- Five-node AC microgrid with 5 kVA node capability
- Arbin battery and supercapacitor tester with environmental chamber

Our Collaborators

- ARUP
- Renewable Energy Systems (RES)
- Transport for NSW
- Australian Energy Market Operator (AEMO)
- TransGrid
- Ausgrid

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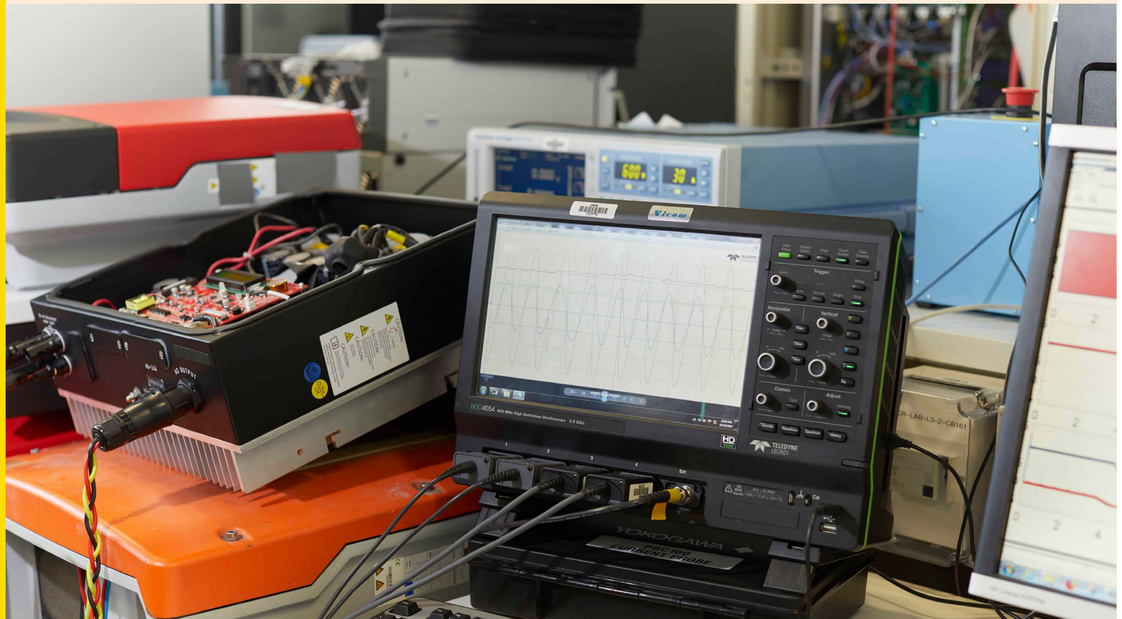
Applications of Advanced Non-linear Control to Inverters for Microgrids

Providing expertise in broad areas of non-linear control engineering, including the application of control design and algorithm analysis for microgrids.



Competitive Advantage

- Advanced analytical techniques to assess the dynamics of non-linear systems, and support the design of non-linear control systems
- An experienced interdisciplinary research team with a proven collaborative track record in fusion of electrical power engineering and advanced control techniques
- Methods for controlling renewables and electrical machines that have broad applicability

Impact

- New, robust inverter control systems that can eliminate high-bandwidth communications
- Advanced inverter control techniques suited to autonomous power systems
- Enhanced understanding of the dynamics of the interaction between inverter-derived generation and converter-supplied load

Successful Applications

- Application of advanced methods of nonlinear control theory to establish the stability of single-phase microgrids using proportional and resonant controllers, as well as phase-locked loop feedback, which confirms the simulated and experimental results

Capabilities and Facilities

- Analysis of non-linear systems
- Non-linear control theory for inverter-interfaced microgrids based on virtual oscillator control, and proportional and resonant controllers
- Laboratory microgrid facility (Tyree Energy Technology Building)
- Real-time digital simulation facilities for hardware-in-the-loop testing

Our Collaborators

- A.W. Tyree Foundation
- Australian Energy Market Operator (AEMO)
- Sungrow

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Cooperative Control of Distributed Energy Storage Systems

Cooperative control of distributed energy storage systems (DESS) is a critical approach in managing distributed energy resources. It enables various energy storage units to work together, maintaining grid stability and reducing the risk of failure. This method promotes efficient use of renewable energy by optimally storing and dispatching power. It also extends the lifespan and boosts performance of the storage units by evenly spreading loading and discharging cycles. DESS cooperative control is key to a resilient and efficient energy infrastructure.

Competitive Advantage

Expertise in developing centralised and distributed multi-agent control strategies for energy storage systems, providing:

- improved performance compared with decentralised control strategies
- advantages in terms of robustness, scalability, security and flexibility over centralised control strategies

Impact

- Cooperative balancing can avoid costly power network upgrades and increase power-supply security

Successful Applications

Development of centralised and multi-agent control strategies for distributed energy storage systems that:

- are robust to communication network delays
- allow state-of-charge balancing with no circulating currents
- feature plug-and-play capability

Capabilities and Facilities

Real-Time Digital Simulators (RTDS) that allow:

- real-time verification of algorithms and simulation of power networks combined with accurate models of energy storage systems and power converters
- hardware-in-the-loop simulation, which is the final step before field verification – this presents an opportunity for rapid research, development and verification, necessary for translating theoretical advances in multi-agent cooperative control into new strategies suitable for deployment in power system networks

More Information

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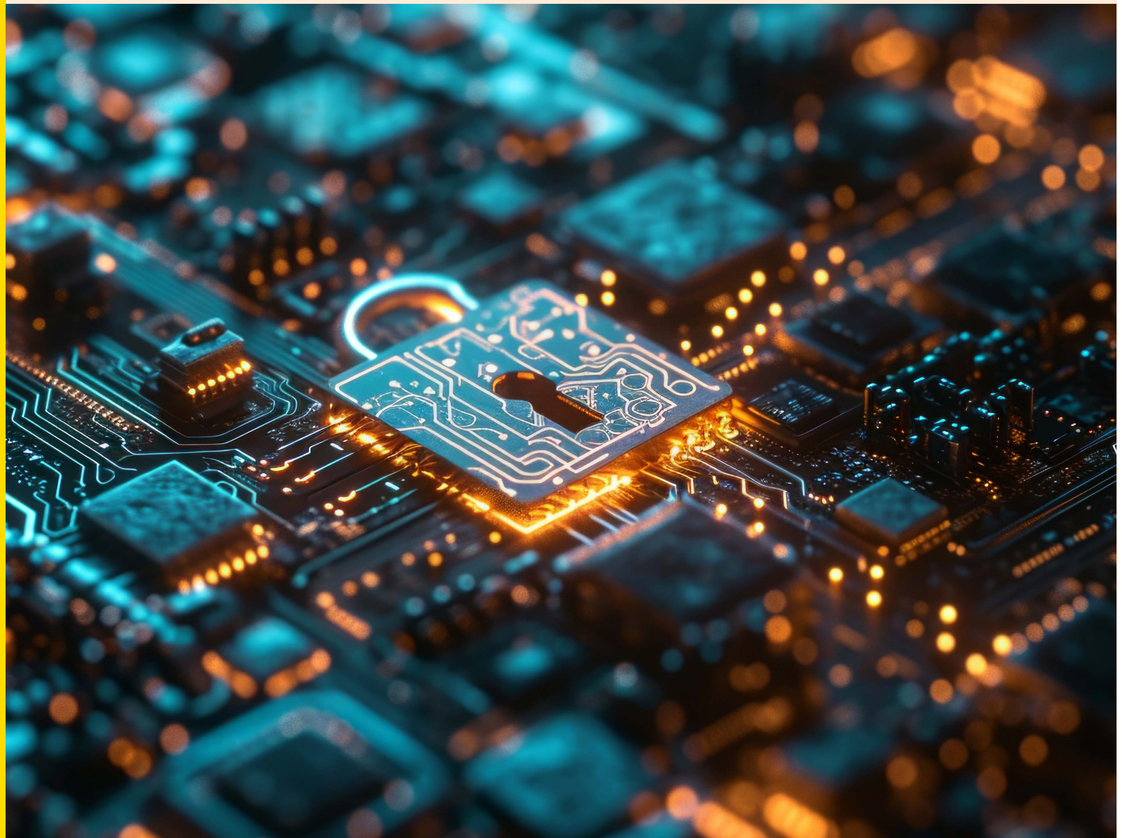
Cyber Security of Power System Control Methods

The widespread adoption of components with communication capabilities and internet-connectivity in power systems have increased the vulnerability of those power systems to damaging and potentially dangerous cyber-attacks. New methods are required to rapidly and accurately detect attacks and protect control systems.



Competitive Advantage

- Detailed modelling of the dynamics of power systems across the essential timescales required
- Expertise in the application of nonlinear systems theory for the detection of attacks on power control systems
- An experienced, interdisciplinary and collaborative research team with a proven track record in the fusion of electrical power engineering and control techniques
- Broad applicability to conventional central grids, as well as grid-connected and islanded microgrids

Impact

- A control theory approach to assessing cybersecurity threats reduces uncertainty

Capabilities and Facilities

- Real-time digital simulation facilities for hardware-in-the-loop testing of power-related communication equipment
- High-voltage and microgrid facilities for experimental verification
- Dedicated communications laboratories

Our Collaborators

- Network operators
- Equipment manufacturers

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Development of Interdisciplinary and Translational Research Capabilities Necessary to Deliver the Digital Grid

The mission of the UNSW Digital Grid Futures Institute is to enable the electrification of society for a smart, sustainable future using research, innovation and training. The Institute combines researchers and talent from multiple disciplines to translate research into meaningful impact.

Competitive Advantage

- An interdisciplinary approach to translation of research to rapidly establish the right team for the right project
- The Institute draws on four years of network building across the full breadth of UNSW research expertise from social sciences, engineering, law and business

Impact

- Creating a translation-focused interdisciplinary research community to support decarbonisation at the scale necessary for major industry
- Supporting SMEs through collaboration and rapid response solutions
- Developing educational solutions to support the knowledge needs of the future energy workforce, including school programs, short courses and community knowledge sharing
- Engage industry and government through research, design, and testing, as well as advising on infrastructure, funding and policy
- Provide insights and thought leadership on all things related to the future grid and its role in decarbonisation

Successful Applications

- Decarbonisation career pathways – development of lifelong learning frameworks to support the workforce required to transition and sustain the energy grid to renewables
- Electrifying Squad – Technology Translation Team

Capabilities and Facilities

- Integration of renewables into the energy grid, from technical perspectives to social adoption
- Social equity of the energy transition, such as community engagement, social license, equity and inclusion
- Privacy and cybersecurity matters relating to the digital grid
- Air quality monitoring to inform policy and regulation

Our Collaborators

- NSW Decarbonisation Innovation Hub
- Trailblazer for Recycling and Clean Energy (TRaCE)
- ARC Research Hub for Integrated Energy Storage Solutions

More Information

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Distributed Energy Resources Laboratory

The Distributed Energy Resources (DER) laboratory is a facility designed for the safe testing of new technologies – including monitoring and communication devices, smart controllers, aggregation (e.g., Virtual Power Plant), market participation software, and other innovative products under development – in a multi-platform environment that simulates real-world conditions prior to roll-out.

Competitive Advantage

- Previously, the only way to test the interaction of DER with the grid was to install devices in the live grid, often in customers' properties – this is costly and laborious
- The DERlab overcomes this limitation by providing a fail-safe testing environment – it simulates a distribution network that can be brought to a user defined operating state into which users can connect a collection of commercial and custom devices

Impact

- Develop protocols for multi-technology solutions to avoid early technology lock-in
- Streamline research and development
- Maximise the number of products that can be used across Australian networks

Successful Applications

- Integration of battery control devices with various batteries
- Behaviour of DER devices under voltage disturbances
- Performance of Vehicle-to-Grid based frequency support
- Islanding and reconnection of a grid forming inverter based microgrid
- Exploring the behaviour of Virtual Power Plants in weak grid conditions
- Power Hardware-in-the-Loop (PHIL) studies of inverter control systems

Capabilities and Facilities

- 9 x solar inverters
- 4 x battery inverters
- 2 x hybrid inverters
- 3 x 5 kVA 4-quadrant programmable power supplies
- 5 kW solar simulator for definable and repeatable DC generation
- 5 x solar PV strings mounted on the roof, including one with DC optimisers
- Solar PV string with micro inverters
- 6 x DC batteries
- AC battery (inclusive of inverter)
- EV charger – bidirectional, single phase

Our Collaborators

- ITP Renewables
- Australian National University
- Battery Storage and Grid Integration Program
- Evoenergy
- UNSW Canberra

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Modelling and Control of Microgrids

The Distributed Energy Resources (DER) laboratory has a range of electronic converters, programmable loads, energy sources and storage systems, RTDS equipment, and a facility to run a 50kW microgrid. The laboratory is used for simulating short-term and long-term experiments to demonstrate dynamic control and energy management algorithms.

Competitive Advantage

- Ability for flexible integration of inverter-interfaced generation into off-grid electricity networks
- Design of control algorithms that include the dynamics of the generation devices
- Creation of dynamic models for active distribution networks
- Enabling small consumers to trade electricity with other users in distribution systems
- Innovative off-grid supply systems designed using these control methods are a fraction of the cost of the purpose-built, remote electricity supply systems

Impact

- Ability to build off-grid flexible electricity networks for remote locations with inverter-interfaced generation
- Control methods that work in active electricity systems without the need for synchronous generators

Successful Applications

- An off-grid renewable-resources-based active distribution network, with complete flexibility for interconnecting new generation devices and loads, has been commissioned for a rural community in India

Capabilities and Facilities

- Developing detailed dynamic models for the entire active distribution network
- Detailed simulation using industry-standard software tools
- Design and analysis of various control techniques

Our Collaborators

- Australian National University

More Information

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Enhancing Electric Vehicle Hosting Capacity through Vehicle-to-Grid Integration in Distribution Networks

Vehicle-to-Grid (V2G) integration has the potential to enhance the hosting capacity of Electric Vehicle (EVs) in distribution networks. By linking EVs to the distribution networks, V2G technology allows bidirectional power flow and enables active participants in the energy ecosystem and grid. This transformative capability drives the transport electrification process toward net zero emissions.

Competitive Advantage

- V2G integration offers a stakeholder-oriented solution for enhancing Electric Vehicle hosting capabilities in distribution networks
- By enabling active participation and stakeholder-centric management for DER in distribution networks, the capability will foster the adoption rate for transport electrification

Impact

- V2G integration impacts stakeholders, such as distribution network operators and EV users – this process will enhance the EV hosting capacity of distribution networks by integrating solar photovoltaic and V2G technologies
- Research contributing to sustainable transport electrification through increased grid reliability and management of active network operation during large-scale penetration

Successful Applications

- Deployed in real-distribution network scenarios in the Australian context
- Hosting capacity estimation in real-suburban distribution feeders
- Dynamic export or import limits for real-distribution feeders

Capabilities and Facilities

- Real-distribution network data
- Test bed and simulation facilities
- Collaborative industry partners

Our Collaborators

- CSIRO
- Essential Energy Australia
- Zepben

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Grid at the Edge: Towards a Net Zero Carbon Grid with Improved Resilience

The Research Group aims to enable a net zero carbon grid with improved resilience by investigating novel sensing, statistical monitoring, online robust optimisation, anomaly detection, and artificial intelligence techniques, particularly the deep learning and (quantum-inspired) reinforcement learning.

Competitive Advantage

- Advanced sensing and data analysis methods for fault diagnosis, process monitoring, and optimisation of smart grids
- Sustainable transportation and energy systems – combined PV-EV hosting capacity calculation and planning
- Efficient computational algorithms for the robust operation of distribution networks under extreme events
- Quantum-inspired reinforcement learning-based lifelong management of smart grids with renewable energy sources

Impact

- Reduce lifetime maintenance costs of renewable assets
- Increase the hosting capacity of EVs and minimise charging costs
- Enhance grid resilience against extreme weather events and cyber-attacks

Successful Applications

- Energy Workbench Server and Zepben
- Mitigating the threat of impacts on infrastructure via reinforcement learning-based decisions (funded by DSTG)
- Intelligent maintenance of transmission grid assets (funded by the Swiss Federal Office of Energy)
- Risk assessment in bulk energy grids (funded by Swiss Competence Centers in Energy Research)
- The vulnerabilities of future interdependent energy network (funded by the Swiss National Science Foundation)

Capabilities and Facilities

- State-of-the-art reinforcement learning-based optimisation
- Deep learning-based data analysis and forecasting
- Energy Workbench Server
- Over 20 high-performance workstations
- PSCAD and PSSE software
- Degradation testing platform
- Ultrasonic and imaging non-destructive evaluation system

Our Collaborators

- Zepben
- Essential Energy
- Swiss Grids
- MTR (Hong Kong)
- Boeing

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Grid Forming Converters

A hardware platform that facilitates the design, development and validation of grid forming (GFM) control for power electronics converters. This maximises grid supporting functionalities from inverter-based resources (IBRs) and battery energy storage systems (BESS) in power electronics defined power systems.

Competitive Advantage

- Expertise in modelling and control of grid-connected power converters
- Expertise in power electronics, combined AC/DC networks, and power-systems integration
- Capability of developing multi-converter power systems
- Capability of replicating extreme grid events
- Capability of implementing power hardware-in-the-loop testing

Impact

- ‘Responsible grid-forming design that coordinates grid supporting services with power and current limits for power converters
- Demonstration of grid support capabilities under extreme grid disturbances
- Implementation of grid-forming control in IBRs and BESS
- Increased large-scale renewables hosting capacity towards 100% inverter-based power systems

Successful Applications

- Broken Hill BESS with grid-forming inverters
- Fault-ride-through strategy for voltage sags up to 90% and frequency disturbances from 47 to 52 Hz

Capabilities and Facilities

- Regatron DC/AC power supplies
- TDK-Lambda programmable DC power supply
- Danfoss power electronics converters
- Modular multilevel converter systems (48 SMs*2)
- Interface with real-time simulators for power hardware-in-the-loop testing

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Grid-Connected Inverter Testing and Assessment

Inverter testing is fast becoming an important capability as the penetration of distributed generation, like photovoltaics and battery storage systems, rapidly increases. A comprehensive test setup that can accommodate inverter capacities between 1kVA and 50kVA has been developed, which allows inverters to be tested to the edge of their performance envelope. The testing system can also be utilised for coarse and fine tuning of inverter control parameters.

Competitive Advantage

- Best-in-class Inverter testing system, operated by staff with diverse experience in testing a variety of inverter types, makes and models
- Specialist knowledge allows the identification of inverter vulnerability to grid disturbances, which may cause unexpected behaviour in inverter makes and models – important for Virtual Power Plant solutions and microgrid providers

Impact

- Testing allows for rapid determination of grid-connected inverter behaviour and control, and the fast assessment of vulnerabilities for a range of typical grid disturbances

Successful Applications

- Over 15 inverter makes and models tested for an ARENA funded project into the effect of distributed energy resources on the distribution grid
- Collaborations with AEMO and network operators on the impact of distributed energy resources on the network

Capabilities and Facilities

- A state-of-the-art inverter and microgrid test platform that can be used to experimentally verify inverter control techniques – includes grid simulators, load emulation, feeder impedances, rotational generation and rotational loads
- Fine-tuning of critical subsystems, such as synchronising algorithms (PLL, FPLL, SOGI, VSG), current mode control, voltage-source forming and fault characteristics

Our Collaborators

- Australian Renewable Energy Agency (ARENA)
- Electranet
- TasNetworks
- Australian Energy Market Operator (AEMO)
- Empower
- Sungrow

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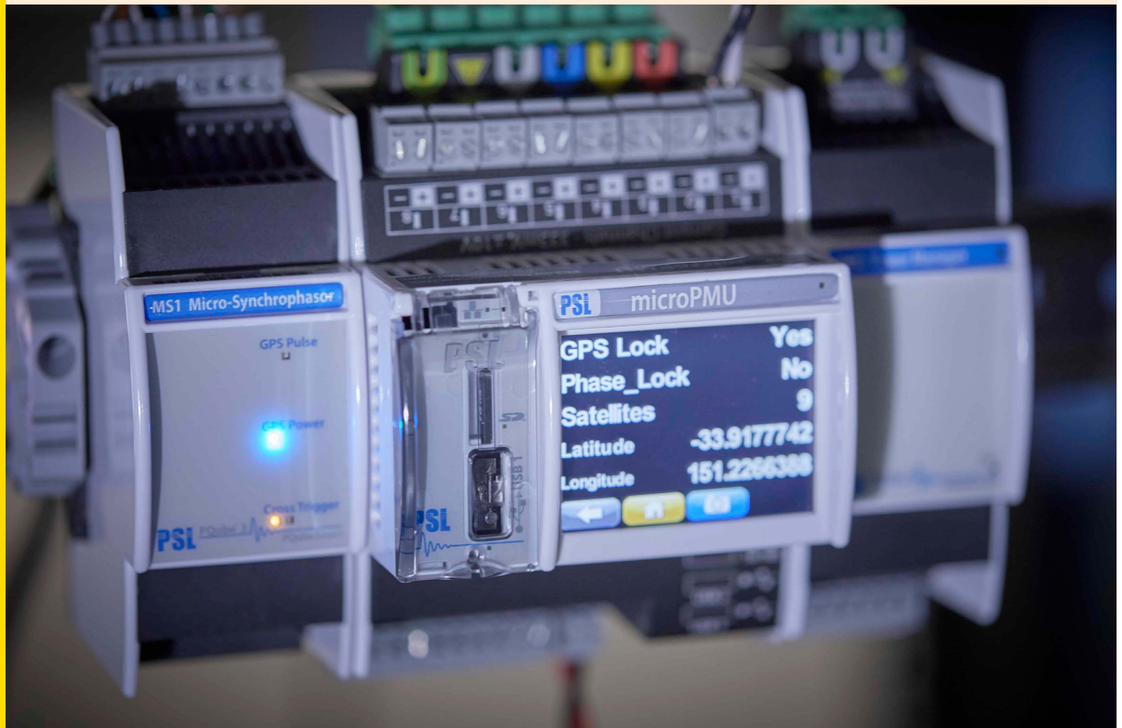
Virtual Power Plant Equipment

Using real-time simulation and testing expertise to assess the potential for maloperation of Virtual Power Plant (VPP) hardware, including inverter disconnections, communication system failures and energy swings between competing VPP operators. Large-scale VPP systems may command the operation of tens of thousands of energy storage and PV inverters, resulting in the aggregation of hundreds of generation and load MW.



Competitive Advantage

- Database of inverter behaviours and disturbance reactions
- Innovative models verified through experimental assessment
- Expertise in hardware-in-the-loop testing and assessment of virtual power plants
- Skills in assessing performance improvements in both technical and economic terms
- Rapid modelling and simulation capability

Impact

- Comparison of peak loads with and without VPP control
- De-risk VPP investments and optimise VPP performance
- Avoidance of large-scale disruption to VPP based on inverter performances
- Proof of concept hardware and software assessment

Successful Applications

- Sungrow – control and power hardware-in-the-loop

Capabilities and Facilities

- A fleet of current inverter makes and models
- 10 kVA experimental DC microgrid with diverse set of loads and generators
- 18-rack RTDS capable of modelling VPP systems
- OPAL-RT real-time simulator for high-resolution simulations

Our Collaborators

- Sungrow
- Hi-Vis Group
- A. W. Tyree Foundation

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Hosting Energy Workbench Server

The Energy Workbench (EWB), developed by Zepben, provides a platform combining relevant network model information into a single source, breaking the traditional siloed storage of critical network data. Hosting EWB at UNSW offers a flexible research environment to support the development of several solutions for emerging industrial challenges.

Competitive Advantage

- Scalable network planning and grid integration platform
- Community edition of the Energy Workbench is a freely available server application
- EWB uses the Common Information Model (CIM)
- Features a range of ‘out of the box’ integrations
- Enables consistent, well-structured access to the digital representation of the network model

Impact

- Enables team members to work directly with data that supports improved network planning and operation
- Reduces unnecessary and error-prone extraction, transformation and loading of data

Successful Applications

- EWB has been used by Zepben for several projects, such as evolve and real-time dynamic operating envelope engine
- Used by several distribution network service providers including Essential Energy

Capabilities and Facilities

- EWB incorporates everything required to ingest, query, visualise and manipulate electrical network data, while analysing and running load-flow studies using python libraries

Our Collaborators

- Zepben
- Essential Energy

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Large-scale Autonomous Microgrid Operated at Constant Frequency

Technology that offers a method for designing autonomous microgrids in the scale of several megawatts using renewable energy and storage. Conventional synchronous generators and renewable energy based generation are harmonised using zonalisation approaches, allowing systems to handle large load changes. Integration with large power systems is also possible through paralleled solid-state transformers.

