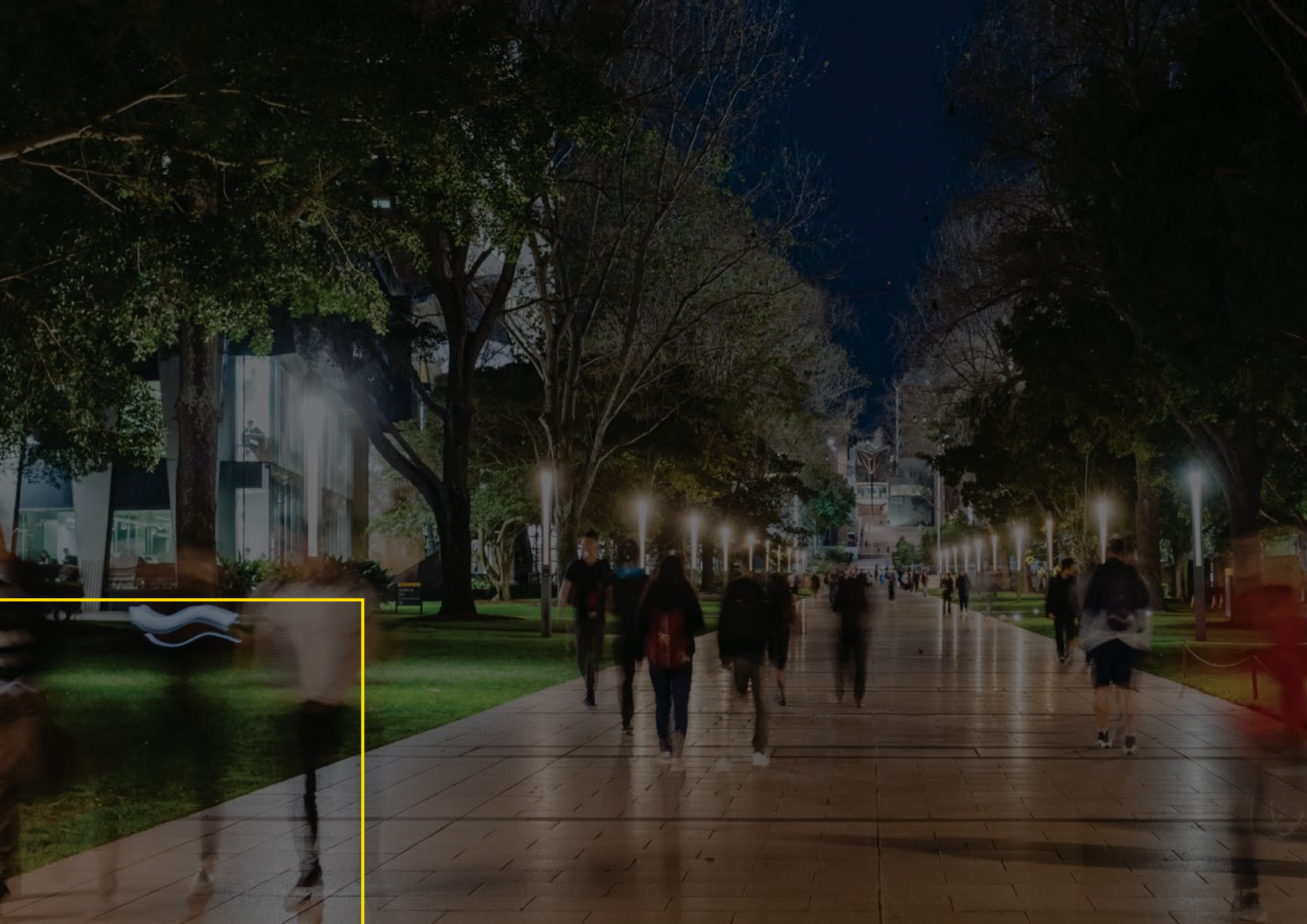