Competitive Advantage

- Improved power quality in large-scale autonomous microgrids
- Heavier loads' switch-in and switch-off
- Significant reduction in using fossil fuels for synchronous generators
- Affordable and convenient energy storage

Impact

- Alleviate pressure from fossil fuel depletion
- Reverse air pollution in some countries that rely heavily on less fine coal-fired generation
- Allow more inhabitants and factory zones to be built with self-sufficient power supply
- Successful Applications
- Laboratory proved concepts at several Kilowatt power levels

Capabilities and Facilities

- Detailed design
- Comprehensive modelling
- Guidelines for choosing hardware to implement the large-scale microgrid

Our Collaborators

- OCET

More Information

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Microgrid Inverter Technologies

Developing innovative inverter control techniques that improve the overall response of microgrids during both normal operation and grid disturbances.

Competitive Advantage

- Pioneering inverter control schemes that enhance the reliability and resilience of microgrids, and are suitable for a wide range of load types

Impact

- Microgrids can support the utilisation of existing renewable resources, as well as the integration of distributed generation – keeping them available helps improve the reliability of supply and reduces both cost and risk
- Their suitability for small-scale microgrids and portable, mobile systems, makes these technologies ideal in disaster relief and other rapid deployment needs

Successful Applications

- The inverter control technology is currently under review by LECO, the electrical distribution operator in Colombo, Sri Lanka

Capabilities and Facilities

- An inverter and microgrid test platform that can be used to experimentally verify inverter control techniques, including grid simulators, load emulation, feeder impedances, rotational generation and loads

Our Collaborators

- A.W. Tyree Foundation
- Australian Research Council (ARC)
- Australian Energy Market Operator (AEMO)
- Australian Renewable Energy Agency (ARENA)
- Empower Energy
- Sungrow

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Microgrid Modelling and Simulation

The expertise to assess the development of microgrids across a range of timescales, from the long-term, lifetime cost of energy, to the short intervals required for protection and control systems, where events can occur – and need to be acted on – within milliseconds.

Competitive Advantage

- A real-time simulation suite capable of modelling and simulating microgrid systems with the immediacy required to perform protection studies, as well as identify potential oscillatory behaviour between fast inverter control systems
- At the forefront of research in the development of microgrids using a wide range of inverter control systems, conventional rotational generation, and energy storage
- Various modelling capabilities, including conventional RMS, EMTP and transient system modelling
- The most powerful digital simulation laboratory in Australia – UNSW's 18-rack real-time simulator is capable of modelling large, and small-scale microgrids, at the finest timescales required for protection and high-speed control systems

Impact

- Ability to assess microgrid system behaviour in real-time
- Reducing the uncertainty and risk in projects through digital simulation

Successful Applications

- The Asian Development Bank conducted a project for LECO, the electrical distribution operator in Colombo, Sri Lanka, using UNSW's microgrid simulation and modelling techniques

Capabilities and Facilities

- A leading inverter and microgrid test platform
- An 18-rack RTDS real-time simulator
- OPAL-RT real-time simulator

Our Collaborators

- A.W. Tyree Foundation
- Australian Research Council (ARC)
- Australian Energy Market Operator (AEMO)
- Australian Renewable Energy Agency (ARENA)
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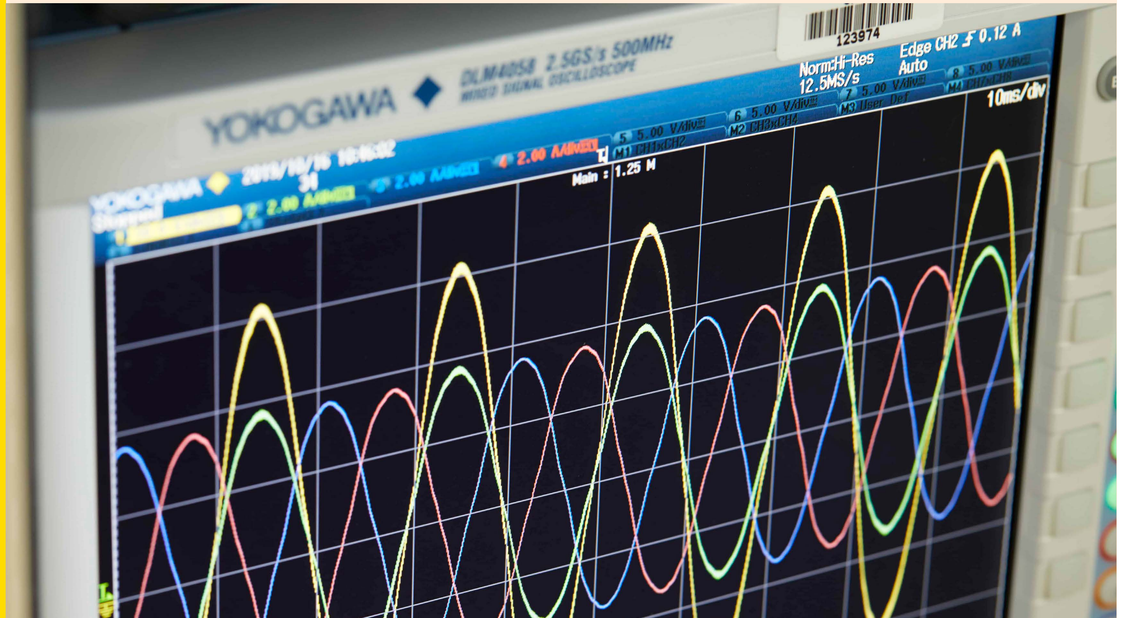
Microgrid-Grid Resynchronisation Systems

A fault occurring on a distribution line can cause circuit breakers to trip, and the microgrid to switch from grid-connected mode to islanded mode. The resynchronisation system sends measurements from the main grid to the microgrid, specifically when microgrids are separated from a weak part of the main grid, to allow the breakers to be closed and the microgrid to be reconnected. A resynchronisation system has been developed to bring the voltage, phase and frequency of a microgrid back into alignment with the main grid in the event of a fault on the distribution line.



Competitive Advantage

- A ground-breaking system that can optimise the load by either minimising the time, or the energy needed, to resynchronise
- An innovative solution that includes microgrid interrogation to determine load diversity, the optimisation of the process of synchronisation to achieve low energy cost, or produce a rapid response

Impact

- The algorithm decides which way to push the voltage amplitude, frequency and phase in order to minimise the time or the energy required to resynchronise the microgrid, based on the estimate of load and generation types

Successful Applications

- Tyree microgrid project
- Lanka Electrical Company, Sri Lanka

Capabilities and Facilities

- 25kVA experimental microgrid with diverse set of loads and generators
- 18-rack RTDS capable of modelling microgrid hardware
- OPAL-RT real-time simulator

Our Collaborators

- A.W. Tyree Foundation
- Australian Renewable Energy Agency (ARENA)
- Asian Development Bank

More Information

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Modular and Scalable Power Electronics for Large-Scale Energy Storage Systems

Unlocking the benefits of large-scale energy storage systems requires advances in power electronics topologies for interfacing and supporting the electricity grid. Multilevel converters can provide optimised, reliable, modular and cost-effective solutions for large-scale multi-megawatt energy storage systems across a range of energy storage technologies.

Competitive Advantage

- Next-generation, modular and scalable power electronics for multi-megawatt energy storage systems
- Highly efficient and reliable redundant solutions
- Extensive range of multilevel power electronics converter prototypes
- State-of-the-art measurement and grid emulation facilities
- Hardware and software validation and testing

Impact

- Next-generation power electronics topologies for large-scale energy storage
- Advanced grid support functions
- Redundant and fault-tolerant implementations
- Technology and cost optimisation, irrespective of energy storage solution

Capabilities and Facilities

- Multilevel converters (scaled-down laboratory prototypes)
- Measurement and grid simulation facilities
- State-of-the-art real-time simulators for grid integration validation, hardware and controller testing, and power hardware-in-the-loop capabilities

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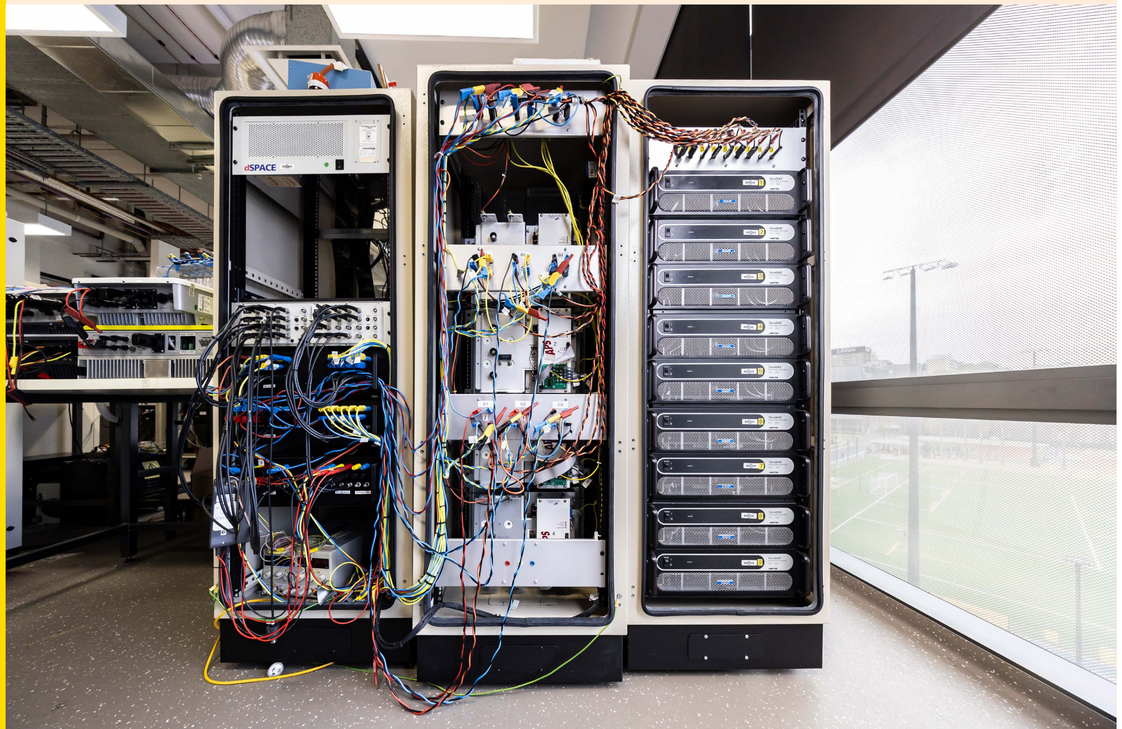
Modular and Scalable Power Electronics for Solar PV

Modular power electronics can provide optimised, reliable and cost-effective solutions for large-scale multi-MW systems across a range of renewable and energy storage applications. Unlocking the potential of large-scale solar PV and energy storage systems requires advances in power electronics topologies for interfacing with, and supporting the electricity grid.



Competitive Advantage

- Next-generation modular and scalable power electronics for multi-MW solar PV and energy storage systems
- Highly efficient, transformer-less solutions
- Reliable and resilient power electronics converters
- Extensive range of topology prototypes
- Hardware and software validation and testing

Impact

- Large-scale solutions for direct connection to medium-voltage networks
- Advanced grid support functions
- Fault-tolerant approaches
- Technology and cost optimisation, irrespective of PV or storage technology
- Capabilities and Facilities
- Scaled-down topologies of all key multilevel converter topologies
- Grid emulation and advanced measurement facilities
- Real-time simulation for grid-integration validation, hardware and controller testing

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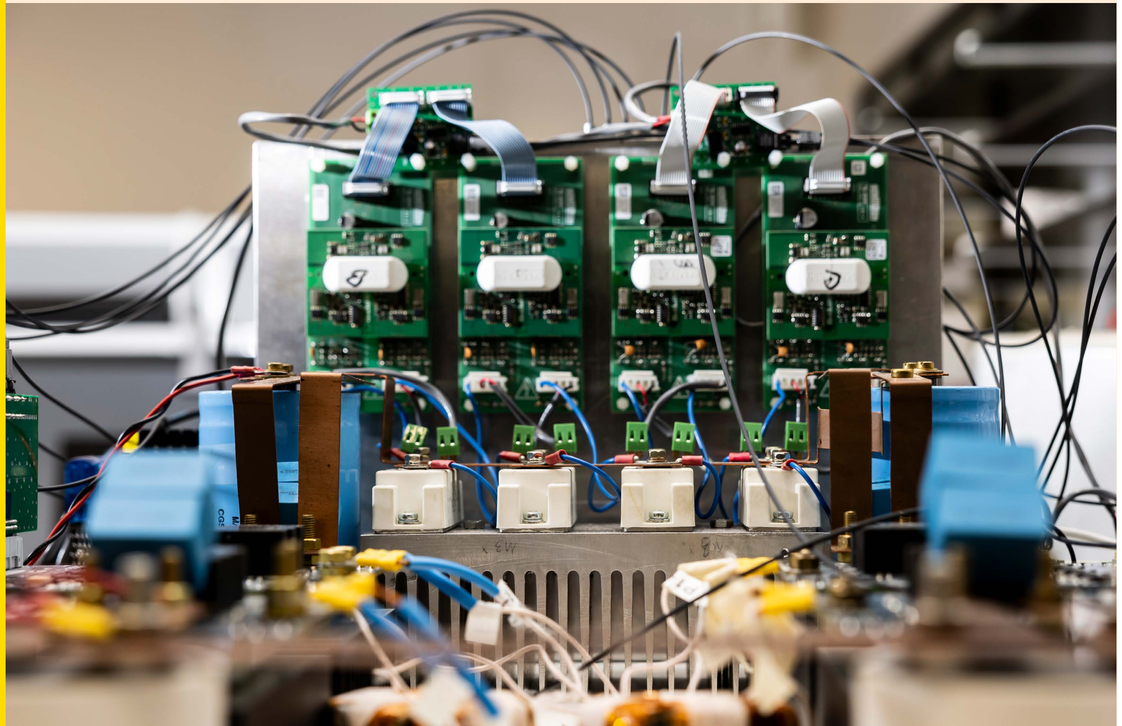
Multi-Phase Machine Drives using Coupled-Coil Inductor Outputs

A five-phase, three-level pulse-width modulated voltage source inverter and associated modulation techniques for multi-phase machine drives. The inverter employs a coupled inductor in each phase-leg to provide three-level output voltages, using only two switches per leg.



Competitive Advantage

- Compared with the popular three-level neutral-point clamped inverter, the coupled inductor inverter uses fewer switching devices, has no dead-time and associated distortion, and the DC-link capacitor voltage does not need to be balanced
- Extensive experience in the assessment and design of space vector modulation strategies
- Invention and modification of two carrier-based pulse-width modulation techniques to reduce the common-mode voltage for multi-phase inverters

Impact

- The establishment of mathematical models of coupled inductors, total inverter current and current stress on DC-link capacitors, provides insight into the way coupled inductors impact system efficiency and current stress in DC-link capacitors

Capabilities and Facilities

- Electrical machine design experience
- Multi-phase machine design techniques
- Multi-phase drives and controls
- Low-speed, high-torque and high-speed load machines

Our Collaborators

- Shandong BOFA Power Machinery
- Motorica

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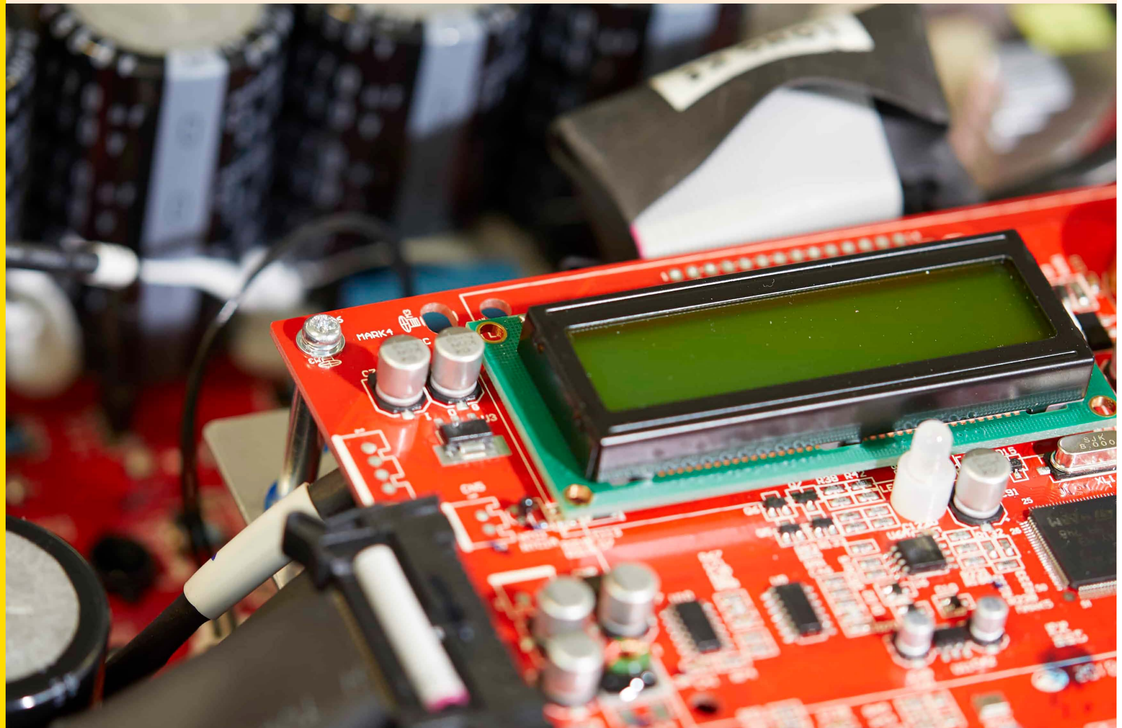
Multi-Timescale Volt/ VAR Optimisation in Smart Distribution Grids

Within an advanced distribution management system, multi-timescale Volt/VAR functionality enhances the efficiency, sustainability, stability and security of a grid. Its impact can be further improved with fast-acting smart inverters and battery energy storage systems.



Competitive Advantage

- Providing predictive control where forecasting uncertainties exist – slow and fast timescale controls are coordinated using two-stage stochastic programming
- Expertise in this area of multi-dimensional optimisation

Impact

- The rapid increase in the integration of intermittent renewable energy sources into existing distribution grids has presented technical challenges, such as voltage rise events
- The multi-timescale operational approach increases the hosting capacity of distribution grids for intermittent renewable energy sources by coordinating the timescales for corrective action across multiple systems – this improves the steady-state stability of distribution grids

Successful Applications

- Proven advantages on simulated distribution feeders, including IEEE benchmarks

Capabilities and Facilities

- Tools, software and real-time simulation capability

Our Collaborators

- A.W. Tyree Foundation

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Novel Analysis and Control of Microgrids

Applying expertise in the analysis and control of microgrids to develop and implement novel solutions.

Competitive Advantage

- Expertise in modelling, analysis, fault detection, fault classification and control of microgrids, including peak demand management, demand response, and fault-ride through operations

Novel approach to:

- detection and classification of disturbances in islanded microgrids
- fault location
- regulating frequency through demand response
- fault ride-through
- energy management systems
- Improved load-shedding techniques

Impact

- Appliance level data analysis and control
- Integration of electric vehicles
- Power demand management
- Novel controllers under unbalanced voltage conditions
- Improved techniques for fault ride-through of power converters
- Cost optimisation of microgrid energy management systems
- Stability of islanded microgrids
- Hierarchical energy managements for microgrids

Successful Applications

- 2021-2022 – Electric Drive Jet Propulsion System for Marine Boating – $178,000 (Industry/ARC Research Hub)
- 2017-2019 – Reliable microgrids for remote communities with a communication-based control architecture – $1.5m (Sir William Tyree Foundation Research Fund)
- 2013-2020 – Analysis and control of DFIG in microgrids – $45,000 (Transfield Foundation)
- 2011-2020 – Micro-generation test facility for the assessment of power quality and hybrid system control – $103,000 (Australian Power Institute)
- Capabilities and Facilities
- Single- and three- phase microgrid test facility in UNSW Electrical Engineering Building
- Three-phase microgrid in UNSW Tyree Energy Technology Building
- Software tools for analysis

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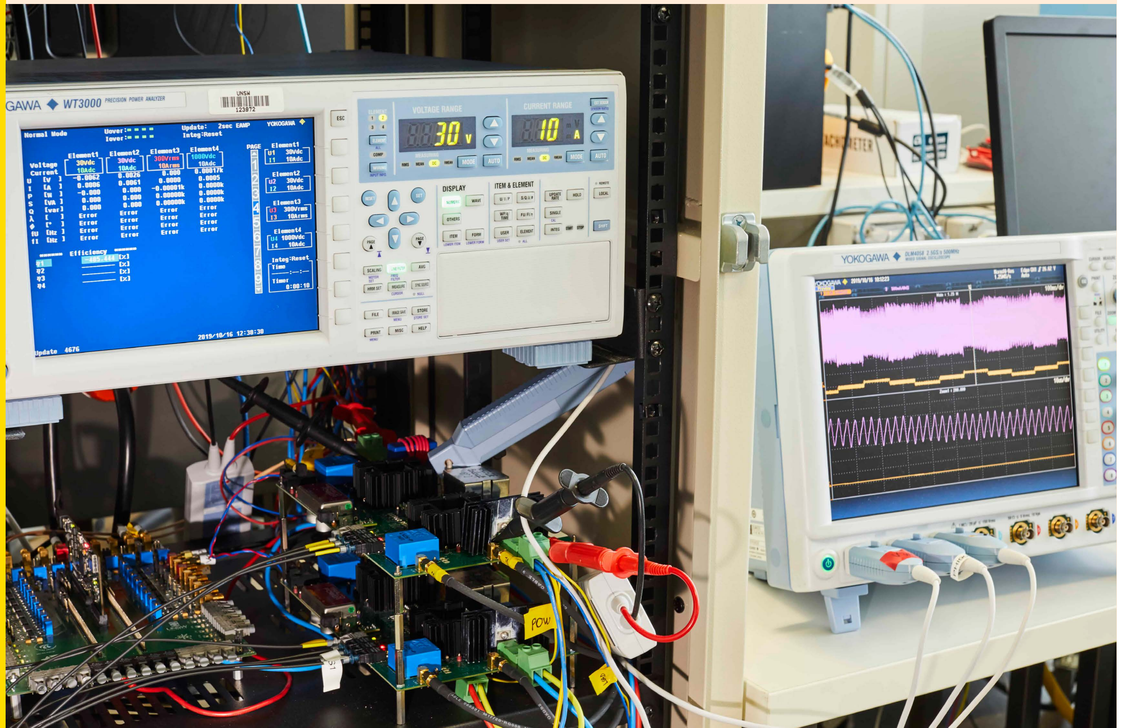
DC Microgrid Operation and Protection

The use of DC microgrids is a potential growth area with a range of platforms, including vehicles, aerospace, marine and rail. UNSW is developing tools, techniques and models to support serious experimental work on hardware prototypes, and is working on protection devices and systems. DC microgrids offer advantages over AC equivalents, such as easier control of voltage profiles, more efficient connection of typical load types via power electronic interfaces, and a reduced need for power factor control.



Competitive Advantage

- Ability to prototype high-efficiency DC-DC hardware and converter technology to enhance microgrid performance

Impact

- The techniques and technologies enhance the efficiency, performance and protection of DC microgrids

Successful Applications

- Tyree microgrid project
- Marine platforms
- Roadside signage
- Water treatment plants

Capabilities and Facilities

- Access to experimental facilities, including:
- 10kVA experimental DC microgrid with diverse set of loads and generators
- 18-rack RTDS capable of modelling microgrid hardware
- OPAL-RT real-time simulator

Our Collaborators

- Hi-Vis Group
- A.W. Tyree Foundation
- Australian Renewable Energy Agency (ARENA)

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UNSW Real-Time Digital Simulation Laboratory

Real-time digital simulation of power and energy systems with sufficient resolution (2-50μs) allows for monitoring, operation, control, testing, optimisation, validation and maintenance of large and complex electricity and energy networks. Digital and analogue interfaces facilitate advanced hardware-in-the-loop (HiL), power hardware-in-the-loop (PHiL), rapid prototyping and batch testing, which accelerate project development and commissioning time.

Competitive Advantage

- Australia's largest real-time digital-simulation laboratory and one of the largest in academic and research institutions globally
- Offers unprecedented simulation capabilities:
- Capacity to simulate >10,000 electrical nodes (phasor), +800 three-phase electrical nodes (EMT) and +2,500 single-phase nodes (EMT)
- Multiple input and output channels
- Expertise in comprehensive modelling and real-time digital simulation of power and energy systems
- Expertise in power electronics, combined AC/DC networks, and power-systems integration
- Ability to develop digital twins
- International and local benchmark model development and validation
- Test-bed systems for educational and training purposes

Impact

- More reliable, secure, stable and efficient networks
- Integration of transmission and distribution modelling
- Integration of advanced energy conversion systems, such as wind turbines, photovoltaic power plants, and energy storage systems

Successful Applications

- Broken Hill Battery Energy Storage System and grid-forming BESS
- High-voltage DC grids for flexible and efficient electricity transmission
- ElectraNet Heywood Interconnector distance protection relay HiL testing
- ElectraNet Heywood Interconnector series compensation protection testing
- Simplified 14-generator Australian network test system

Capabilities and Facilities

- 18-rack, 90-PB5 card RTDS real-time digital simulator
- 1 x OPAL-RT OP5033XG (7 cores) real-time digital simulators
- 1 x OPAL-RT OP5607 real-time digital simulator
- 4 x OPAL-RT OP4500 real-time digital simulators
- 4 x Omicron CMS100 power amplifiers
- 7 x PLEXIM PLECSBox
- 1 x Typhoon HIL604 + HiLConnect
- 1 x Typhoon HiL602
- Interface with Regatron DC/AC supplies for PHiL testing

Our Collaborators

- Australian Energy Market Operator (AEMO)
- Australian Energy Market Commission (AEMC)

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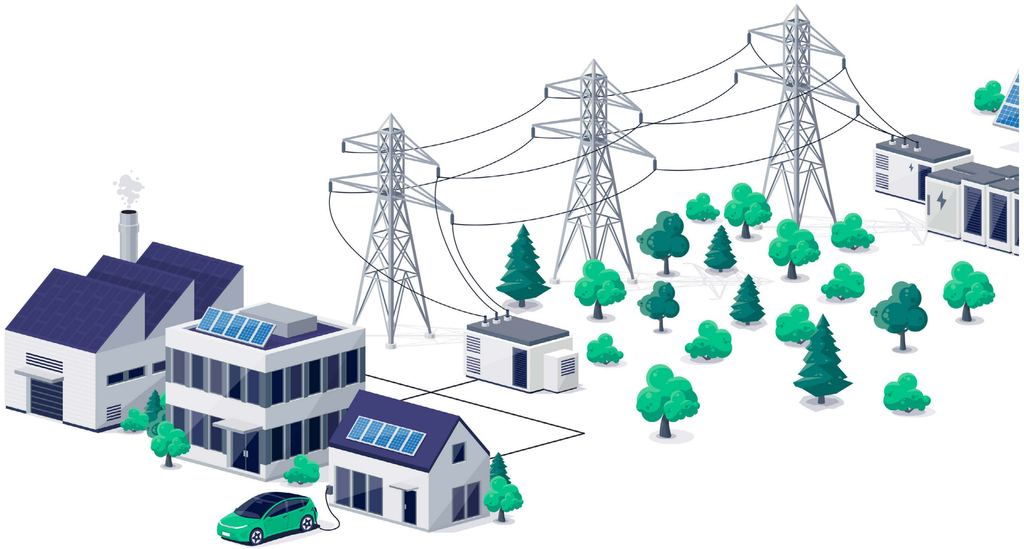
Reconfigurable Energy Storage Systems and Power Converters

Reconfigurable energy storage systems and power converters offer an innovative solution for the cost-effective interconnection of renewable sources and energy storage systems (ESS). These systems can adapt their topology and control schemes to optimise performance under variable conditions, ensuring efficient energy conversion and management.



Competitive Advantage

Development of reconfigurable ESS and power converters that can:

- Be adapted online to fulfil different operating modes
- Feed a load from various ESS and renewable sources
- Feed a load from the battery system or from a backup power source, regenerative mode, intra-module balancing mode and charging mode

Impact

- Unlike conventional systems, the reconfigurable power converter shares components among different operating modes, which makes them more compact
- Existing redundant modes increase reliability

Successful Applications

- Reconfigurable power converter system prototype that combines batteries, EVs, PV generation, and grid connection

Capabilities and Facilities

- Reconfigurable ESS and power converter prototyping
- Hardware-in-loop simulation for rapid assessment of control techniques
- Hardware testing capability up to 50kVA, 1kV, 400A
- Arbin Instruments battery tester
- Cadex C8000 battery testing system with a load capture unit
- Hioki battery simulator
- GAMRY Model REF3000 potentiostat
- LiBa WorkStation
- TempEvent temperature chamber with EUCAR 5 level capability

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Solid-State Transformers for Microgrids and Battery Charging

Solid-state transformers (SSTs) utilise power electronic converters on either side of a medium frequency (20-100 kHz) transformer. This provides bi-directional power flow, while addressing the fast control and protection objectives of modern microgrids and battery charging systems. SSTs overcome many limitations of 50 Hz utility transformers by offering higher power density and significantly reducing the size of power transformers.

Competitive Advantage

- Demonstrated capability in the design of converters and controllers for SSTs with 20 kHz transformer
- Modular design capability to supply higher power via series and parallel interconnections
- Designed, built and tested a 4kW SST at UNSW in 2018

Impact

- Global market size for SSTs is currently valued at an estimated $100b, and is increasing at a rapid rate. This is due to their inherent ability for fast control and protection of power flow in both directions, high efficiency, and smaller footprint (implying high power density).
- SST will underpin the development of the intelligent grid – a grid that is not only smart, but capable of controlling the flow of power and energy through the expanding network, and remediating power quality and reliability for consumers and generators alike
- Research undertaken at UNSW on SSTs resulted in several IEEE conference publications and Transactions

Successful Applications

- Intensive research in SST development is currently underway in several universities across Europe, USA and Japan, in conjunction with industries
- This research has attracted the attention of an Australian company with extensive experience in energy systems, resulting in the submission of a joint grant application to develop a 60kW SST for application in microgrid and battery charging installations

Capabilities and Facilities

- UNSW has a proven track record in the design of SSTs. Although it has a reasonable infrastructure at low power levels, scaling up the existing 2kW SST will require further infrastructure development.

Our Collaborators

- Trailblazer for Recycling and Clean Energy (TRaCE)

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Virtual Power Plants Based on Energy Storage Systems

The coordination of a large number of energy storage systems (ESS) can be simplified by dynamically clustering them into virtual power plants (VPPs). This creates an integrated network that functions as a unified and flexible power plant, which offers several benefits. Managing variability and intermittency associated with individual systems becomes easier through VPPs.
By combining the capacities of multiple ESS, VPPs can optimise energy usage, reduce peak demand and facilitate a more resilient and reliable grid. The primary technical challenge involves harmonising different types and capacities of ESS, while addressing the unique behaviours of individual customers. It requires monitoring the continual connections and disconnections of ESS, as well as potential changes in the power network.

Competitive Advantage

- Expertise in developing distributed multi-agent control strategies for ESS and their aggregation into virtual power plants based on operating requirements and energy storage properties

Impact

- VPPs can reduce network costs by improving the utilisation of the network asset, and providing opportunities through technical innovation, for peer-to-peer trading in the future
- VPPs can help reduce the roadblock associated with limited hosting capacities on feeders

Successful Applications

- Development of algorithms for online peer-to-peer based distributed aggregation of ESS into virtual power plants, thereby improving the utilisation of available energy storage capacity and reducing grid power losses

Capabilities and Facilities

Real-Time Digital Simulators (RTDS) that facilitate:

- Real-time verification of algorithms and simulation of power networks combined with accurate models of energy storage systems and power converters
- Hardware-in-the-loop simulation (the final step before field verification) that presents an opportunity for rapid research, development and verification – this is necessary for translating theoretical advances in multi-agent cooperative control and aggregation algorithms into new strategies suitable for deployment in power system networks

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Infrastructure Investment Assessment

The push towards a renewable energy system presents increased risk, uncertainty and opportunity. As many organisations assess their current exposure to risk from their energy-related investment portfolio, or contemplate new investments, they require tools that assist decision making and risk management, including technical and economic performance.

Competitive Advantage

- Multidisciplinary expertise to facilitate more informed decisions
- Expertise in real-time simulation to assess technical constraints
- Rapid system modelling and simulation capability

Impact

- De-risk and protect existing investments
- Determine technical and operational impacts of third-party investments
- Identifying optimal location and sizing of storage at all scales

Successful Applications

- Identifying minimum inertia requirements in the National Electricity Market (NEM)

Capabilities and Facilities

- A fleet of open-source tools for system performance assessment
- 18-rack RTDS capable of modelling power system impacts
- OPAL-RT real-time simulator for fast simulations

Our Collaborators

- Transgrid
- Australian Energy Market Operator (AEMO)

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Facilitating Network Integration of Distributed Solar PV

Addressing the characterisation of photovoltaic (PV) generation variability to help network operators appropriately plan for high distributed PV penetration. A method for estimating the amount a low-voltage feeder can accommodate without exceeding upper voltage limits has been developed, as well as methods to manage distribution voltage levels. Whilst the electricity grid can accommodate distributed PV generation, at higher penetration levels, we address two key impacts – voltage variability and voltage rise – contributing to the successful technical integration of distributed PV generation.

Competitive Advantage

- Comprehensive characterisation to describe the behaviour of PV generation variability throughout the day and year
- Creation of a simple and efficient method for estimating the level of PV generation a low-voltage feeder can accommodate, without exceeding upper voltage limits
- Expertise in methods for integrating PV systems, controllable loads and other devices, such as electrical storage, to manage distribution voltage levels

Impact

- Simple and efficient methods for estimating maximum distributed generation capacity of a feeder that doesn't require new communication infrastructure – shown to be more efficient and equitable than similar current proposed methods
- A tool in which network and microgrid operators can quickly and easily determine approximate values of maximum PV generation for their distribution feeders
- An original distributed voltage control method using residential PV systems and controllable loads to ensure upper/lower voltage levels are maintained within regulation limits

Successful Applications

- Feeder modelling for distribution operators

Capabilities and Facilities

- Software tools to expedite analysis of feeder capability
- Real-time digital simulation facilities to verify models

Our Collaborators

- Australian PV Institute (APVI)
- Endeavour Energy
- Australian Renewable Energy Agency (ARENA)

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Energy Markets

UNSW is striving towards least-cost and least-regret integration of renewables into energy markets. We are cognisant of Australia's role in the global energy transition and seek to extend the impact of our work beyond our borders. Our work focuses on the challenges and opportunities of clean energy transition within market-oriented electricity industries. We believe in data-driven research inputs and open-source research outputs.

Australia is uniquely positioned to support the energy transition of our neighbouring countries in the Pacific region. In particular, Australia has the potential to produce excess renewable energy resources that could be shared across borders. In the context of our global region of island nations (compared to regions with shared borders and electrical interconnection) renewable hydrogen export is a promising option.

Atmospheric Measurements of Greenhouse Gas Emissions for Verifying Carbon Accounting and Mitigation

Measuring the rates of greenhouse gas emissions from facilities using atmospheric observations verifies National Greenhouse and Energy Reporting (NGER) submissions, identifies mitigation opportunities, and reduces carbon risk. UNSW Sydney specialises in identifying sources of greenhouse gas emissions and quantifying the rates of emissions from facilities and regions using car, drone, and aircraft-based measurement systems. We can design measurement systems to track net zero progress using continuous ground, airborne or satellite-based greenhouse gas measurement systems.

Competitive Advantage

- Australia's only provider of simultaneous car or aircraft-based measurements of the atmospheric concentrations of methane, carbon dioxide and carbon monoxide
- Leaders in confirming fugitive emission estimates from facilities and verifying satellite observations of greenhouse gas emissions

Impact

- UNSW methane studies, affiliated with UNEP Methane Science projects, have been cited in Australia's National Inventory Submissions to demonstrate independent verification of emissions estimates

Successful Applications

- Mapped and reported numerous gas leaks throughout Australia, resulting in improved safety
- Identified greenhouse gas mitigation opportunities for both industry and government
- Quantified emissions from power plants, coal seam gas developments, coal mining, feedlots, agricultural landscapes, landfills, waste management facilities, gas distribution networks, and other sources

Capabilities and Facilities

- Monitoring facility emissions using time series measurements of greenhouse gases
- Isotope studies for source identification
- Car-based surveys for mapping sources of greenhouse gas emissions
- Drone-based surveys for quantifying the rates of greenhouse gas emissions from factories, landfills, and waste facilities
- Aircraft-based surveys for quantifying the rates of greenhouse gas emissions from mines or regions
- Verifying satellite observations of greenhouse gas emissions

Our Collaborators

- Australian and State Governments
- United Nations Environment Programme – Methane Science Studies

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City Futures Research Centre

The City Futures Research Centre (CFRC) has evolved into a national leader in scholarly applied public interest research on our cities since 2005. We collaborate with a range of academic researchers, both within UNSW and other universities across Australia and overseas. Our applied focus includes strong partnerships with local, state and federal government agencies, as well as industry stakeholders and community groups, to develop evidence-based ideas for addressing the complex challenges of urban change and growth.

Competitive Advantage

- CFRC partner with more than 100 businesses, government, and community organisations in Australia and internationally on specific projects, translating research into practice and real-world impact
- Research focuses on six themes – compact cities, housing, healthy built environments, sustainable mobility, urban analytics, and urban planning

Impact

- CFRC's work advances the understanding of cities focusing on people, places, policies and technologies, with a focus on the major urban challenges of city equity, housing, productivity, sustainability, resilience, governance and renewal. This is undertaken in partnership with governments, industry, not-for-profit organisations, and communities. CFRC is committed to advancing the United Nations' Sustainable Development Goals with over 90% of projects related to at least one goal.

Successful Applications

- Secured almost $14 million revenue in grants over the past five years
- Internationally recognised leading researchers on housing, land-use planning, active transport, sustainable development, and urban equity issues
- Developed innovative urban big-data analytics, as well as visualisation and modelling technology, to provide innovative and sustainable solutions to urban problems – includes the RAISE toolkit, Transport Oriented Development Atlas, a National Cycling Data Analytics platform, and a Cycling Infrastructure Scenario Builder
- Provided solutions in residential energy use by creating resources to improve energy efficiency for lower-income households, and to support sustainability retrofits in strata titled properties

Capabilities and Facilities

- Conducts high-level policy reviews and evaluations, providing evidence-based recommendations to policymakers
- Investigates qualitative impacts of energy poverty on disadvantaged households, and inform on targeted interventions
- Specialises in analysing energy usage patterns in the residential sector to guide energy efficiency strategies
- Understands the challenges facing the adoption of sustainable building practices in apartment and strata titled properties aligned to unique aspects of their financing, design, construction, and management
- Conducts research on active transport and sustainable mobility solutions, contributing to the development of policies and infrastructure that promote walking, cycling, and public transportation, reducing carbon emissions and enhancing urban liveability
- Equipped with a world-class City Analytics Lab featuring advanced GIS technology for urban analytics, modelling and visualisation, supporting innovative urban planning solutions

Our Collaborators

- Australian Research Council (ARC)
- Australian Housing Urban Research Institute (AHURI)
- Australian Urban Research Infrastructure Network (AURIN)
- Australian Cycling Environmental Health Foundation
- Bicycle Network
- Bicycle Industries Australia
- City of Sydney
- Community Housing Industry Association (CHIA)
- Commonwealth Bank of Australia
- FrontierSI
- Heart Foundation
- Housing Australia
- iMOVE Cooperative Research Centre
- NSW Office for Sport
- PEXA
- Penrith City Council
- Wollongong City Council
- Transport for NSW
- We Ride Australia

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Collaboration on Energy and Environmental Markets

The Collaboration on Energy and Environmental Markets (CEEM) undertakes interdisciplinary research into the challenges and opportunities of the clean energy transition within market-oriented electricity industries. Key aspects of this transition are the integration of large-scale renewable technologies and distributed energy resources (generation, storage and 'smart' loads) into the electricity industry.

Competitive Advantage

- The CEEM is unique in that it brings together experts across engineering, data science, business, social sciences and law
- One of Australia's leading research groups on restructured electricity industries with more than a decade of experience delivering expert solutions on market design, regulatory arrangements, and related policy framework development
- Extensive expertise in the electricity market and distributed energy modelling, application of data science to energy problems, and the development of open-source tools

Impact

- Analysis of the role of variable renewable generation – from distributed energy resources, storage and demand-side flexibility for the transition of electricity systems and markets, to the integration of high penetration renewable energy, both centralised and distributed

Successful Applications

- Open-source tools, including energy market dispatch and planning, tariff design, power-purchase contracting, distributed energy sharing and aggregation models
- Interdisciplinary frameworks for policy, market and regulatory assessment, and design
- Analysis of the impacts and value of distributed energy resources and demand-side flexibility on networks and power systems

Capabilities and Facilities

- Multidisciplinary research team including engineers, data scientists, social scientists, lawyers and business experts
- Expertise in energy modelling using proprietary software, and the development of open-source tools

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Demand-Side Flexibility and Distributed Energy Resources

Conducting interdisciplinary research into technical, economic, social and policy drivers, and barriers to integration of Distributed Energy Resources (DER). This includes solar, home and community batteries, electric vehicles, efficient electric appliances and provision of demand-side flexibility by households and businesses.

Competitive Advantage

- Focused on restructured electricity industries with over a decade of experience in conducting market design, regulatory arrangements, and related policy framework development
- A multidisciplinary approach encompassing engineering, business, social sciences and law, with a strong track record of industry partnerships
- Team members participate in International Energy Agency collaborative tasks on integration of high-penetration DER

Impact

- Provide data, tools and analysis to enhance understanding of DER integration challenges
- Help drive the development of technologies, regulation, business models and market design, to facilitate demand flexibility and improve integration of renewable generation

Successful Applications

Development of open-source tools:

- modelling impact of distributed solar curtailment and response to grid disturbances
- modelling embedded networks and local energy sharing arrangements
- rooftop solar potential assessment and techno-economic impacts
- network impacts of uncontrolled and ‘smart’ electric vehicle charging
- tariff modelling and analysis tools
- residential pre-heating and cooling model
- solar hot water load-shifting model
- Rigorous analysis of network and bill impacts of DNSP trial of cost-reflective tariffs
- Analysis of the interactions between different DER technologies and the impacts on individual and aggregate load profiles as seen by the broader market
- Assessment of opportunities for development of household energy flexibility
- Submissions to policy and regulatory processes

Capabilities and Facilities

- Expertise in electricity market and distributed energy modelling, from data science applications to energy problems and the development of open-source tools
- Access to high performance computing facilities on campus, and at the National Computational Infrastructure in Canberra

Our Collaborators

- All levels of Government
- National Electricity Market (NEM) institutions
- Network businesses
- Industry associations
- NGOs
- Consultants, renewable energy developers, distributed energy businesses, and startups

More Information

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Development of Building Codes and Standards

Developing the science behind legislative building codes and minimum energy performance standards in many locations around the world.

Competitive Advantage

- Providing access to leading-edge technology for various countries
- Specialists in reducing energy consumption in the building sector
- Expertise in improving thermal and visual comfort, productivity and environmental quality across the building sector

Impact

- Proven track record in delivering significant energy consumption and carbon emissions reductions
- Contributing to the development of legislative codes that define the energy consumption, cost, environmental quality and carbon emissions of buildings globally
- Reducing heat-related mortality and morbidity

Successful Applications

- Collaboration with a number of Governments and Regional Authorities, including the European Commission and Government of Greece

Capabilities and Facilities

- Laboratory capable of performing a wide range of energy and environmental measurements in buildings
- Mobile energy bus with thermal cameras, tracer gas equipment, IAQ sensors and analysers, light and daylight measuring equipment, and a drone for performing aerial measurements
- A wide range of environmental simulation tools for assessing building performance

Our Collaborators

- European Commission
- Government of Greece
- Governments of Seychelles, Mauritius, Madagascar, Comoros
- Northern Territory Government

More Information

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Energy Asset Valuation

Expertise in uncertainty modelling, risk analysis, and asset valuation on energy generating and storage facilities that are subject to operational constraints, investment flexibility, and market uncertainties.

Competitive Advantage

- Ability to conduct market-based asset valuations, taking energy production and storage process options into account
- Expertise in assessing the optimal timing for investment in energy assets, despite an uncertain policy environment

Impact

- Enabling the optimal adoption of clean technology to combat climate change
- Creating sustainable operations that achieve environmental stewardship

Successful Applications

- Valued thermal generating units subject to physical constraints, such as ramping, minimum up/down times, overfiring and preventive maintenance
- Compared tradeable permits and carbon taxes in terms of how each instrument can effectively induce clean technology adoption
- Valued the investment of a fast pyrolysis facility for producing cellulosic biofuels in Iowa

Capabilities and Facilities

- Unit commitment problem in a power grid
- Clean technology investment valuation
- Optimal natural gas storage and operations

More Information

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Integration of Energy Efficiency and Renewable Energy into Industry

Applying expertise in energy metering and monitoring to develop and implement energy-efficient solutions.

Competitive Advantage

More than 15 years of experience in industry-driven R&D both in Australia and internationally:

- Development and implementation of energy efficiency roadmaps
- Strategic energy metering and monitoring
- Holistic energy efficiency assessment in industry
- Energy accounting from process department to factory level
- Renewable energy integration into factories through microgrids
- Management of energy supply and demand in factories

Impact

- Helping industry save money and become ‘greener’ by increasing energy efficiency and integrating renewable energy into their operations

Successful Applications

- Significant reduction in energy costs and associated environmental footprint in the aluminium, pharmaceutical, metal fabrication, waste management, and heavy engineering industries:
- 45% energy consumption reduction in aluminium industry
- 51% energy consumption reduction in pharmaceutical industry
- 43% energy consumption reduction in metal fabrication
- Successful planning and implementation of an onsite microgrid in a pharmaceutical company, which resulted in 85% onsite renewable energy generation

Capabilities and Facilities

- Extensive energy metering and monitoring equipment
- Propriety energy consumption models for various industrial processes
- In-house energy flow analysis and optimisation software for industry

Our Collaborators

- Alcoa
- Baxter International
- Preformed Line Products
- FIP Brakes International
- SUEZ Australia & New Zealand
- IFU Hamburg

More Information

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Energy Governance and Local Capacities

Associate Professor Wu is a leading scholar in environmental movements, state-society relations, and global governance with two decades of field experience in East Asia, Southeast Asia, and Central Asia. She currently serves on the Executive Committee of the International University Climate Alliance and edits the AUP Environment and Society in Asia Book Series.

Competitive Advantage

- Expertise in environmental politics in East Asia, Southeast Asia, and Central Asia, in particular China, Vietnam, Kazakhstan and Mongolia respectively
- Scholarship on environmental movement and governance

Impact

- Delivery of keynote speeches at international energy-related policy forums and conferences
- Consultancy to state and international agencies in the field of climate change and energy transition
- Market risks for renewable energies (2017) – Royal Netherlands Academy of Arts and Social Sciences (KNAW)
- Expert review of global strategic implications of the emerging markets for renewables and new energies

Successful Applications

- Democratic Transition and Environmental Protection (2017) – Social Science Research Council, Singapore
- Comparative analysis of environmental governance (including climate mitigation) in transitional economies, in particular Eastern Europe and Southeast Asia

Capabilities and Facilities

- Social scientific research methods (both qualitative and quantitative)
- Broad research networks in Asia, North America, and Oceania

Our Collaborators

- Global Greengrants Fund (USA)
- Global Environmental Institute (China)
- Blue Moon Fund (USA)

More Information

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Flexible Operation of Energy-Intensive Processes for Industrial Scale Demand-side Power Management

Many industrial processes such as aluminium smelting are highly energy intensive. Australian aluminium smelters use more than 12 percent of total electricity generated in Australia. One effective way to reduce their environmental footprint is to power them with renewable energy. However, the challenge with renewable energy is intermittency. An industrial scale demand-side power management approach acts as a virtual energy storage technique to help stabilise the grid with significant penetration of renewable energy generation.