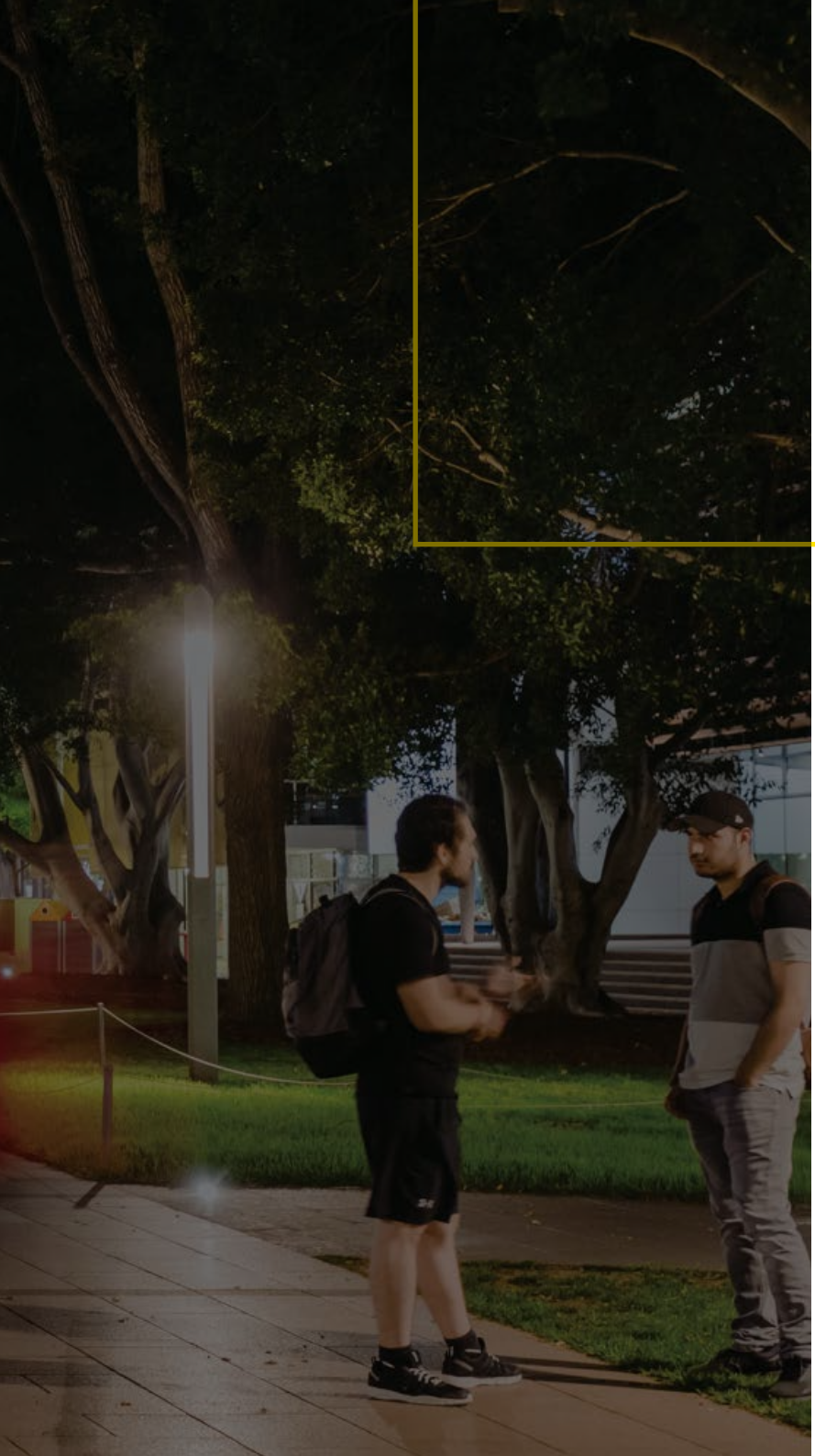
UNSW