Competitive Advantage

- Developed capability of flexible operation of industrial processes (power modulation) – can be implemented to dynamically adjust the production rate with the time-varying availability and cost of electricity
- Advanced process control techniques based on contraction theory
- Advanced smelting cell real-time monitoring and control techniques enabling power modulation
- Sophisticated dynamic models for cell operations and control developed from industrial data and experiments using production cells
- Know-how and intellectual property in power modulation

Impact

- Significant improvements in flow battery systems
- Greater flexibility in battery operation for optimised charging and discharging with time-varying input/output power for integration with renewable power sources
- Improved voltage stability and power
- Helps reduce manufacturing costs

Successful Applications

- Power modulation operations at Emirates Global Aluminium (UAE) and TRIMET (Germany)

Capabilities and Facilities

- Smart sensing systems for online monitoring of aluminium smelting cells (patent granted)
- Advanced soft sensing techniques for aluminium smelting cells (patent granted)
- Optimal cell control techniques that take advantage of thermal capacity of smelting cells for maximised operational economy and flexibility

Our Collaborators

- Emirates Global Aluminium (UAE)
- TRIMET (Germany)

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Global Climate Governance and Community Resilience for Clean Energy Transition

Leaders in the research of global climate governance, disaster relief and community resilience in the Indo-Pacific region.

Competitive Advantage

- Thought-leadership for today's global challenges, including human factors affecting clean energy transition and production

Impact

- Undertaken extensive research on global climate governance
- Supported policies in strengthening disaster relief and human resilience in relation to climate change and clean energy transition in the Indo Pacific region

Capabilities and Facilities

- Offer cutting-edge research expertise via the following research groups:
- Environmental Futures
- Asia-Pacific Development & Security
- International Ethics
- Maritime Security

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Governance for Sustainable Mobility

Research to identify the governance pathways necessary for the transition to more sustainable mobility, including active transport and electric vehicles (not just cars, but also buses, bicycles and micromobility). Sustainable mobility is essential for the climate transition, and is also critical in meeting a wide range of health, economic and social justice goals.

Competitive Advantage

- Expertise in planning, property and environmental law
- Advanced skills in sociolegal analysis using mixed methods, including qualitative interviews, observations and naturalistic studies
- Global networks and strong links with state and local government

Impact

- Supporting and accelerating the transition to sustainable mobility, particularly cycling
- More sustainable, efficient and inclusive regulatory frameworks for urban governance
- Governance pathways for better management of streets and transport infrastructure

Successful Applications

- First major study of food delivery cycling in Australia
- Social and economic analysis of parklets and governance of kerbside parking
- Sociolegal analysis of infrastructure for electric vehicles (EVs)

Capabilities and Facilities

- Understanding how regulatory frameworks operate on the ground, as diverse actors engage in different ways with the laws that structure cities
- Transport and urban governance analysis with an emphasis on gender and marginalised groups

Our Collaborators

- Office of Road Safety
- James Martin Institute for Public Policy
- RACE for 2030
- City of Sydney
- Uber
- The Committee for Sydney
- Urbis

More Information

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Life-Cycle Engineering of Energy Supply and Energy Technologies

Expertise across sustainable manufacturing and product development, life-cycle engineering and manufacturing, and closed-loop manufacturing. Extensive experience implementing renewable energy and energy storage solutions for the manufacturing industry.

Competitive Advantage

First in Australia, and one of the worlds-first to develop hands-on capability in:

- Holistic energy efficiency assessment in manufacturing
- Renewable energy integration into factories through microgrids
- Management of energy supply and demand in factories
- Cradle-to-cradle battery supply chain sustainability, integrity and transparency
- Environmental impact assessment of battery supply chains

Impact

- Millions of dollars saved for the manufacturing industry

Successful Applications

- Implementation of energy-efficient technology
- Achieving industry-wide impact by serving as an invited expert advisor to the NSW government's energy efficiency program
- Contributing technical expertise in the Australian Government industrial energy efficiency program

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Regulatory Strategy and Governance

A strategic and academically rigorous approach to regulatory analysis and design, with a focus on best governance practice, ensuring regulatory responses are robust and evidence-based.

Competitive Advantage

- A renowned team of global leaders with a shared regulatory mindset and extensive experience in both regulatory and governance design

Impact

- At a time where there is increasing pressure for regulators to act, the challenge remains for both those who set, and are governed by regulations. This only highlights the critical nature of robust research and well-considered analysis.

Successful Applications

- Research utilised by regulators around the world
- Locally, the team has worked with the ACCC, ACMA, ASIC and the Treasury at a Federal level, as well as many NSW agencies
- Globally, the team has worked with regional regulators, including Cambodia, China, Laos, Malaysia, Thailand, Singapore and New Zealand

Capabilities and Facilities

- The research network has members across a number of regulatory disciplines, including networked industries and emerging technologies
- All team members have deep experience as both regulators and advisers to those operating within regulations

Our Collaborators

- Cyber Security Cooperative Research Centre

More Information

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System-Level Energy Market Modelling

Modelling the operation and expansion of energy systems and markets, with a focus on Australia's National Energy Market. This includes system-level impacts of decarbonisation and future net zero scenarios, to understand different approaches to planning, operation and market reform for integrating large-scale Variable Renewable Energy (VRE).

Competitive Advantage

- A research group with over a decade of experience in conducting system and market modelling and developing open-source tools
- Multidisciplinary approach encompassing data and engineering science, business, social sciences and law
- Strong track record of industry partnerships with diverse stakeholders, including DNSPs, retailers, technology suppliers, and regulators

Impact

- Contribute to system planning and policy design to develop an effective and efficient pathway to a future high VRE, zero emissions electricity system

Successful Applications

Open-source tools:

- dispatch and optimal planning (NEMO)
- capacity expansion (Open-CEM)
- market simulation (NEM-Lite)
- data access (NEMOSIS)
- power-purchase contracting
- Integration of distributed energy modelling in electricity market models
- Analysis of VRE impact on and participation in frequency management and Frequency Control Ancillary Services (FCAS) markets
- Interdisciplinary frameworks for policy, market and regulatory assessment and design, informing numerous submissions to regulatory and market rule change processes

Capabilities and Facilities

- Modelling expertise using proprietary and open-source software
- Access to high performance computing facilities on campus, and at the National Computational Infrastructure in Canberra

Our Collaborators

- All levels of Government
- National Electricity Market (NEM) institutions
- Network businesses
- Industry associations
- NGOs
- Consultants, renewable energy developers, distributed energy businesses, and startups

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Renewables in High-Temperature Industrial Processes

Among various energy applications, high-temperature industrial processes are some of the most difficult to decarbonise. However, renewable fuels and/or concentrated solar-thermal energy, have the potential to address this challenge if existing processes can be adapted.

Competitive Advantage

- Deep modelling and experimental capability in high-temperature, multiphase, chemically reacting flow
- Expertise in techno-economic modelling

Impact

- Enables the integration of renewables into high-temperature industrial processes from early stage concept development, through to design and scale-up, and techno-economic assessment

Successful Applications

- Research focused on the integration of solar-thermal energy into the alumina production process

Capabilities and Facilities

- Experimental solar furnace ~700 suns
- Comprehensive, in-house modelling capability for turbulent, multiphase, chemically reacting flow

Our Collaborators

- Alcoa
- Australian Renewable Energy Agency (ARENA)

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Artificial Intelligence for Rock and Ore Characterisation

An innovative platform for using advanced data analytics methods, based on convolutional neural networks and generative adversarial networks. These methods enable the prediction of important properties of rock and ore, to improve efficiency and promote automation in minerals and energy resources engineering.

Competitive Advantage

- Ability to determine mineral contents of rock/ore at high-resolution using machine learning
- Ability to predict porosity, permeability, and relative permeability curves of reservoir rock
- Leading the automatic identification of:
- patterns and features in rock/ore images
- fractures in drill cores

Impact

- Automated analyses of drill cores for identifying features of interest
- Improved efficiency in the mining industry through the reliable determination of mineral contents
- High-fidelity reservoir models to optimise recovery

Successful Applications

- Tested on several reservoir rocks where petrophysical properties were predicted with high accuracy
- Tested on multi-mineral rocks with mineral contents identified

Capabilities and Facilities

- Computational facilities for training and testing
- High-resolution X-ray CT scanners

More Information

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Improving Mineral Resources Recovery

The increasing demand for materials in the renewable energy and energy storage sectors is driving production of low-grade ores and non-traditional mineral resources. These resources largely undergo purification through physical separation processes. The performance of separation processes directly impacts the production of valuable minerals and metals. By advancing the science of mineral separation and developing innovative technologies and integrating ore properties into separation efficiency, the separation performance can be improved to optimise the production of these valuable minerals.

Competitive Advantage

- Expertise in processing difficult-to-recover minerals using froth flotation, with the aim of maximising resource recovery and reducing emissions during downstream processing
- Expertise in connecting ore properties to separation performance with the goal of minimising energy consumption and optimising the recovery of metals essential for clean energy and emerging technologies
- Proficiency in process development for the recovery of essential and critical minerals from both traditional and non-traditional sources
- Experience and access to a diverse range of ore and surface characterisation techniques
- Competence in assessing the energy demand response of essential and critical minerals processing plants through analysis for facilitating the mineral industry's transition towards renewable energy sources

Impact

- Identification and implementation of advanced control strategies, optimisation techniques, and process modifications, to improve the efficiency, effectiveness, and overall performance of mineral separation processes with a specific focus on essential and critical minerals

Successful Applications

- Analysis of process parameters on plant performance

Capabilities and Facilities

- Custom-built techniques for characterisation and extraction of metals required for clean energy and emerging technologies
- Mineral/air water surface characterisation facilities
- Well-established mineral processing and surface chemistry laboratories, with direct access to the state-of-the-art Mark Wainwright Analytical Centre offering various analytical capabilities, including Micro CT scans

Our Collaborators

- Australian Research Council (ARC)
- Australian Coal Association Research Program (ACARP)
- BASF
- Breville
- BHP

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Regulating Energy Transitions and Security

Research charting the legal and regulatory pathways that will influence the transition to a more sustainable energy regime. Notably, the choice of technology and its impact on climate, water, food and society, and how the competing goals of energy security and environmental sustainability will be managed.

Competitive Advantage

- Expertise in natural resources, environmental and energy law
- Advanced skills in applying quantitative surveys, qualitative interviews and legal analysis to enhance the implementation of energy law and regulation
- Global networks and expertise in regulating the food-energy-water nexus

Impact

- Ensuring energy transitions achieve more optimal social and environmental outcomes
- More sustainable, efficient and integrated regulatory frameworks for energy developments
- Governance pathways for better management of contested environment, social and economic goals

Successful Applications

- Identifying international reforms to balance energy security and sustainability
- Development of more integrated legal frameworks for managing unconventional gas and its impacts on food and water

Capabilities and Facilities

- Law and policy design optimisation for governing energy and its impacts on food, water and the environmental system
- Access to leading energy law and regulatory scholars in the UK and USA through the PLuS Alliance

More Information

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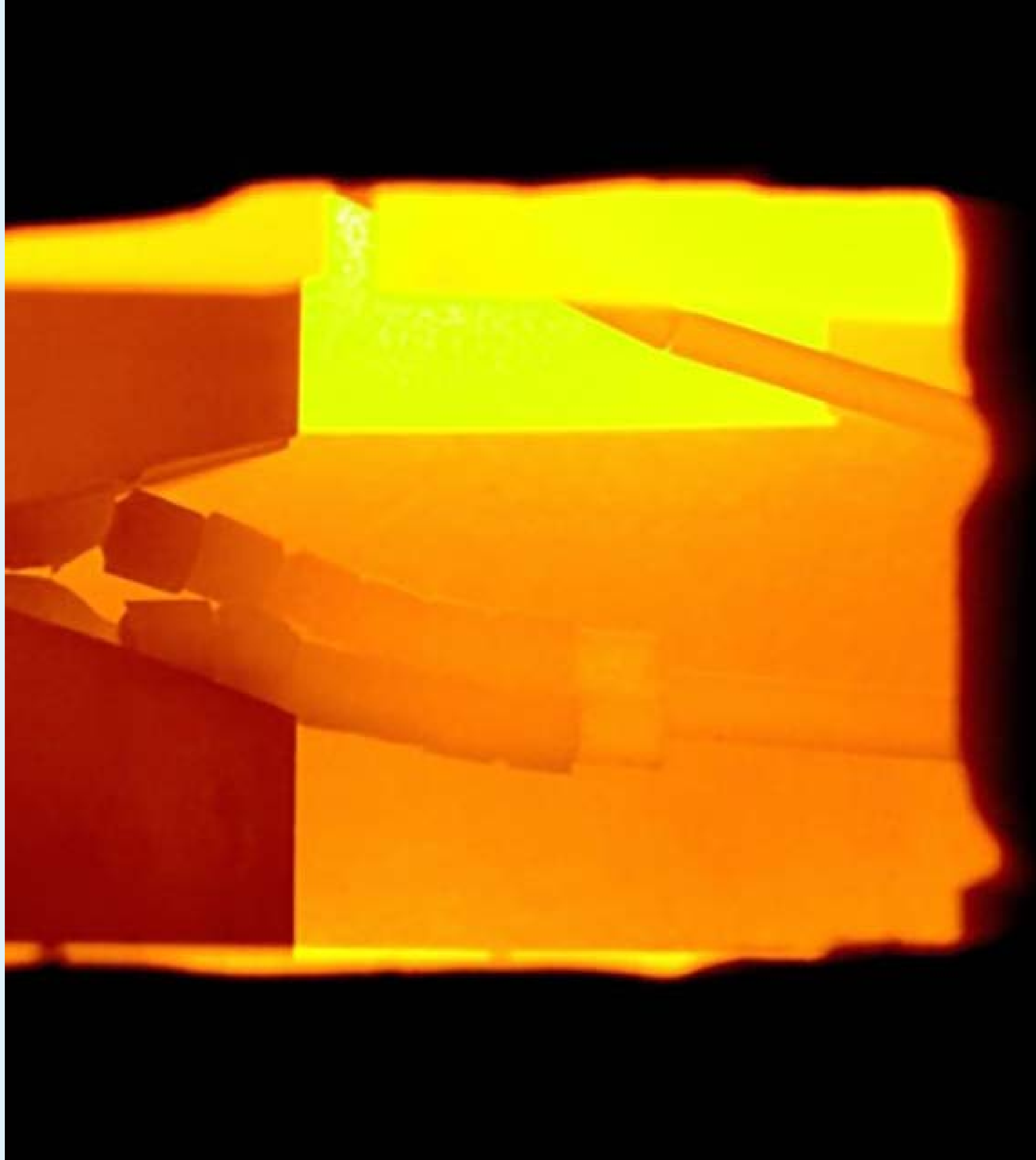
Thermo-Mechanical Properties of Advanced Engineering Materials

Material characterisation, mechanical testing, failure analysis, and lifetime prediction across a range of harsh and challenging energy-production environments. Delivering a better understanding of materials to develop advanced and novel alloys, ceramics, and bioinspired composites that are energy-efficient and economically viable.



Competitive Advantage

- Ability to test material performance in extreme environments – e.g., nano-mechanical testing up to 600oC in electron microscopes, macro-scale, testing from cryogenic to 1500oC, corrosive and oxidising environments, vacuum, inert gas, aqueous and biological conditions
- Novel material damage and crack propagation models to capture stochastic damage, variable amplitude loading, creep-fatigue, and overloads
- Development of characterisation of conventional and novel materials, such as high-entropy alloys, intermetallic, and bioinspired composites

Impact

- Improved lifetime predictions for materials
- Novel materials to handle challenging environments
- Informed design and sustainment planning for challenging environments

Successful Applications

- Evaluation of fatigue and creep-fatigue of Ni-based superalloys for advanced turbines and reactor designs
- Development of novel crack propagation models to support the design of advanced turbines and reactors
- Fracture and fatigue evaluation of heat resistant alloys up to 1300°C for advanced energy applications
- Small-scale testing of materials at ambient to elevated temperatures

Capabilities and Facilities

- In-situ Alemnis Nanoindenter with temperature control
- Deben micro-tester for in situ observation of deformation and fracture
- Instron multi-axial testing frames with temperature and environment control
- Novel material damage and crack propagation models

Our Collaborators

- Amorphous Metal Solutions GmbH
- Australian Nuclear Science and Technology Organisation (ANSTO)
- CSIRO
- Heraeus Group
- NASA Jet Propulsion Laboratory
- Plansee SE
- SBI International GmbH
- SPEE3D
- Titomic
- US Department of Energy

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Empowering Consumers

UNSW is striving towards a consumer-led energy transformation, which provides clean, affordable, reliable and equitable energy to all. We see the opportunity that exists in the rapid uptake of consumer energy resources, including rooftop solar that is on track to increase four-fold by 2050, which can be leveraged through energy system flexibility. However, for households, we recognise the risk of increasing inequity and energy poverty, and acknowledge the importance of securing social license. We also understand that businesses must ensure that environmental sustainability does not come at the cost of continued competitiveness and productivity. Thus, we are focused on research and technology outcomes that will improve the quality of life of citizens, as well as securing our future economic prosperity.

To achieve this goal, we are focused on research and development in three key areas:

Technology

Developing and deploying new technologies that improve energy efficiency and reduce emissions, helping energy users, large and small, achieve their net zero ambitions.

Consumer Energy Resources

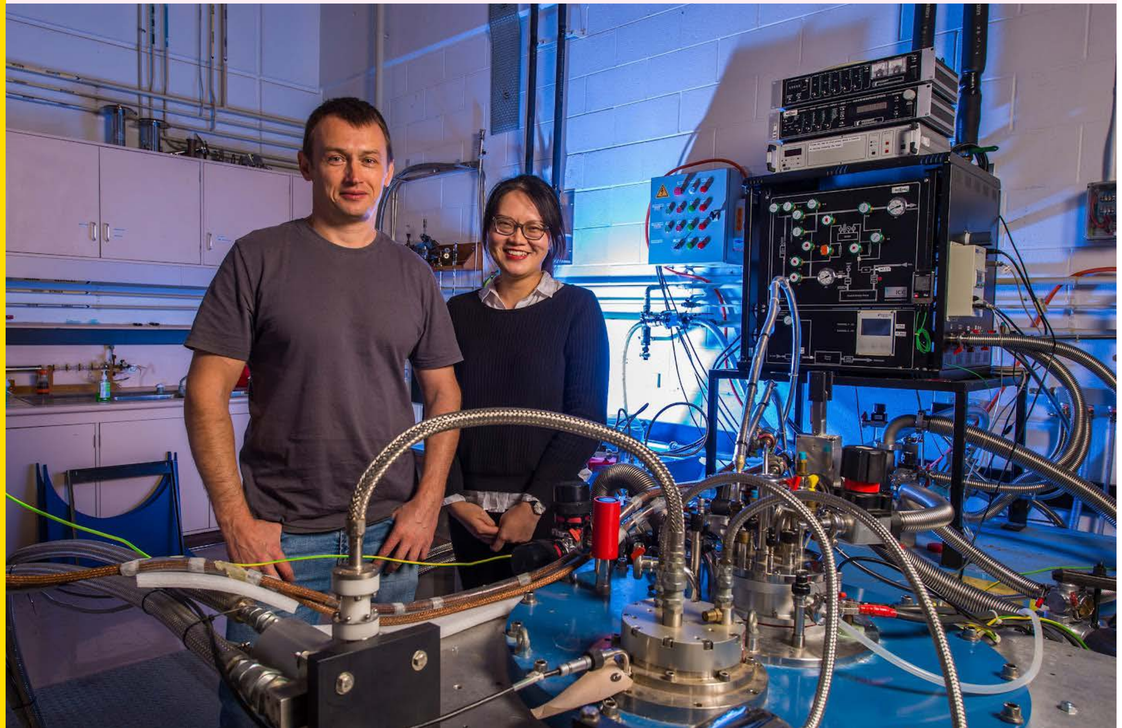
Leveraging flexibility in consumer energy resources to lower bills, improve grid resilience and integrate more renewable energy.

Energy equity

Putting people first in the energy transformation to deliver a more equitable future for all, considering the community voices in relation to energy governance, user-centred planning and a just transition.

Artificial Electronic Materials – A Novel "Beyond CMOS" Technolog

The fabrication of artificial electronic materials by combining conventional semiconductors with nanofabrication techniques paves the way to reducing power consumption in semiconductor electronic devices.



Competitive Advantage

- Electron beam lithography of lateral two-dimensional lattices on nanometer scale
- Complete cycle (design–fabrication–electrical characterisation) for proof of principle devices
- Developed process for p- and n-type devices
- Electrical low-temperature characterisation of semiconductor devices

Impact

- Artificial electronic materials offer an alternative path to tackling increasing energy consumption by the IT industry

Successful Applications

- Development of fabrication techniques for patterning of artificial lattices
- Evidence of artificially formed band structure in conventional semiconductors
- Voltage-controllable artificial band structure: from linearly dispersing to flat bands

Capabilities and Facilities

- Full suite of electronic equipment for low noise, low-temperature electrical measurements down to 30mK and magnetic fields up to 12T
- Piezoelectric sample rotation at mK temperatures
- 300mK/7T cryostat for quick sample turn-around
- Variable temperature insert for device characterization between 1.5 and 300mK
- Access to ANFF-UNSW and ANU facilities for device fabrication

More Information

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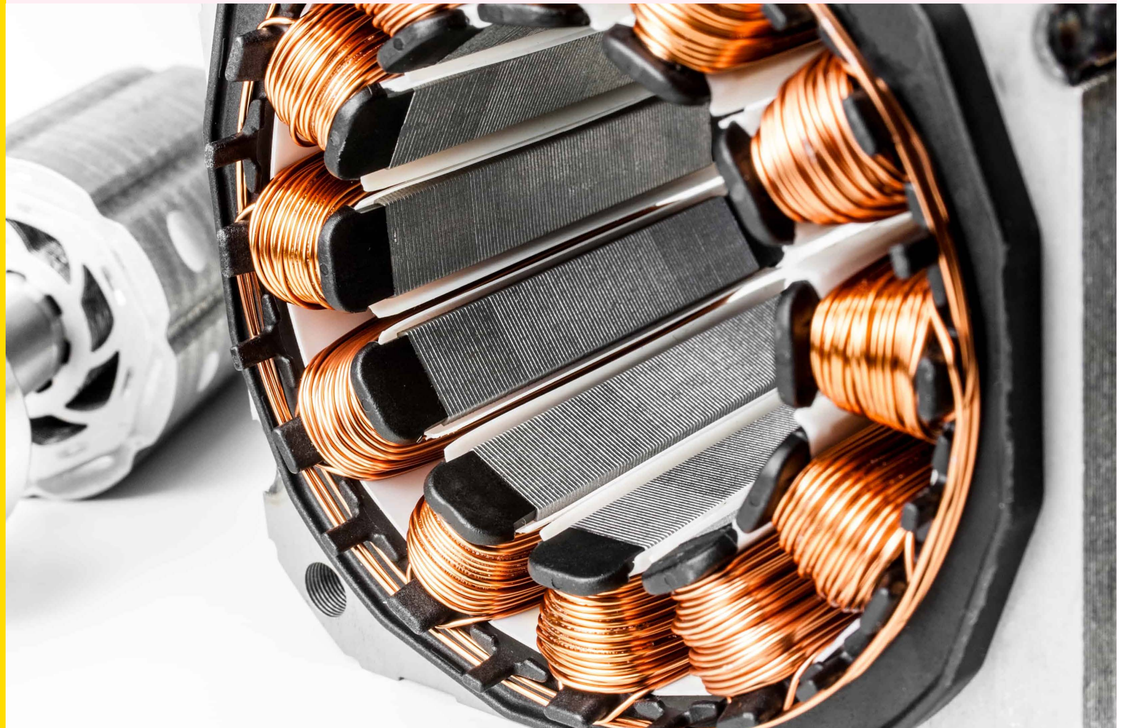
Application of Concentrated-Wound Machines

As the world strives to electrify transportation through electrical powertrains, electrical machines and drives will become even more prevalent. Concentrated-wound machine technology offers improved machine performance in these applications, reducing the risk of fault propagation in the machine.



Competitive Advantage

- Years of experience in the research and development of concentrated-wound and fractional slot machines, particularly permanent-magnet machines
- Leading winding techniques that improve machine performance
- Ability to mass-manufacture windings
- Patented technology

Impact

- Increased efficiency through reduced rotor losses and lower torque ripple
- Improved performance of electric vehicles and other powertrains
- Improved operation under machine faults

Successful Applications

- Applications in powertrains, electric vehicles and aerospace
- Two proofs of concept prototype at UNSW labs
- Adoption of the technology is in advanced phases for several applications outside Australia

Capabilities and Facilities

- Electrical machine design software
- Advanced machine control algorithms to improve torque ripple, speed range and efficiency
- Prototypes ready for commercialisation

Our Collaborators

- Motorica

More Information

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Development of Advanced Cool Materials for Buildings and Cities

Developing advanced reflective cool materials for buildings and cities that significantly reduce the demand for cooling buildings and counterbalance the impact of urban overheating.

Competitive Advantage

- Knowledge and expertise to improve environmental quality in deprived urban zones, and enhance the sustainability and survivability of low-income households

A successful track record of:

- Reducing the surface temperature of materials by up to 15oC
- Decreasing ambient temperatures by up to 2oC
- Lowering the cooling energy consumption of buildings by up to 40%

Impact

- High efficiency and low-cost materials reduce the cooling demand of buildings and cities, improving their environmental conditions
- Improving building efficiency reduces the cost to cool buildings, and contributes to the reduction of heat-related mortality and morbidity

Successful Applications

- Commercialisation of industrial products globally
- Collaboration and testing of advanced products with a number of major industrial companies, such as Daikin Chemicals and Isomat

Capabilities and Facilities

- Laboratory capable of performing a wide range of energy and environmental measurements for development and testing of building materials
- Spectrophotometer to measure the spectral characteristics of materials
- Accelerating ageing chamber for conducting ageing studies
- Equipment for measuring emissivity, thermal conductivity, and many other optical and thermal parameters of materials, including thermal cameras

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Energy Conservation in Buildings

Modern and intelligent building technologies and designs that minimise the energy consumption of commercial and residential buildings to improve efficiency, reduce cost, and save lives.

Competitive Advantage

- Expertise in minimising energy consumption and improving thermal and visual comfort
- Recognised achievements in reducing energy consumption, carbon emissions, and indoor pollutants

Impact

- Improving indoor thermal comfort and reducing instances of heat-related mortality and morbidity
- Improved health, refined comfort, and greater productivity with minimum energy consumption

Successful Applications

- Expertise successfully applied to more than 500 large-scale building projects globally
- Collaboration with major construction companies

Capabilities and Facilities

- Laboratory capable of performing a wide range of energy and environmental measurements in buildings
- Mobile energy bus with thermal cameras, tracer gas equipment, IAQ sensors and analysers, light and daylight measuring equipment, and a drone for performing aerial measurements
- A wide range of tools to simulate energy usage in buildings

More Information

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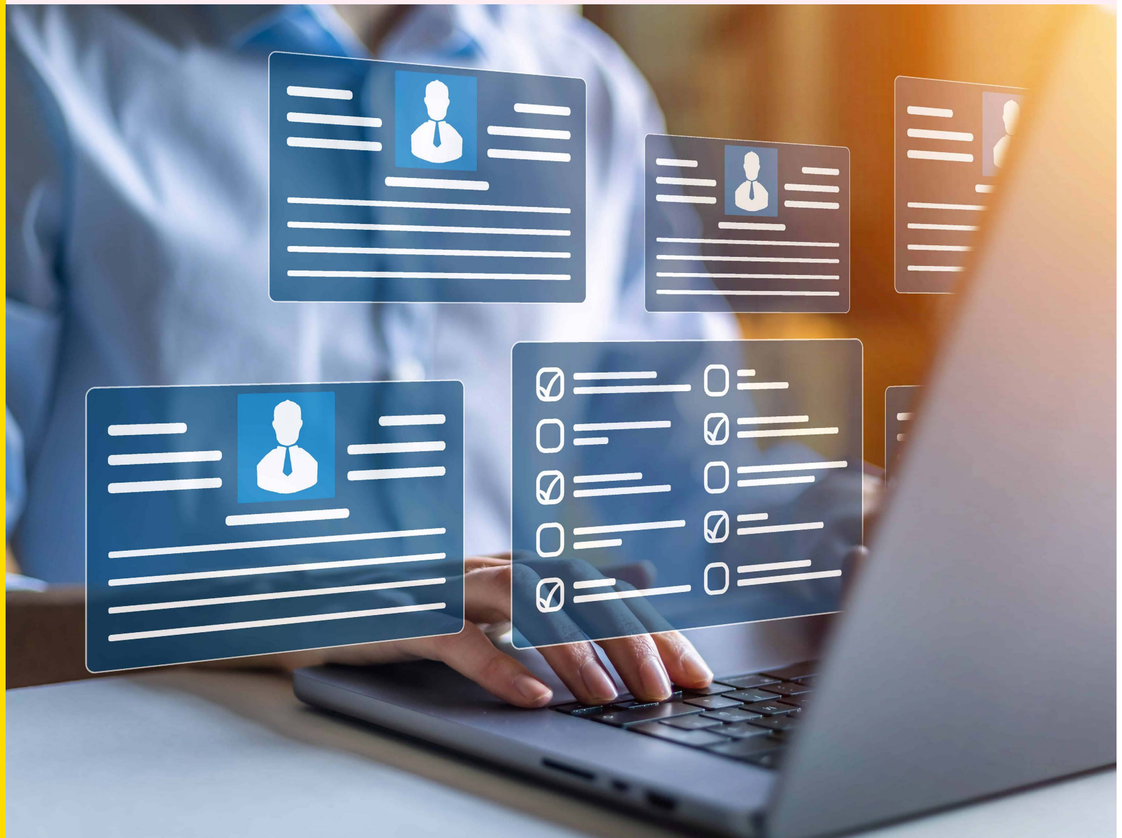
Consumer Data Right

Offering a strategic, evidence-based and academically rigorous approach to issues stemming from Consumer Data Right – a regulatory intervention through which customers can access anonymised data to compare and switch providers – ensuring compliance and the appropriateness of market responses.



Competitive Advantage

- An Australian team with deep involvement in the development of Consumer Data Right thinking within the finance, energy and telecommunications industries
- Extensive experience in regulatory compliance and marketing response
- All team members have experience as both regulators and advisers to those subject to regulations

Impact

- Research has been used by regulators internationally
- Worked with the Australian Competition & Consumer Commission (ACCC) and The Treasury to develop Consumer Data Right thinking
- Worked with businesses in the banking sector to develop their response strategy

Successful Applications

- Professor Pamela Hanrahan is one of Australia's leading authorities on financial services law and regulation – provided significant support to the Hayne Royal Commission
- Associate Professor Rob Nicholls is a leading researcher on the regulation of networked industries – recently served as the process auditor for a number of ACMA remedial directions
- Professor Peter Leonard is globally recognised for his work in data governance

Capabilities and Facilities

- The research network has members across a number of regulatory disciplines, including networked industries and emerging technologies
- Team members have been deeply involved in non-regulatory strategies in response to regulatory intervention

Our Collaborators

The Treasury

More Information

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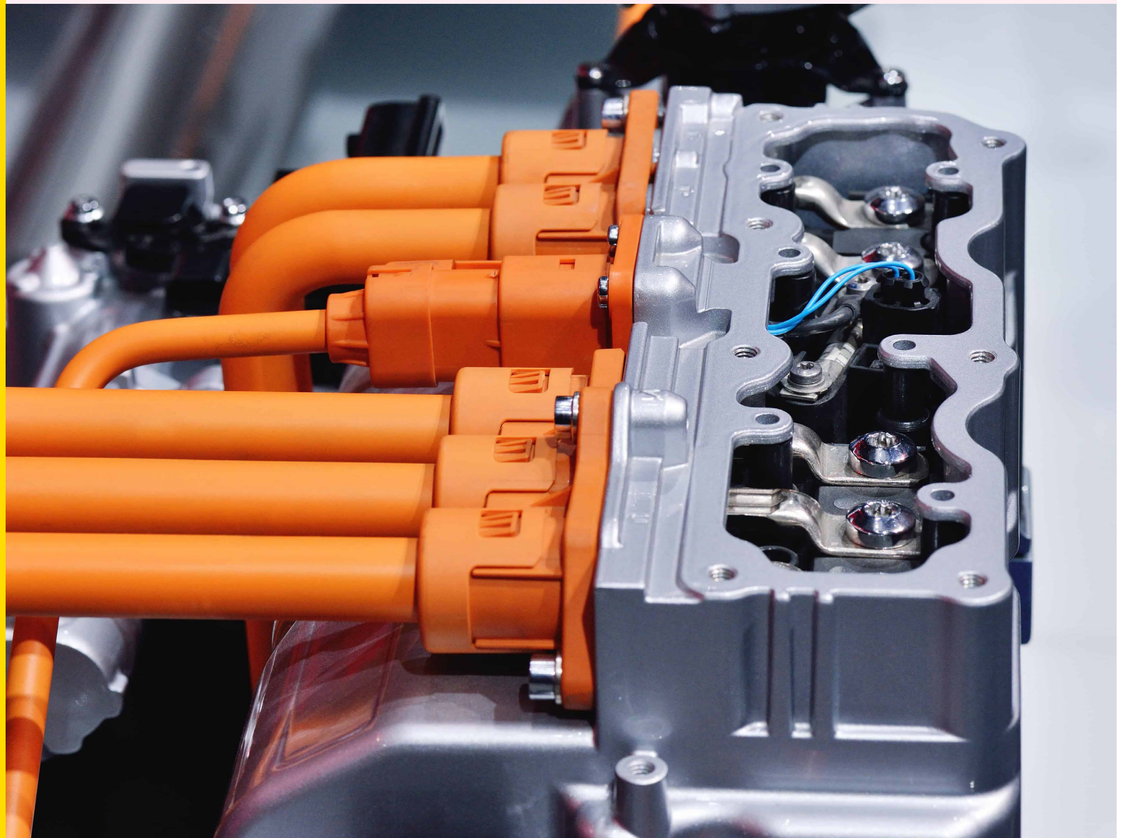
Diagnostics for Electric Drives

The development of techniques for diagnosing failures in electric drives and conducting research on fault prognosis.



Competitive Advantage

- Innovative techniques to diagnose faults in drive systems and to self-heal
- Experimentally verified control techniques and code for fault identification and recovery
- Expertise in improving the economics of renewable generation, particularly wind power
- Experience in the drive and control of multi-phase machines

Impact

- Electric drives currently use 60 to 65 per cent of all electrical energy generated across the globe. Many of them require, or would benefit from, some form of diagnostics to identify faults and imminent failure
- Diagnostic techniques lead to reductions in unplanned maintenance and maintenance costs, and shorter outage times

Successful Applications

- Demonstration of self-healing techniques for electrical drives

Capabilities and Facilities

- Electrical machine design for performance improvements under faulted operation

Our Collaborators

- Motorica

More Information

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Energy Deprivation Among Low-Income Families

Rising energy costs, limited access to low-energy appliances and poor-quality housing, have forced many low-income families to sacrifice daily essentials and social connections in order to keep a roof over their heads. In order to overcome this problem, strong political leadership and support of community programs is required.

Competitive Advantage

- Experience in the provision of detailed, first-hand accounts regarding the impacts of energy deprivation – from skipping meals and medication, to widespread loneliness and social isolation
- Capabilities in reviewing housing and social policies
- Australian and international expertise on outcomes of deprivation

Impact

- Policy change to improve the quality of housing
- More equitable social and financial support for low-income families

Successful Applications

- Demonstrated carbon reductions by retrofit implementations
- Submissions to, and an invitation to present at, Senate Inquiry public hearings
- Discussions on policy development with industry bodies and government agencies

Capabilities and Facilities

- Extensive knowledge of housing and social policies in Australia
- Collaborative relationships with social and housing development industries
- Strong ties with international experts on housing policy development

Our Collaborators

- NSW Department of Planning, Housing and Infrastructure
- The Salvation Army
- Public Interest Advocacy Centre
- Australian Council of Social Service (ACOS)

More Information

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Energy Efficiency and Renewable Energy Systems

Energy-efficient buildings, building integrated and building applied PV energy systems, for low-energy buildings and highly-efficient fluid handling systems.

Competitive Advantage

- Expertise in the analysis of energy systems to enhance energy efficiency, renewable energy integration, and techno-economic optimisation

Impact

- Step changes in energy performance through the integration of highly optimised and efficient renewable energy systems
- High-efficiency fluid handling systems capable of delivering significant energy and emissions savings for commercial and residential buildings

Successful Applications

- Led the CRC for Low Carbon Living (CRCLCL) program with many successful projects adopted by industry
- Algorithms to predict energy demand and solar system performance for individual dwellings adopted by an industry partner
- Highly efficient fluid handling systems for HVAC in buildings, including optimised HVAC design adopted by industry partner
- Highly efficient solar thermal, PVT fluid handling systems, with world record COP for solar pool heating implemented in conjunction with an industry partner
- Energy-efficient building design and modelling adopted by industry partners

Capabilities and Facilities

- Techno-economic analysis of energy and renewable systems, measurement, modelling, and forecasting
- Development of multipurpose renewable energy systems (PV/Thermal)

Our Collaborators

- BlueScope Steel
- CSR
- AECOM
- Solar Analytics
- Simply Better Pool Savings

More Information

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Low-Cost Energy-Efficient Technology for Homes

Energy poverty is a serious issue for our society that threatens the lives of vulnerable and low-income households. Combatting it means developing appropriate low-cost technologies and combining them with advanced monitoring technologies.

Competitive Advantage

- Significant experience in developing low-cost, energy-efficient technologies that lower energy needs and provide comfort to low-income households, at minimum cost

Proven solutions that:

- Decrease energy consumption by up to 70%
- Reduce carbon emissions by up to 50%
- Improve indoor thermal comfort by up to 70%
- Lower the level of indoor pollutants by up to 90%

Impact

- Meaningful improvements in the quality of life of low-income households

Successful Applications

- Several large-scale retrofitting projects in low-income dwellings worldwide
- Collaboration with major government institutions to alleviate energy poverty

Capabilities and Facilities

- Laboratory capable of performing a wide range of energy and environmental measurements in buildings
- Mobile energy bus with thermal cameras, tracer gas equipment, IAQ sensors and analysers, light and daylight measuring equipment, and a drone for performing aerial measurements
- A wide range of tools to simulate energy usage in buildings

More Information

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High Performance Architecture Research Cluster

The High Performance Architecture research cluster aims to deliver research innovation in design, planning and management of high performance buildings and cities.

Competitive Advantage

Conducts innovative research across five key areas:

- Microclimate and urban heat mitigation and adaptation
- Net zero carbon buildings and communities – Alistair Sproul and UNSW Collaboration on Energy and Environmental Markets (CEEM)
- Building lifecycle assessment and embodied carbon emissions
- Sustainable, resilient, regenerative and smart cities
- Sustainable development and construction

Impact

- Efficient use of renewable sources in buildings and communities
- Optimisation for near zero or positive energy buildings and communities
- Reduction in embodied energy and carbon across a building's lifecycle
- Impact analysis of urban overheating on energy, peak electricity demand, health, survivability and sustainability, environmental quality and economy

Successful Applications

- The Cool Roofs mitigation potential in Australia
- Urban Heat and mitigation potential in Riyadh
- Improving the present and future climate and microclimate in the City of Parramatta
- National Heat Vulnerability Observatory – Smart and Cool Places Phase 1, applied in the Dubbo Region and Maitland City in collaboration with the NSW Department of Planning and Environment
- Microclimate and Urban Heat Island Mitigation Decision-Support Tool
- Advanced hybrid ventilation systems for schools
- Energy Efficiency Training and Information: Commercial Buildings

Capabilities and Facilities

- High Performance Architecture Lab, including a range of mobile devices and equipment – from EnergyBus, drone, thermal comfort meter, air quality monitoring and photometric sensors, to infrared camera, infrared thermometers, thermal constants analyser, and Xenon arc weathering chamber

Our Collaborators

- Federal, state and local governments
- Developers, urban planners and building designers

More Information

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High-Speed Switched Reluctance Machines

Switched reluctance machines offer many advantages in high-speed rotating applications, particularly low-phase number and low pole number machines, such as the 4/2 machine.

Competitive Advantage

- Experts in high-speed, fault tolerant technology
- Knowledge of a broad range of prototyping capabilities, from sub-kW to 50kW
- Leading-edge tools for the analysis, design and fabrication of novel rotors using 3D printing

Impact

- The rotor is robust being a single stack of laminations that requires no windings or permanent magnets – allows the rotor to spin at high speeds
- Windings can be manufactured separately then mounted on the machine, which reduces size and cost
- The potential for very high-speed motors and generators up to 50,000 rpm

Successful Applications

- Applications in electric vehicle powertrains
- White-good applications
- Vacuum pumps

Capabilities and Facilities

- Experience in switched reluctance electrical machine design
- Fault-tolerant machine design techniques
- Low-phase number drives and controls

Our Collaborators

- Bao Feng Industries

More Information

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High-Capacity Dynamic Rock Reinforcement System and Testing Facility for Underground Mines

A novel high-capacity dynamic rock reinforcement system and industry-based testing facility that will contribute to making deep mines safer and more sustainable in the future.

Competitive Advantage

- Advanced high-capacity dynamic ground support design and testing facility
- A rock reinforcement system that will help the mining sector achieve high productivity and economic growth

Impact

- Enhancing safety and productivity in underground mines
- This research is critically significant for UNSW to maintain its leading role in mine safety performance and mining technology internationally

Successful Applications

- Application to high-capacity dynamic ground support in deep stressed orebodies and high-stress mining environments
- Envisioned use in extreme underground environments such as burst-prone areas, including block caving mining methods
- Maintaining high safety standards and productivity in the competitive global resources market

Capabilities and Facilities

- Access to the industry's new high-capacity dynamic testing facility
- Testing dynamic bolts capable of >70 tonne capacity and capable of withstanding seismic energy of >50 kJ
- Equipment for designing, developing and building a new high-capacity dynamic bolts

Our Collaborators

- JENNMAR Australia
- South32

More Information

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Implementation Science

Expertise in the application and evaluation of tailored strategies to overcome the psychosocial and environmental factors affecting the adoption of new innovations into complex systems. This ensures the benefits of technology reach those who need it most, including individuals, families, communities, as well as public and private organisations.

Competitive Advantage

- Identifying gaps between evidence and practice
- Co-designing innovations for implementation
- Measuring behavioural and contextual factors affecting translation of innovations
- Co-designing tailored, targeted, and generalisable strategies for maximum impact
- Identifying the key mechanisms behind implementation success

Impact

- Reduced adverse patient safety events in healthcare
- Increased number of cancer patient referrals into genetic services
- Capacity building within organisations for evidence-based implementation
- Demonstrated differences between theory-based and intuitively-driven implementation success

Successful Applications

- Cost-effective implementation of new innovations into organisations and community settings
- Broad, cost-effective implementation using specialised training models and scale-up frameworks

Capabilities and Facilities

- Extensive systems for interactive implementation training, collaborative data collection and analysis, and ongoing coaching
- Diverse expertise in the design and application of implementation theories, models, and frameworks
- Vast experience across a variety of complex innovations for implementation
- Impact and process evaluation specialists to measure change and explore mechanisms of impact

Our Collaborators

- NHS UK
- Over 60 Australia-based healthcare organisations
- Digital Futures Grid
- South-Eastern Sydney Local Health District

More Information

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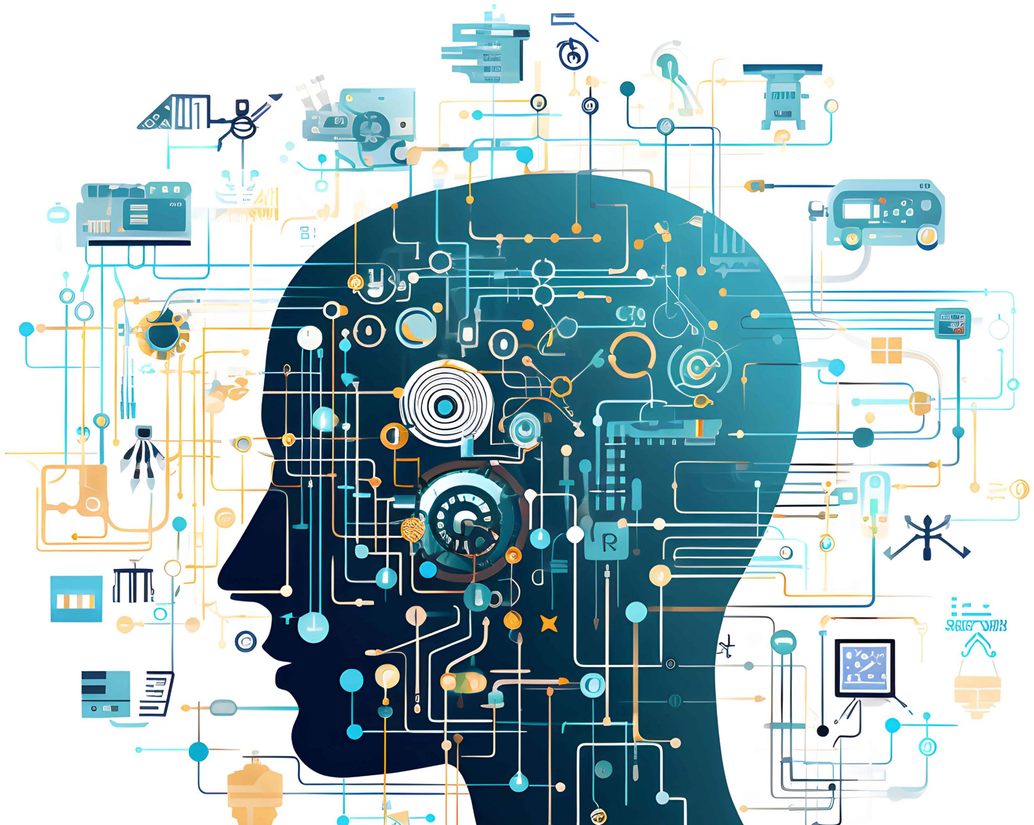
Knowledge Data Analytics

Leveraging extensive experience and international capability in the storage, analytics, visualisation and security of data and models, to deliver impactful systems and solutions across multiple domains
electricity and water, which are the cornerstone for a greener and more sustainable future. The key issue in achieving large-scale commercialisation of this technology is cost reduction.



Competitive Advantage

- A novel, holistic approach to managing data storage, indexing, querying processing, and optimisation
- Advanced solutions to analyse different types of data for descriptive and predictive applications
- Flexible and powerful interface to interact with intelligent applications, including visualisation, and explaining predictive models for enhanced understanding and debugging support
- Expertise in detecting unknown adversarial attacks, including adaptive white-box attacks, and protecting intelligent models from attacks

Impact

- A more secure, efficient, intelligent and holistic solution for data storage, modelling, and understanding

Successful Applications

- Analysing text data and extracting knowledge from unstructured online documents for D2D CRC projects
- Predictive modelling for users in large enterprises that are vulnerable to cyber-attacks

Capabilities and Facilities

- Large-scale data processing and modelling platform

Our Collaborators

- CRC

More Information

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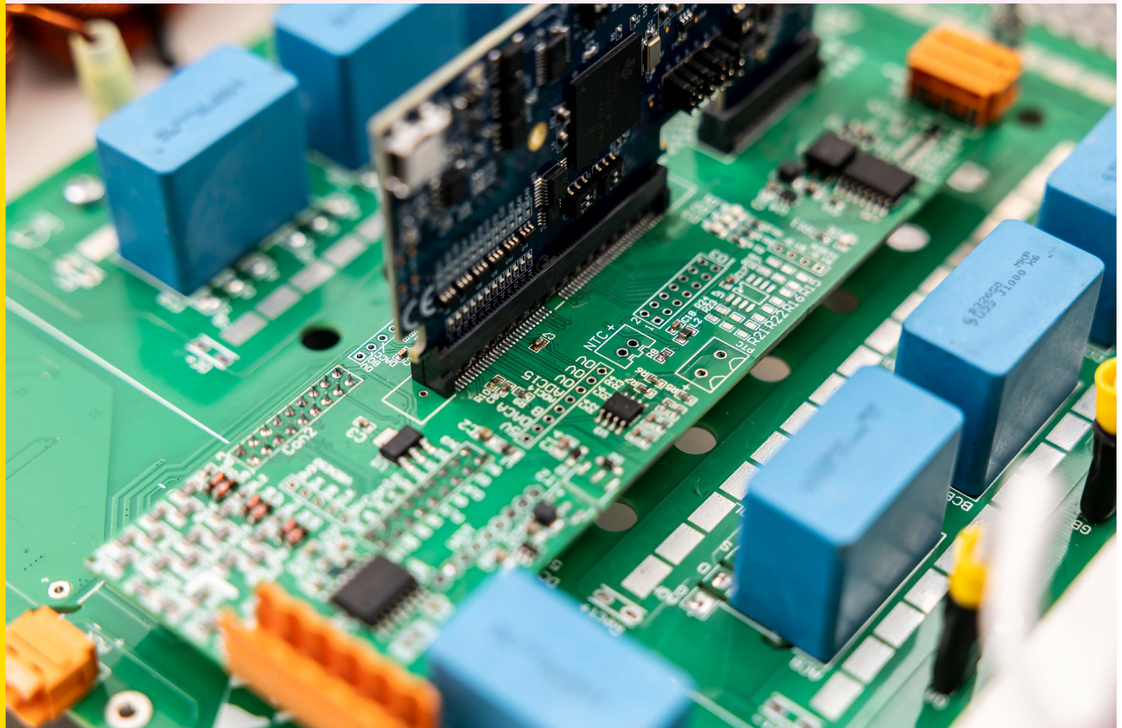
Linear Electrical Machine Drive Systems

Linear electrical machines are used in an increasing number of applications, including down-hole pump applications and electrical launch systems. Both a permanent-magnet mover and a line-start linear electrical machine drive system have been designed for linear machine drive systems. Together, they optimise periodic motion and enhance the line-start capability of the permanent-magnet linear synchronous machine.



Competitive Advantage

- Leading-edge rotor technologies developed for specific applications
- Experience in a wide range of conventional and advanced linear machine control techniques (vector and scalar control, sliding-mode control, model-predictive control)
- Ability to rapidly develop and prototype controllers
- Custom linear machine design and prototyping
- Expertise in using damping windings for modelling and drive strategy
- Ability to deliver higher tolerance in the estimated position

Impact

- Development of linear machine solutions to support a rapidly growing market
- Tuning improvements and robust control techniques improve the tracking and performance of controllers and yield faster responses
- Line-start within all ranges of initial mover position
- Rapid acceleration to synchronous speeds without the need for accurate position sensor

Successful Applications

- The development of a down-hole pump for the pumping industry
- Up to 6% reduction in overshoot of the periodic motion
- Prototype electromagnetic launch system
- General linear machine drive systems

Capabilities and Facilities

- Advanced machine control algorithms to improve force control, position and speed tracking
- Linear electrical machine design software
- Prototype controller ready for commercialisation
- Hardware setup for testing linear machines, with two types of mover
- dSPACE 1104 real-time experimental platform
- Complete motion control system

Our Collaborators

- Motorica

More Information

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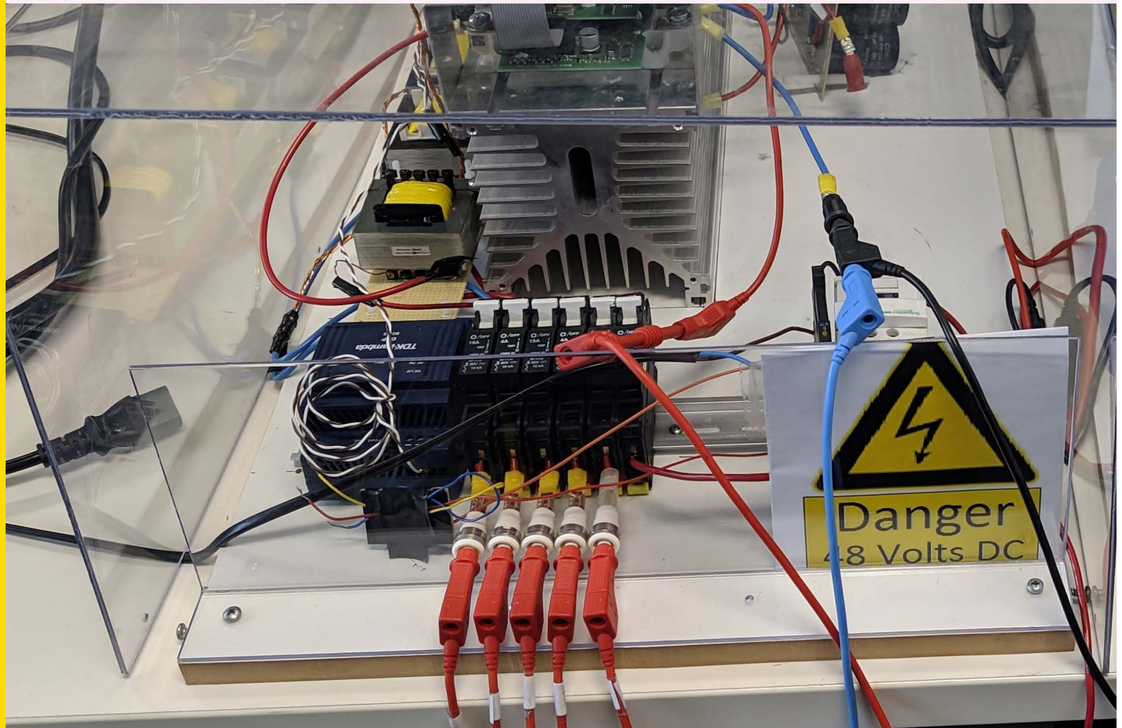
Linear Electrical Machine Drives

Linear electrical machines are used in an ever-increasing number of applications, with solutions developed for down-hole pump applications and electrical launch systems. Recent developments also include a new type of permanent magnet rotor with improved starting performance via the integration of a conducting ladder-slot arrangement. This new type of rotor allows the machine to rapidly accelerate under the action of induction principles to the synchronous speed where the permanent magnet flux can then be used to increase the force.



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Impact

- Development of linear machine solutions to support a rapidly growing market
- Tuning improvements and robust control techniques improve the tracking and performance of controllers and yield faster responses

Successful Applications

- The development of a down-hole pump for the pumping industry

Capabilities and Facilities

- Advanced machine control algorithms to improve force control, position and speed tracking
- Linear electrical machine design software
- Prototype controller ready for commercialisation

Our Collaborators

- Motorica

More Information

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More Energy-Efficient Affordable Housing

There is strong government appetite to increase the capacity of the affordable housing sector in Australia through new construction, redevelopment and management transfer programs. While assistance programs to raise energy efficiency already exist, barriers continue to constrain the full potential of industry to deliver outcomes.

Competitive Advantage

- Long-standing relationships with affordable housing industries both in Australia and abroad
- Interdisciplinary global collaboration with academic and industry experts
- Capabilities in reviewing housing and social policies

Impact

- Policy change to improve industry's capacity to boost assistance
- Improved housing quality and energy efficiency for vulnerable households

Successful Applications

- Advisory to government agencies and the affordable housing development industry

Capabilities and Facilities

- Extensive knowledge of housing and social policies in Australia
- Collaborative relationships with housing development industries and the community sector
- Strong ties with international experts on housing policy development and energy poverty alleviation

Our Collaborators

- NSW Department of Planning, Housing and Infrastructure
- CSIRO

More Information

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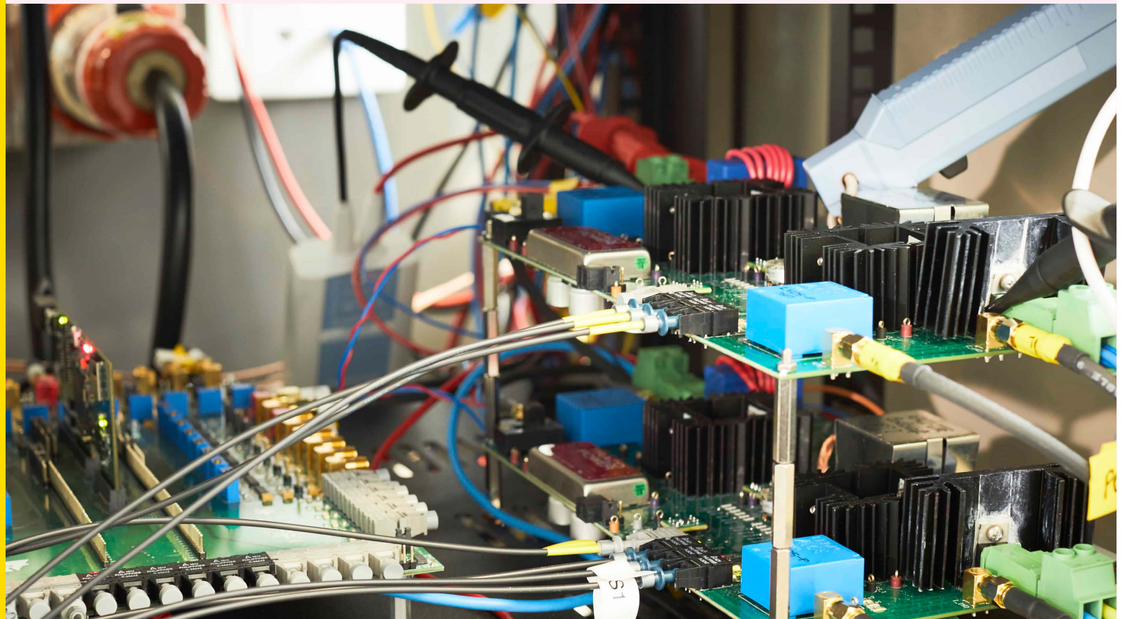
Multi-Step Model Predictive Control for Power Electronics and Electrical Drives

Model predictive control has emerged as a promising alternative control technique for power electronic applications. It provides rapid dynamics and responses to demand changes, and can handle multiple variables and system constraints, while achieving a fast, dynamic response.



Competitive Advantage

- The use of a computationally efficient optimiser, specifically Sphere Decoding Algorithm (SDA)
- Experience in the practical application of n-multistep MPC using SDA in power electronics systems and electrical drives

Impact

- Demonstrable improvement in electrical machine and drive performance
- Ability to predict future horizon response and control capabilities
- Reduced harmonic distortion and higher efficiency in machine drives and converter systems

Successful Applications

- These advanced control techniques have been applied, and shown to be effective in:
- Conventional induction machine drives
- Three-level inverter systems, including neutral-point clamped and flying capacitor technologies

Capabilities and Facilities

- Rapid prototyping of multistep predictive control techniques
- Multiple testing platforms, including machine types and inverter topologies

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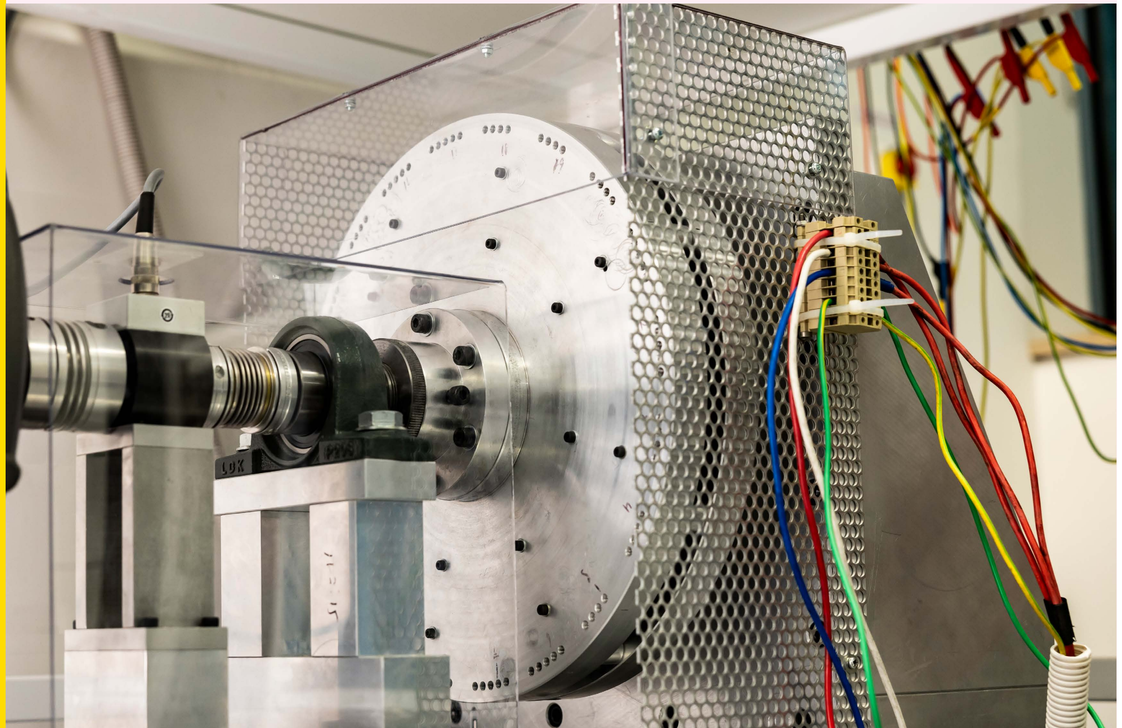
Novel Axial Flux Machine Design

The development and assessment of ground-breaking and innovative axial machines. Axial flux machines have a form factor that suit the in-hub motors of electric vehicles. These have been used for many years as the motor of choice for the world record-breaking Sunswift Racing team, and are a popular electrical generator for both small and large-scale wind turbines.



Competitive Advantage

- Innovations that include printed circuit board (PCB)-mounted windings, three-phase machines and multi-phase variants, and permanent-magnet machines with a unique flux-weakening capability
- Extensive experience in axial-flux machine design, analysis and control
- Expertise in finite-element analysis and its application in axial flux machine design
- Academic team with expertise in design, operation and control sectors
- Specialist knowledge of electrical machine design

Successful Applications

- Small-scale wind turbine generator
- Novel electrical generator for a specialised applications
- Preferred motor of the Sunswift Racing team

Capabilities and Facilities

- Electrical machine design experience
- Multi-phase machine design techniques
- Multi-phase drives and controls
- Low-speed, high-torque and high-speed load machines

Our Collaborators

- Hummingbird Electronics

More Information

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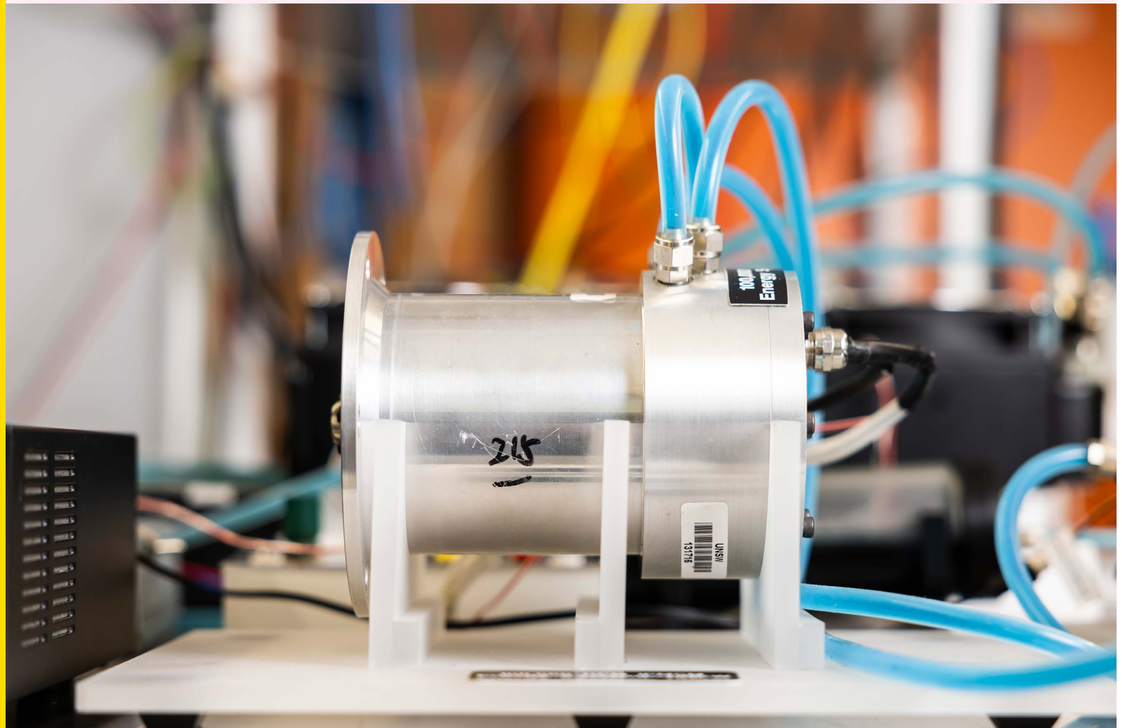
Permanent-Magnet Machines for Electric Vehicles

Strong capabilities in designing and optimising various permanent-magnet (PM) machine geometries, and developing advanced control techniques to further improve electric vehicle performance.



Competitive Advantage

- Expertise in PM machine design and control
- One of the world's first to develop mechanical sensorless control for an interior PM (IPM) machine, and a fractional-slot concentrated wound IPM machine
- Patented PM machine technologies with wide flux-weakening range – a requirement for traction drives in electric vehicles
- Developing advanced on-line parameter identification techniques

Impact

- Electric machines with higher efficiency and better performance for EV-powertrain
- Motors with wider constant power operation for traction applications

Successful Applications

- Sensorless control techniques from zero to full speed for PM motor drives
- World's first experimental verification of fractional-slot concentrated wound stator with IPM rotor
- Development of PWM-based sensorless control and high-speed IPM machines
- Patented technologies of fractional-slot IPM machines
- Patent application – Novel multi-objective optimisation techniques for PM machines

Capabilities and Facilities

- Finite-element packages, including Maxwell 2D/3D, Magsoft and ANSYS, with optimisation tools developed in-house
- Simulation platforms (Matlab–Simulink, PSIM), FPGA and DSP systems with high-performance signal acquisition, estimation and switch gate-drive interfaces
- Two and three-level inverters
- Several machine drive set-ups complete with shaft position sensors, torque sensors and highly dynamic loads
- Four-quadrant dynamometer for testing direct-drive wind generators
- High-speed (>50,000 rpm) PM machine test bed (work-in-progress)

Our Collaborators

- Conry Tech
- CSIRO
- Wisconsin Electric Machines and Power Electronics (WEMPEC)

More Information

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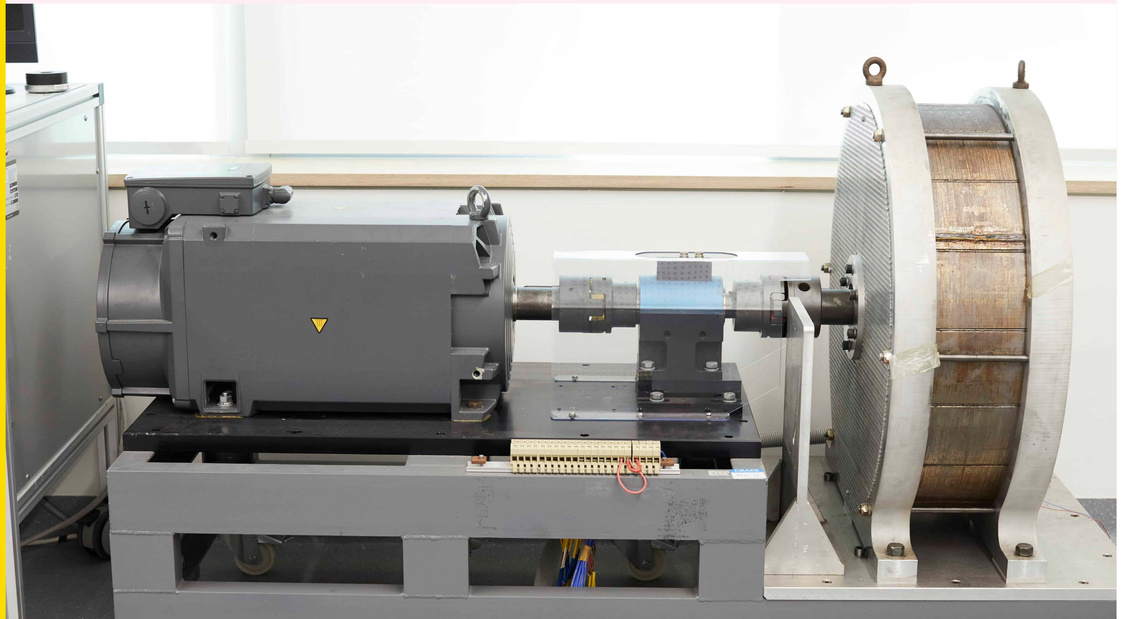
Permanent Magnet Synchronous Machines for Wind Energy Conversion

Specialists in the design and control of permanent magnet (PM) type electric machines. This is backed by strong capabilities in design optimisation and control of various PM machine geometries for low-speed, high-torque applications such as direct-drive wind energy conversion.



Competitive Advantage

- Expertise in designing direct-drive PM generators with compact size and negligible cogging torque
- One of the world's first to develop fractional-slot concentrated wound interior PM machine for direct-drive wind energy conversion
- Advanced control techniques for the generator-side converters of Wind Energy Conversion
- Advanced techniques for online parameter identification with potential usability in remote condition monitoring of off-shore generators

Impact

- Direct-drive PM generators of compact size and with negligible cogging torque
- Cost-effective controller suitable for roof-top applications

Successful Applications

- Advanced control techniques for direct-drive PM generators
- Patented fractional-slot concentrate wound PM machine technology
- Pending patent application – design optimisation package for PM machine

Capabilities and Facilities

- Finite-element packages, including Magsoft and ANSYS, with optimisation tools developed in-house
- Simulation platforms (Matlab–Simulink, PSIM), FPGA and DSP systems with high-performance signal acquisition, estimation and switch gate-drive interfaces
- Two and three-level inverters
- Several machine drive set-ups complete with shaft position sensors, torque sensors and highly dynamic loads
- Four-quadrant dynamometer for testing direct-drive wind generators

Our Collaborators

- CSIRO
- Wisconsin Electric Machines and Power Electronics
- Toshiba
- Regal Beloit

More Information

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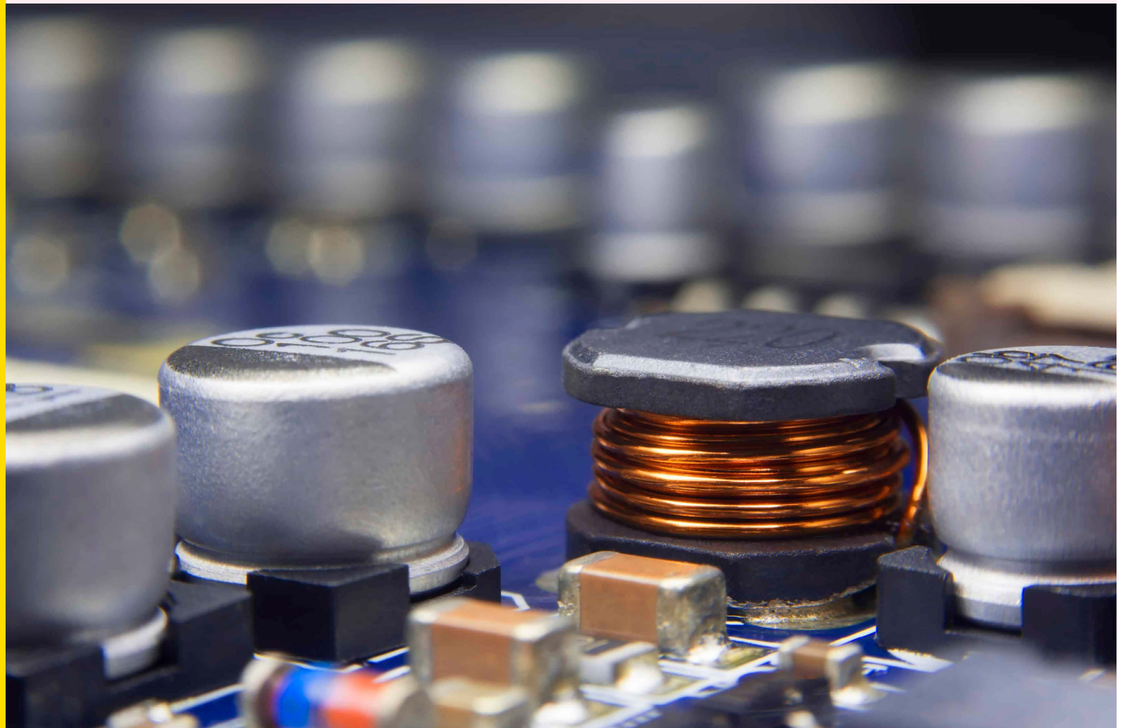
Planar Magnetics

Developing new planar structures and verifying simplified models for both high- and low-power applications, while exploring new, flexible matrices of magnetic components that can be reconfigured online. As the power electronics industry continues to grow, and power supplies become smaller, from consumer electronics to large electric vehicles, there is increasing demand to miniaturise. Planar magnetics is a space-efficient technology that allows magnetic components to be tightly integrated with their circuit.



Competitive Advantage

- Novel planar magnetic matrices for flexible power supply systems
- Improved high-frequency transformers and inductors using planar electronics
- Advanced tools for the analysis, design and fabrication of novel magnetics
- Bespoke planar magnetic design and analysis

Impact

Planar magnetics:

- reduces the cost of integrating magnetic components into mass production
- revises standards that currently underestimate capacity
- improves the performance of magnetic components
- The ability to reconfigure matrices of magnetic components online, delivers greater efficiency to transformers and inductors

Successful Applications

- Applications in solid-state high-frequency transformers
- DC-DC power converters for supercapacitor storage and water treatment applications

Capabilities and Facilities

- Planar magnetics design and analysis tools, including finite element modelling
- Test and measurement systems to assess benefits and performance

Our Collaborators

- Shandong BOFA Power Machinery
- Motorica

More Information

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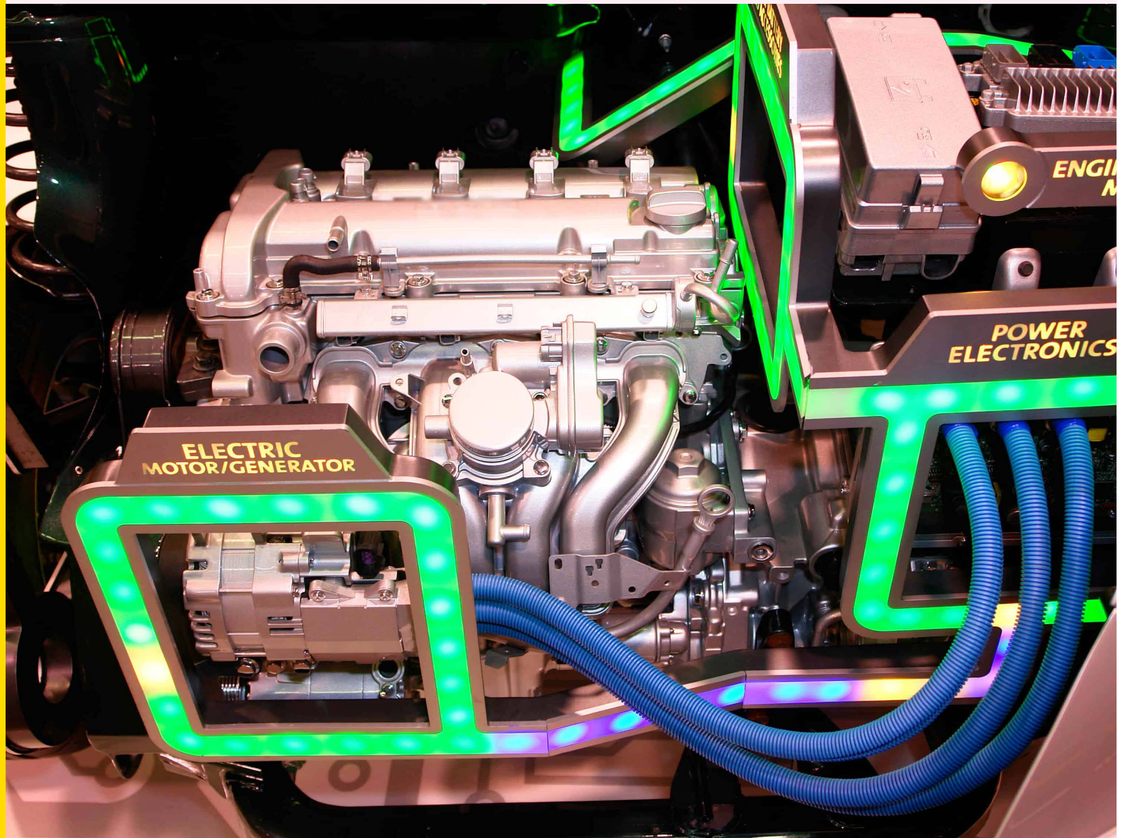
Power Electronics Diagnostics

The ability to model both healthy and faulted conditions to enable the development of proper control strategies that keep electric machines operational when faults occur.



Competitive Advantage

- Analysis of the failure mechanism in inverters for three- and multi-phase machines
- Inverter design optimisation to minimise the potential for failure
- Development of control strategies for high-reliability inverter-driven machines that enable operation post-failure

Impact

- Improved the performance and reliability of inverters and inverter-based machines through experience-based design

Capabilities and Facilities

- Comprehensive experimental-rig for testing and analysing inverters for electric machines
- dSPACE 1006 rapid modular systems for rapid-control prototyping
- dSPACE MicroLabBox

Our Collaborators

- Motorica
- Hummingbird Electronics

More Information

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Power Management of Smart Solar-Powered Street Furniture

Developing strategies to manage the power requirements of solar-powered street furniture – such as traffic/warning signs, streetlights, interactive street screens, smart bins, park benches for charging mobile devices, home furniture or pavements with integrated solar panels – to ensure it is self-sustaining and integrated with energy storage.

Competitive Advantage

- Development of power management strategies for the self-sustained operation of street furniture
- Ability to maximise the illuminance efficacy of street lighting/traffic signs through the development of converters and modulation techniques
- Expertise in the optimal sizing of solar panels and energy storage for specific street furniture load profiles

Impact

- Solar-powered street furniture can be used to develop micro-grids for small apartments, increase safety or improve customer experience

Successful Applications

- Energy consumption optimisation for solar-powered traffic signs

Capabilities and Facilities

- Power electronics laboratory
- PV simulators
- Hardware testing capability up to 50kVA, 1kV, 400A
- Arbin Instruments battery tester
- Cadex C8000 battery testing system with a load capture unit
- Hioki battery simulator
- GAMRY Model REF3000 potentiostat
- LiBa WorkStation
- TempEvent temperature chamber with EUCAR 5 level capability

Our Collaborators

- Hi-Vis Group

More Information

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Reinforcement Learning for Operations and Maintenance Planning

World-leading Research Group in the field of machine condition monitoring that brings together two primary areas of expertise – wear debris and vibration analyses – for applications in the field of machine condition monitoring.

Competitive Advantage

- Ability to integrate wear and vibration analysis to monitor machine condition, and predict the remaining life of critical assets
- Cutting-edge diagnostic and prognostic tools to inform maintenance decision makers
- Expertise across a range of technologies, including signal processing, wear analysis, and digital twin and Artificial Intelligence (AI)-based techniques
- Collaboration with universities and industries on a domestic and global level

Impact

Advanced techniques for generating significant economic benefits and increased safety for personnel by:

- Providing an early warning of possible faults and/or failures of mechanical components (e.g., gears and bearings)
- Diagnosing their severity
- Predicting their remaining useful life
- Optimising their operation and maintenance using deep learning approaches, such as reinforcement learning

Successful Applications

- Gearboxes used in defence forces and aerospace
- Drivetrains in wind turbines
- Gearboxes, bearings, engines used in transportation, mining processes, and agriculture

Capabilities and Facilities

- One-stage and multi-stage gearboxes, and bearing test rig with multiple sensors, to generate data under various health and operating conditions
- Wear testing and analysis facilities and expertise
- Advanced vibration signal processing techniques, including torsional vibration and transmission error, for fault detection and diagnosis of critical components (e.g., gearboxes, bearings, IC engines)
- Integrating tribological and vibration information to achieve continuously updated wear assessment and prediction models, for condition monitoring and remaining useful life (RUL) prediction
- Using continuously updated digital twin models, and AI technology, to simulate machines and their components in healthy condition, and with faults of different types, severity, and locations
- Using reinforcement learning for operation and maintenance schedule optimisation

Our Collaborators

- Defence Science and Technology Group (DSTG)

More Information

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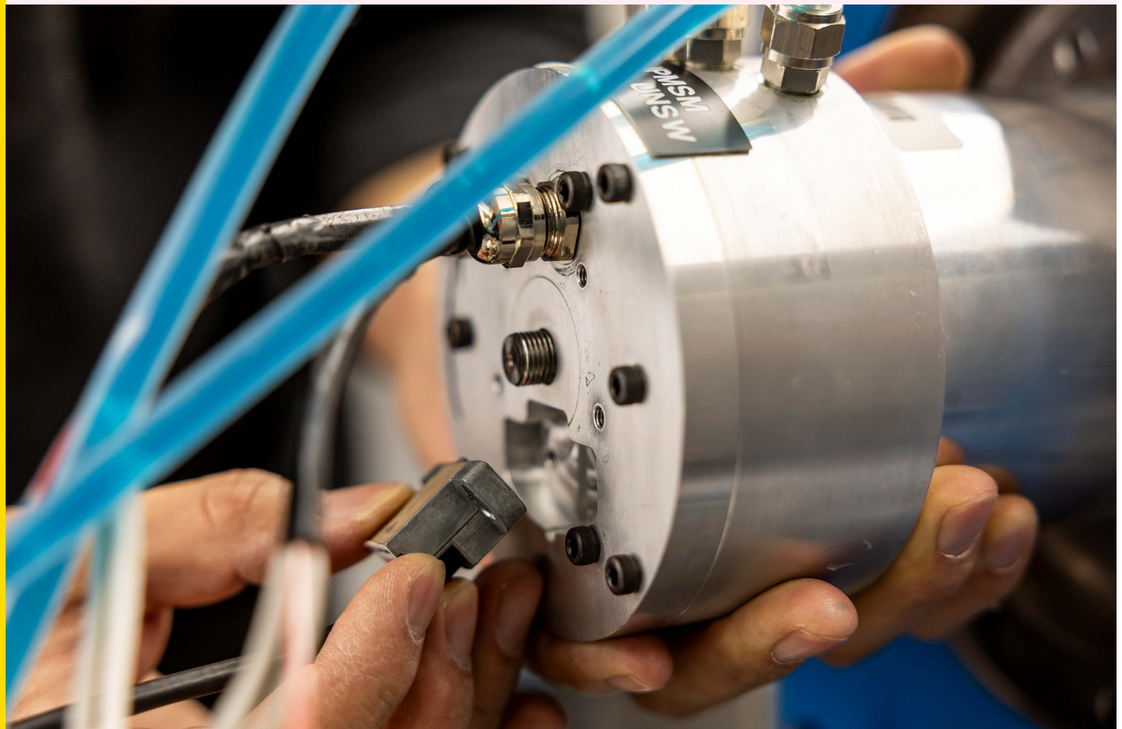
Removing the Need for Sensors in Permanent-Magnet Synchronous Machines

The sensorless control of permanent-magnet machines over their full speed range, including zero speed.



Competitive Advantage

- Several techniques that are leading contributors to the sensorless control of permanent-magnet synchronous motors (PMSM)
- Recently perfected a new current derivative-based sensorless-control technique for PMSM
- The first to develop a fast, online technique for estimating all electrical parameters of PMSM, making it possible to monitor the health of permanent magnets in the machine's rotor, without requiring any sensors in the rotor

Impact

- Many modern electric drives require sensorless drive capability to avoid using sensors in the rotor. The estimation of the rotor position and speed without using shaft sensors lowers costs and improves the reliability of variable-speed drive systems.

Successful Applications

- Sensorless control techniques from zero to full speed for PM motor drives
- Development of PWM-based sensorless control and high-speed Interior PM machines

Capabilities and Facilities

- Simulation platforms (Matlab–Simulink, PSIM), FPGA and DSP systems with high-performance signal acquisition, estimation and switch gate-drive interfaces
- Several machine drive set-ups complete with shaft position sensors, torque sensors and highly dynamic loads
- Four-quadrant dynamometer for testing direct-drive wind generators

Our Collaborators

- CSIRO
- Wisconsin Electric Machines and Power Electronics Consortium (WEMPEC)
- Toshiba

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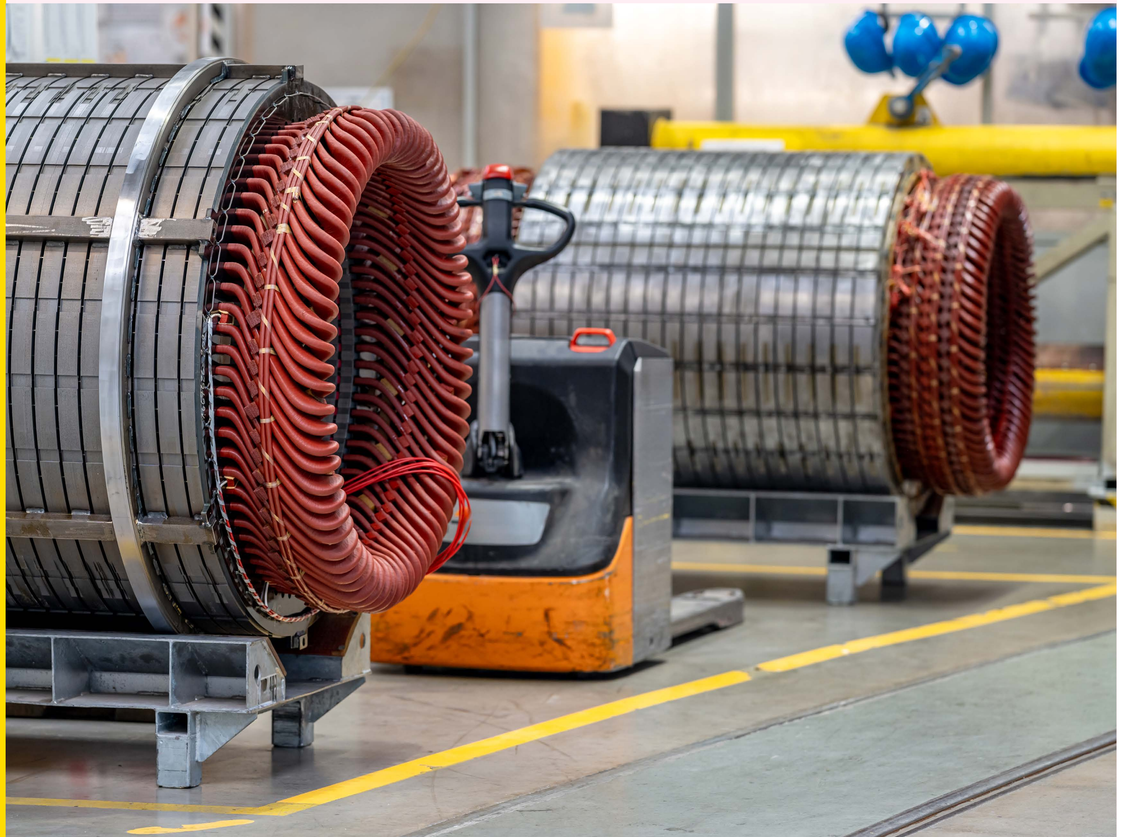
Safety-Critical Electric Drives for High-Value Industries

The research and development of various fault-tolerant electrical drives for use in applications requiring the highest level of reliability.



Competitive Advantage

- Expertise in the design and control of novel, power-dense multi-phase electric drives for use in safety-critical applications, including rail transportation, electric vehicles, marine propulsion drives and aerospace
- Provision of best-in class power density for permanent-magnet machines through innovative five-phase generator technology that uses fractional-slot, concentrated-wound electric machines
- Patented control techniques for drives with faults
- World-leading drives with new, multi-phase designs for enhanced torque production, smooth ripple-free torque, and fault tolerance

Impact

- Many high-value and high-growth industries rely on electrical drives for processing materials, compressing gas and transportation. More efficient and reliable machine drives improve the yield and performance of both new and existing installations.

Successful Applications

- Open winding multi-phase drive system for fault tolerance

Capabilities and Facilities

- Electrical machine design experience
- Multi-phase machine design techniques
- Multi-phase drives and controls
- Low-speed, high-torque and high-speed load machines

Our Collaborators

- Motorica

More Information

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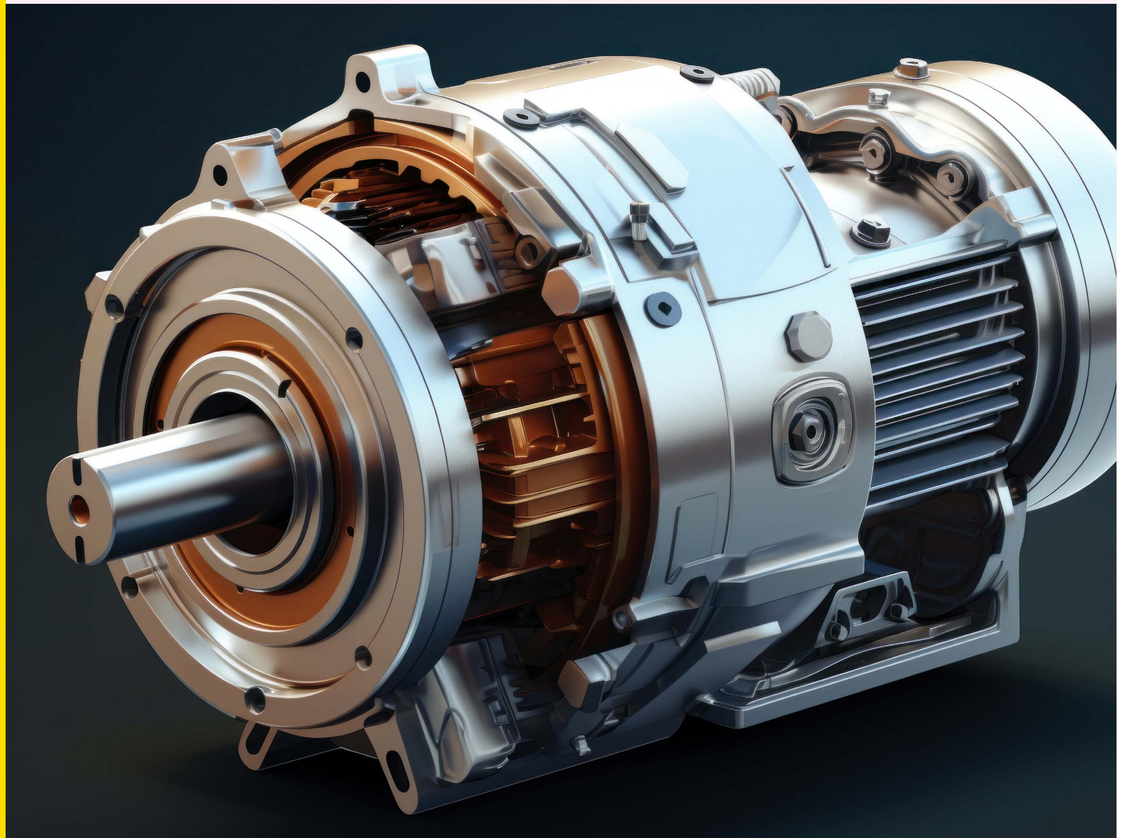
Safety-Critical Electric Drives

Expertise in the design and control of novel, power-dense multi-phase electric drives for safety-critical applications, including rail transportation, electric vehicles, marine propulsion drives and aerospace.



Competitive Advantage

- Novel five-phase generator technology using fractional-slot, concentrated-wound electric machines – provides best-in-class power density for permanent magnet machines
- Drives that incorporate novel multi-phase designs for enhanced torque production, smooth ripple-free torque, and fault tolerance

Impact

- More efficient, safer transport solutions

Successful Applications

- Open winding multi-phase drive system for fault tolerance

Capabilities and Facilities

- Four-quadrant dynamometer
- Bi-directional grid simulators
- High-speed load machines
- Medium-voltage testing

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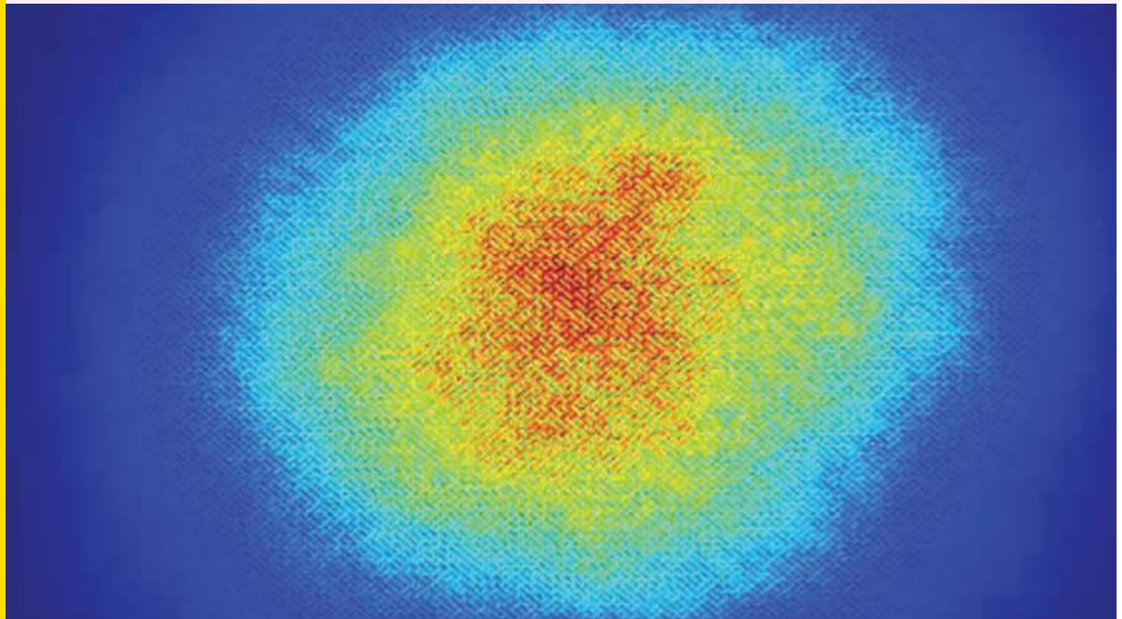
Simulation and Modelling of Nano Electronic Materials and Devices

An expert in electronic material and device simulation using hybrid quantum and classical methods. The research group leverages in-house numerical simulation software that has contributed to the development of energy-efficient transistors, optoelectronic devices, and semiconductor quantum technologies.



Competitive Advantage

- Simulation-based design guidance for new material and device technologies
- In-house simulation software capable of multi-million atom electronic simulations
- Quantum mechanical modelling of current flow in solid-state devices
- Integrated multi-physics simulation capabilities for electronic materials – strain, electrostatics, phonons, spin dynamics, carrier scattering

Impact

- Computer-aided design (CAD) and optimisation of solid-state quantum computers
- Understanding the role of material disorder in electronic devices
- Design of energy-efficient electronic and optoelectronic devices

Successful Applications

- Helped achieve record performance metrics in silicon quantum computing devices
- Led to patented designs of nanoscale energy-efficient transistors for industry partners
- Guided successful design of Quantum Hall interferometers in III-V material stack
- Tools and capabilities used globally in semiconductor quantum device groups, companies, and government laboratories

Capabilities and Facilities

- Variety of material simulations, including Group III-V, Group IV, 2D materials, and atomic defects
- High-performance object-oriented software platform in C++
- Unified material-to-device simulation framework from 3D to low-dimensional nanodevices

Our Collaborators

- ARC Centre of Excellence for Quantum Computation and Communication Technology (CQC²T)
- ARC Centre of Excellence in Future Low-Energy Electronics Technologies (FLEET)
- Silicon Quantum Computing (SQC)
- Diraq

More Information

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Supporting Net zero and Climate-Positive Communities

Designing procedures and developing technologies to optimise energy conservation and renewable energies in communities on a global level.

Competitive Advantage

- Expertise in using systems that deliver advanced community-based renewable energy, energy-conservation, and innovative integrated controls
- Specialists in producing zero- or negative-energy requirements, minimising carbon emissions, and optimising thermal and visual comfort
- Proven ability to reduce total energy needs by up to 100%

Impact

- Zero-energy communities provide sustainable, healthy environments with a reduced need for capital investment and lower running costs

Successful Applications

- Design and implementation of technologies for four zero-energy communities in Cyprus, Italy, France, and the UK

Capabilities and Facilities

- Laboratory capable of performing a wide range of energy and environmental measurements in buildings for the development and testing of mitigation technologies
- Mobile energy bus with thermal cameras, tracer gas equipment, IAQ sensors and analysers, light and daylight measuring equipment, and a drone for performing aerial measurements
- A wide range of environmental simulation tools for different cities and building projects

Our Collaborators

- OPAC 38
- British Gas
- ABB
- FIBRAN

More Information

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Synchronous Reluctance Machines and Drives

Development of a new type of synchronous reluctance machine that has a skewed, axially-laminated rotor, which solves the problem of torque ripple typically associated with traditional rotors.

Competitive Advantage

- Innovative axially-laminated skewed rotor that improves machine performance and creates near-zero torque ripple
- Novel multi-phase winding techniques improve torque output
- Advanced tools for the analysis, design and fabrication of novel rotors using 3D printing
- Ability to produce smaller, cheaper machines
- Impact
- The rotor structure can be operated at very high-speed, making it useful in many emerging applications
- Synchronous reluctance machines and drivers are cheaper and more efficient than conventional field-excited and permanent-magnet synchronous machines, as they don’t require permanent-magnets, or rely on rotor currents

Successful Applications

- Applications in electric vehicle powertrains and high-speed drive applications for Australian and Chinese industries

Capabilities and Facilities

- Electrical machine design experience
- Multi-phase machine design techniques
- Multi-phase drives and controls
- Low-speed, high-torque and high-speed load machines

Our Collaborators

- Shandong BOFA Power Machinery
- Motorica

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Technologies to Reduce the Cooling Demand of Cities

Developing advanced mitigation technologies that combat the need for increased energy consumption in cities to cope with local and global climate change.

Competitive Advantage

- Invaluable experience in decreasing the temperature of cities and mitigating urban heat, and a demonstrated ability to improve outdoor thermal comfort by up to 60 per cent during peak period
- Expertise in decrease the energy consumption of buildings, including:
- A reduction in the peak ambient temperature by up to 3oC
- Up to 40% less energy consumed to cool buildings

Impact

- Producing better thermal conditions in cities, while consuming significantly less energy
- Significant reduction in heat-related mortality and morbidity

Successful Applications

- Implemented in approximately 100 large-scale mitigation projects globally

Capabilities and Facilities

- Laboratory capable of performing a wide range of energy and environmental measurements in buildings for the development and testing of mitigation technologies
- Mobile energy bus with thermal cameras, tracer gas equipment, IAQ sensors and analysers, light and daylight measuring equipment, and a drone for performing aerial measurements
- A wide range of environmental simulation tools for different cities and building projects

Our Collaborators

- Energy Efficiency Council
- Northern Territory Government
- City of Parramatta
- BlueScope

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Climate Risk and Response

Uncertainty about the risks of climate change and how these will play out presents significant challenges and opportunities. The UNSW Institute for Climate Risk and Response (ICRR) is a team of researchers with a unique blend of expertise in climate science, behavioural science, business law and governance. In partnership with industry, the ICRR drives an innovative research agenda, focusing debate on the risks and opportunities of our changing climate.

Competitive Advantage

- A multidisciplinary institute providing an objective, authoritative voice that can deliver insights and advice to industry and government on strategies to address climate risk

Impact

- Driving a new research agenda and shaping the debate on climate risk and response
- Enabling robust planning for climate change impacts by industries, governments and policy makers
- Practical new approaches to climate risk and how to best respond
- A new generation of professionals equipped to translate and communicate complex climate information into actionable solutions for decision-makers

Capabilities and Facilities

- Access to climate science, behavioural science, as well as economic and legal perspectives on climate risk and appropriate responses
- An interdisciplinary perspective leading to industry co-created opportunities in research and professional education

Our Collaborators

- The UNSW ICRR is a startup institute looking to engage with partners in the financial sector, government (state and federal), and broader industry, including SMEs.

More Information

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Zero and Positive Energy Buildings

Making zero-energy buildings a reality through the development of technology and design procedures that optimise energy conservation and the use of renewable energy, while delivering the best possible thermal and visual comfort and environmental quality for all who work or live in them.

Competitive Advantage

- World-class application of technology to deliver optimum value with minimum capital outlay and operating cost

Proven ability to:

- Reduce annual energy consumption and carbon emissions by up to 100%
- Decrease indoor pollutants by up to 90%
- Improve indoor thermal comfort by up to 70%

Impact

- Minimising carbon emissions of residential and commercial buildings globally
- Reducing heat-related mortality and morbidity

Successful Applications

- Technology and design of more than 50 large-scale zero-energy international building projects

Capabilities and Facilities

- Laboratory capable of performing a wide range of energy and environmental measurements in buildings
- Mobile energy bus with thermal cameras, tracer gas equipment, IAQ sensors and analysers, light and daylight measuring equipment, and a drone for performing aerial measurements
- A wide range of environmental simulation tools for assessing building performance

Our Collaborators

- ABB
- Daikin Chemicals
- FIBRAN
- 3E
- AVAX

More Information

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A Just Energy Transition

The development of a masterplan and social justice framework for the implementation of a net zero emissions climate transition. This social justice blueprint will combine effective mitigation strategies to empower consumers and enhance leadership capacity in different regions.

Competitive Advantage

- The first project to incorporate robust measures in relation to the social justice benefits of a climate transition in Australia.
- Delivering a unique, yet important outcome by combining the most appropriate infrastructure/ technologies for a climate transition, and the social justice dimension, particularly the needs of vulnerable communities.

Impact

- Climate transitions will involve significant changes to energy generation and supply, the organisation of infrastructure, and lifestyles. All these changes involve key ethical choices about the fairest way to deploy and pay for new technologies, adaptation and mitigation measures.
- A successful transition must reduce emissions. The benefits and burdens of a transition, such as its financial cost, lifestyle sacrifices, monetary benefits, must also be fairly shared within society. This dimension is critical to ensure vulnerable individuals and communities are not further disadvantaged by any transition strategies.

Our Collaborators

- Samso Energy Academy, Denmark
- Renew
- Sustainability Victoria
- Central Victorian Greenhouse Alliance
- Little Sketches
- Hepburn Wind
- Hepburn Shire Council

More Information

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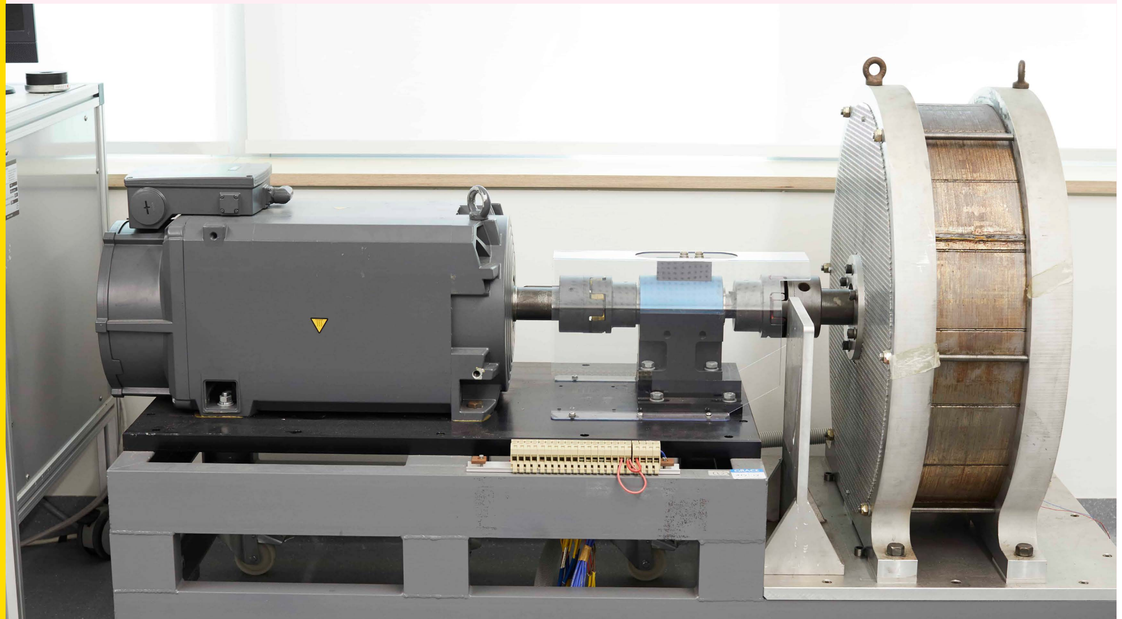
Advanced Control Methods for High-Performing Electric Machines and Drives

The push towards the widespread adoption of electric vehicles has accelerated technological advancements in electric machines, sensors, electric drives, and batteries. These new technologies have prompted the need for new control systems that optimise the performance of individual components and the overall system.



Competitive Advantage

- Advanced control methods that are broadly relevant to applications involving the use of electrical machines and drives
- Expertise in nonlinear systems and control theory for the design and analysis of advanced control systems
- Expertise in the modelling of power electronics and electrical machines
- An experienced, interdisciplinary and collaborative research team with a proven track record in the fusion of electrical machines, power electronics and advanced control techniques

Impact

Improved performance of converters and electrical machines in terms of:

- Speed of response
- Regulation performance
- Operations in field weakening
- Robust operation of systems with parameter variation

Capabilities and Facilities

- Laboratories for electrical machine testing and characterisation, power electronics and electrical drives
- Real-time digital simulation facilities for hardware-in-the-loop testing

Our Collaborators

- Motorica

More Information

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Energy-Efficient Mobility Systems

Exploring the behaviours that influence how individuals and firms make decisions, in an attempt to understand and predict the current and future demand for energy-efficient mobility systems.

Competitive Advantage

- Specialisation in preference elicitation and discrete choice analysis
- Expertise in understanding how different agents will engage with new technologies and services
- High-level skills in the measuring the impact of informational differences on individual preferences
- Significant value-add to both industry and government, through the development and provision of technologies and services that fulfil consumer needs, and the design of supporting policy and regulatory frameworks that maximise societal benefit

Impact

- Understanding and predicting the economic, social and environmental impacts of a current or future policy on the demand for goods or services

Successful Applications

- Cooperative Research Centre for Low Carbon Living (CRCLCL) project with the NSW Office of Environment and Heritage to evaluate the market share for electric vehicles, and understand consumer attitudes, opinions, and preferences for electric vehicles and charging stations
- An international project with the Argonne National Laboratory (USA) to study autonomous vehicles and their impact on the transport system
- UNSW Digital Grid Future Grant for studying the market update of EVs equipped with photovoltaic panels

Capabilities and Facilities

- A data visualisation lab (City X Lab)
- Travel Choice Simulation Laboratory (TRACS Lab)
- A team of experts in choice modelling

Our Collaborators

- Office of Environment and Heritage (via CRCLCL)
- CSIRO
- U.S. Department of Transportation
- Argonne National Laboratory

More Information

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Energy Stakeholder Social Research

Clean energy transitions and their associated technological and policy innovations involve a diverse range of social and cultural drivers and barriers, with far-reaching social impacts. We conduct qualitative and quantitative social research to develop a nuanced understanding of these complex intersections – from the perspectives of stakeholders, including residential, commercial and industrial customers, retailers, DNSPs, generators, developers, technology companies, advocates and community groups, regulators and policymakers.

Competitive Advantage

- Multidisciplinary energy research group with over a decade of experience in the restructured electricity industry
- Energy-focused social scientists and multidisciplinary researchers embedded in the Faculty of Engineering, working with colleagues from the School of Humanities and Languages and Social Science, in collaboration with engineers and technical specialists, to conduct synergistic social and technical research
- Strong record of industry partnerships with diverse stakeholders, including DNSPs, retailers, technology suppliers, as well as energy users and advocates

Impact

- Leverage diverse stakeholder perspectives to inform the development of technologies, business models and policy, and help drive a just and effective energy transition

Successful Applications

- User research attached to industry-led tariff trials and technology pilots
- Ethnographic analysis of community outreach processes to inform future engagement
- Social impacts of, and responses to, grid outages
- Stakeholder research on drivers, preferences and barriers to voluntary renewable energy procurement
- Submissions to policy and regulatory processes and reviews of public submissions to consultations

Capabilities and Facilities

- Experienced social scientists, engineers and multidisciplinary researchers with a strong track record of conducting mixed-method socio-technical research on Australia's clean energy transition
- Real-world experience from regular engagement and consultation with industry, government, public and other stakeholders
- A forward-looking perspective on clean energy transitions

Our Collaborators

- All levels of Government
- National Electricity Market (NEM) institutions
- Network businesses
- Industry associations
- Consumer advocates
- Consultants, renewable energy developers, distributed energy businesses, and startups

More Information

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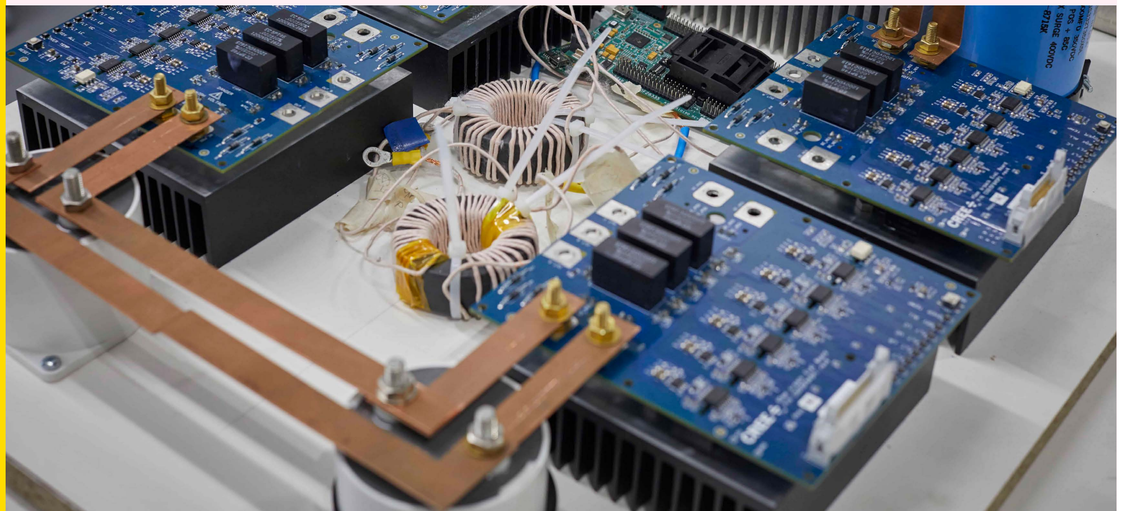
Methodologies for Fault Diagnosis in Power Electronic Systems Operating in Harsh Environments

In harsh environments like mines, power electronic systems are exposed to extreme temperatures, dust, moisture, hazardous conditions, dynamic power loads, cyclic and mobile operation. Methodologies have been developed to diagnose and rectify these faults as quickly as possible in order to minimise potential revenue losses.



Competitive Advantage

- Development of leading troubleshooting procedures for fault diagnosis
- Innovative, self-aware diagnostic systems for safety-critical drives

Impact

- Improved reliability of equipment in hazardous environments

Successful Applications

- Fault diagnosis methods for power electronic systems in the mining industry

Capabilities and Facilities

- Power electronics laboratory with state-of-the-art equipment
- PV simulators
- Hardware testing capability up to 50kVA, 1kV, 400A
- Arbin battery and supercapacitor tester with environmental chamber

Our Collaborators

- Austindo

More Information

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Energy in Public Art

Opening post-industrial and ecologically sensitive sites to public viewers through the conception and deployment of energy systems in public art.

Competitive Advantage

- Ability to create bespoke expressions of energy in art applicable to broad public display and specific site requirements
- Load shedding coupled with local energy production and storage enabling energy powered artwork to be deployed in hitherto inaccessible sites
- Development of simple robust operating systems capable of being adapted and deployed on eco-sensitive and remote sites

Impact

- Expanding the potential for technical public artwork to be used in site regeneration
- Raising awareness of energy production and storage to a broader non-technical audience through employed visual based methodology

Successful Applications

- Post-industrial sites – UK, Germany, Australia
- Ecologically sensitive sites – Australia, New Zealand
- Arid zones – Australia
- Community site activation – Turkey, UK, Ireland, Australia, New Zealand

Capabilities and Facilities

- Systems development and assembly
- Assistance with visualisation of technical/energy systems through employment of fine art
- Activation of specified sites through ecologically sensitive artistic intervention

Our Collaborators

- Jaycar Electronics
- Rights Community Action UK
- Silex Solar
- BP Solar
- Randwick City Council
- Broken Hill Art Exchange

More Information

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Green Energy Statecraft for Australia's Renewable Superpower Ambitions

Professor Elizabeth Thurbon and Dr Alexander M. Hynd are advancing a collaborative, multi-year research and impact agenda developing the concept of Green Energy Statecraft - a highly ambitious and strategic 'whole of nation' approach to governing the green transition that recognises and the broadly defined security drivers and implications of the energy shift.

Competitive Advantage

- As political scientists, we are distinguished by our expertise in questions of state capacity and strategic techno-industrial governance, by our strong national and international research and policy network, and by our ability to work across disciplines, unifying previously siloed conversations among social science researchers about the national security drivers and consequences of the green energy transition

Impact

- We are currently socialising the Green Energy Statecraft concept among Australian energy and economic policymakers, to support bold Australian initiatives to become a Renewable Energy Superpower

Successful Applications

- The mindset and practice of Green Energy Statecraft can already be identified – in part – in the actions of key decision makers in Australia's key Northeast Asian energy partners
- In traditionally neoliberal states, the makings of Green Energy Statecraft can be seen in the US' Inflation Reduction Act, Britain's Clean Superpower policy agenda, and Australia's proposed Future Made in Australia Act

Capabilities and Facilities

- Professor Thurbon and Dr Hynd are well networked among the strategic economic and energy elites of Indo-Pacific states, and Professor Thurbon has a record of high achievement as an internationally-recognised scholar and expert of East Asia's green industrial shift. See https://www.elizabeththurbon.com/

Our Collaborators

- Professor Andrew Walter, University of Melbourne
- Professor Susan Park, University of Sydney

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Off-grid Solar Markets and Repair in Africa and the Pacific

We are a multidisciplinary collaboration across ADA, Engineering and UNSW Business with internationally recognised expertise relating to off-grid energy systems, markets and geographies in the Global South. We have been involved in projects engaging in various off-grid infrastructure technologies (pico-solar enterprises, installations in critical infrastructure (hospitals, schools, etc) and mini-grid systems), as well as different governing approaches (community-based, private sector, government). We are currently leading two major projects in Africa and the Pacific (with funding from the Australian Research Council and Australia Department of Foreign Affairs and Trade), expanding how the off-grid sector can integrate improved repair praxis to improve its sustainability.

Competitive Advantage

- We are experts in understanding off-grid solar markets
- We have particular methodological expertise in measuring and understanding the social, economic and political impact of energy transitions in off-grid communities
- We are world leaders in the area of small-scale off-grid solar repair, including currently active projects across Africa and the Pacific

Impact

- Launched the Off-grid Solar Repair in Africa Whitepaper in 2023
- Have been commissioned to author the Global State of Solar Repair report for the upcoming Global Off-Grid Lighting Association (GOGLA) expo in 2023
- We have been working closely with private enterprise, non-for-profit organisation, investors and governments to develop different guidelines to enhance off-grid solar quality and repair

Successful Applications

- The Zambia-based organisation SolarAid has integrated repair technicians into its off-grid solar enterprise to extend the life of its solar products
- Integrating a gender approach into off-grid solar repair in Vanuatu, including close collaboration with female engineers from the Vanuatu Institute of Technology

Capabilities and Facilities

- We bring technical, economic, policy and critical analytical lens to examining and understanding off-grid solar markets and their impacts around the world

Our Collaborators

- Australian Department of Foreign Affairs and Trade
- SolarAid
- CLASP
- Zuwa Energy
- Vanuatu Institute of Technology
- Kwame Nkrumah University of Science and Technology (KNUST)
- Global Off-Grid Lighting Association (GOGLA)
- Department of Energy (Vanuatu)
- Vanuatu Disability Promotion and Advocacy (VDPA)
- Mzuzu University

More Information

Scientia Associate Professor Paul Munro

Arts, Design and Architecture

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Short Courses

Managing Urban Heat – Art, design and architecture

Developed by industry-leading experts in the field of High Performance Architecture (HPA) at UNSW's School of Built Environment, the Managing Urban Heat short course equips participants with the scientific knowledge, practical methods, and cutting-edge tools needed to effectively manage urban heat and create cooler, more comfortable cities.

Uncover the key factors influencing urban climates, including population growth, industrial and transport-related waste heat, development patterns, and sustainable urban planning. Through a comprehensive exploration of best-practice case studies and evidence-based approaches, participants will gain valuable insights and learn from real-world examples.

Net Zero Homes - Engineering

Climate change is happening now, and requires immediate action. Seven of the last ten years have been the hottest on record across the globe. Australia is experiencing more extreme weather more often: floods, droughts, bushfires and more floods. The need for this course is reinforced with every extreme event in Australia and the world.

The design of our homes is one way we can act now that will reduce the acceleration of climate change, and adapt to a future climate. Homes are built to last 50 years or more in most cases, so the need to create a net zero home is very important.

Investment in this course is equivalent to less than 0.5% of a new home, and adopting the design principles and sustainability solutions outlined in this course is an opportunity for individuals to save thousands in bills over the lifetime of the dwelling, in addition to saving the planet!

This program focuses on the practical application of effective sustainable design, with a focus on building science and energy and water solutions; an action you can adopt now to reduce your reliance on the grid, reduce your emissions, and increase your contribution to a net zero economy.

Who should attend?

- Designers
- Engineers
- Architects
- Planners
- Developers
- Innovators
- Sustainability experts

This course is presented by The Australian Graduate School of Engineering (AGSE)

Grid Integration of Renewables Using PSCAD – Engineering

Delivered in partnership with Aurecon, this course combines several timely topics in power engineering and the grid integration of renewable energy resources using PSCAD.

PSCAD is the industry standard for power system electromagnetic transient simulations and is the preferred software used by Network Service Providers (NSPs) in the National Electricity Market (NEM) for grid integration studies. Participants will learn to build and analyse different power system models including a grid-connected voltage source converter (VSC) in PSCAD, which shall progress into introducing investigating applications of PSCAD to validate the various National Electricity Rules (NER) clauses found within the Australian Energy Market Operator (AEMO) connection application checklist for grid integration.

Grid Integration of Renewables Using PSCAD: Advanced - Engineering

Delivered in partnership with Aurecon, this course combines several timely topics in power engineering and the grid integration of renewable energy resources using PSCAD.

PSCAD is the industry standard for power system electromagnetic transient simulations and is the preferred software used by Network Service Providers (NSPs) in the National Electricity Market (NEM) for grid integration studies. Participants will learn to build and analyse different power system models including a grid-connected voltage source converter (VSC) in PSCAD, which shall progress into introducing investigating applications of PSCAD to validate the various National Electricity Rules (NER) clauses found within the Australian Energy Market Operator (AEMO) connection application checklist for grid integration.

Facilities and Centres

Tyree Energy Technologies Building (TETB)

UNSW Digital Grid Futures Institute

Real-Time Digital Simulation (RTDS) Laboratory, UNSW

Australian Centre for Advanced Photovoltaics

Australian PV Institute

Solar Industrial Research Facility

ARC Training Centre for The Global Hydrogen Economy

Particles and Catalysis Research Laboratory (PartCat), UNSW

Materials Energy Research Laboratory in Nanoscale (MERLin)

The Mark Wainwright Analytical Centre (MWAC)

ARC Research Hub for Integrated Energy Storage Solutions

Flow Battery Research Laboratory, UNSW

The German-Australian Alliance for Electrochemical Technologies for the Storage of Renewable Energy

ARC Training Centre for Fire Retardant Materials

The Collaboration on Energy and Environmental Markets

NSW Decarbonisation Innovation Hub

Working With Us

UNSW works with a variety of partners including government, high-calibre corporate partners, small-medium enterprises and community groups in Australia and overseas. UNSW operates at the forefront of global research and design to help deliver transformational innovations that advance Australia's capabilities and are instrumental in defining the future landscape. By partnering with UNSW, your organisation will gain opportunities to access innovative research, ground-breaking discoveries and the very best students – the next generation of leaders.

We offer a broad range of engagement models and have decades of experience partnering with small and large organisations to deliver:

- Multidisciplinary expertise at the centre of leading and emerging research
- Access to world class technologies and infrastructure
- Dedicated industry-facing and government-facing organisational units, such as UNSW Industry and Innovation and UNSW Division of Enterprise
- Highly effective partnership models including research strategy advice and support
- Collaborative research leveraging third party and government funding
- Access to our national and global research partners including Group of Eight Australian Universities; the international PLuS Alliance with Kings College London and Arizona State University; the New South Wales NUW Alliance with the University of Newcastle and University of Wollongong; the joint venture with Western Sydney University
- Access to students through professional development programs, projects and our industry placement program
- Customised and bespoke initiatives

We look forward to working with you to develop real world applications

Contact Us

UNSW Industry and Innovation (I&I)

Partner with us

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