Clean Energy

Capability Portfolio

UNSW, Your Energy Research Partner





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FROM THE PRESIDENT AND VICE-CHANCELLOR

UNSW aims to have a positive global impact as a result of our research and teaching, by nurturing critical thinking, and through a commitment to solving the grand challenges it faces.

We take seriously our role as a servant of society and we know that the work we do can be transformative for individuals and communities.

At this critical juncture in the health of our environment, clean energy is taking centre stage.

The Clean Energy Capability Portfolio showcases UNSW's credentials as a pioneering, world-leading innovator in this field. Our cutting-edge centres and facilities, well-established networks, and commitment to lead by example on sustainability and environmental stewardship offer unrivalled opportunity for industry, community and government partners.

This document highlights the full breadth of our university's capabilities across clean fuels, decarbonisation of the grid with renewables, electrification of industries and transport, and energy storage.

As Australia transitions to cleaner energy sources, our success will lie in our ability to innovate. And the ability to innovate will rely on strong partnerships between research institutions, industry and government.

At UNSW, we continuously seek out opportunities to collaborate across the country and across sectors, to achieve the best outcomes for the communities we serve.

As you read this Capability Portfolio, I encourage you to consider how we might work together towards our common goals of a cleaner, more sustainable future for people in Australia and worldwide.

Professor Ian Jacobs
President and Vice-Chancellor, UNSW

FROM THE DEPUTY VICE-CHANCELLOR RESEARCH & ENTERPRISE

The UNSW Division of Enterprise is responsible for facilitating engagement between our academics and partners from industry, government and the community. In the last four years we have doubled our partner engagement delivering high impact and high-quality outcomes through contract and collaborative research, consulting, short courses and executive education.

UNSW is committed to engaging with our partners to deliver social progress and economic prosperity, generating impact, mutual benefit and value. In support of this mission, the Division of Enterprise aims through collaboration and innovation to bring together the greatest minds within global industry, policy, academia and our community and build a culture of knowledge exchange.

Over the last 30 years, UNSW has established itself as one of the world's leading research and technology hubs for clean energy innovation. The growing economic and social costs of this rapidly changing environment highlight the urgency for widespread transition from finite fossil fuel-based energy to cleaner and renewable resources that are readily available for all.

We have a critical role to play in working together with our local and international partners to address the most pressing global energy issues including reliability, affordability and sustainability, translating UNSW's vast and varied expertise into practical clean energy solutions and so accelerating global uptake of new energy technologies.

UNSW hosts Australia's most comprehensive entrepreneurship program. Our dedication to nurturing the critical elements of an innovation ecosystem underscores the development and potential impact of our on-campus precincts within industries united in pursuit of a clean energy future.

With the release of this Capability Portfolio we invite our partners, both prospective and current, from industry, government and the community, to examine just some of the expertise being showcased within, and look forward to exploring opportunities for collaboration, innovation and impact.

Professor Nicholas Fisk
Deputy Vice-Chancellor, Research + Enterprise, UNSW

CLEAN FUELS

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Emerging Technologies Around Hydrogen Production and Storage, Catalysis for CO_2 Conversion and Integrated Power Systems

A leading photo(electro)catalysis and nanomaterials research group with expertise and focus around catalysis processes that are thermal, electrochemical, photothermal and photoelectrochemical. The group has a highly efficient and low cost Photovoltaic-Electrolysis (PVE) system to produce renewable fuels by harvesting the full spectrum of sunlight.

Competitive advantage

- Production of renewable fuels (e.g. H2, CO, ethanol) using cost-effective and active electrolysers powered by photovoltaic cells
- Electrodes are comprised of earth abundant elements without using any expensive noble metals
- Electrolysers can use natural seawater as the electrolyte to produce chlorine on the anode and hydrogen on the cathode

Impact

- Enhanced Australian energy security by using infinite and diffusive solar energy
- Alleviate global warming by reducing the carbon footprint
- Off-grid fuel generation in remote strategic sites

Successful applications

- PVE electrolysis for Hydrogen generation

Capabilities and facilities

- Wide range of nanomaterials development techniques
- State-of-the-art instrument for particle and material characterisation
- Several electrolysers for testing catalyst performance
- In-situ studies capability

Our partners

- RayGen Resources Pty Ltd
- Shenzhen Kohodo Sunshine Renewable Energy Co. Ltd
- Beijing Zhongchao Haiqi Technology Co Ltd

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Solar Thermal CO_2 Methanation

A state-of-the-art integrated photothermal system for carbon dioxide conversion to methane and facilities for catalyst synthesis for large scale production.

Competitive advantage

- Integrated system incorporating photothermal technology to run the methanation reaction
- Uses solar heating as the main driving force to heat up the catalyst for CO_2 conversion
- A very high CO_2 conversion can be achieved using a Ni-based catalyst, with virtually 100% selectivity towards methane

Impact

- Alleviate global warming by recycling CO_2 into synthetic fuels
- Effective use of abundant and free energy from the sun

Successful outcomes

- The construction and commissioning of a Solar Thermal Plant for integrated CO_2 methanation with hydrogen production via catalysed water electrolysis

Capabilities and facilities

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

Our partners

- CSIRO Energy

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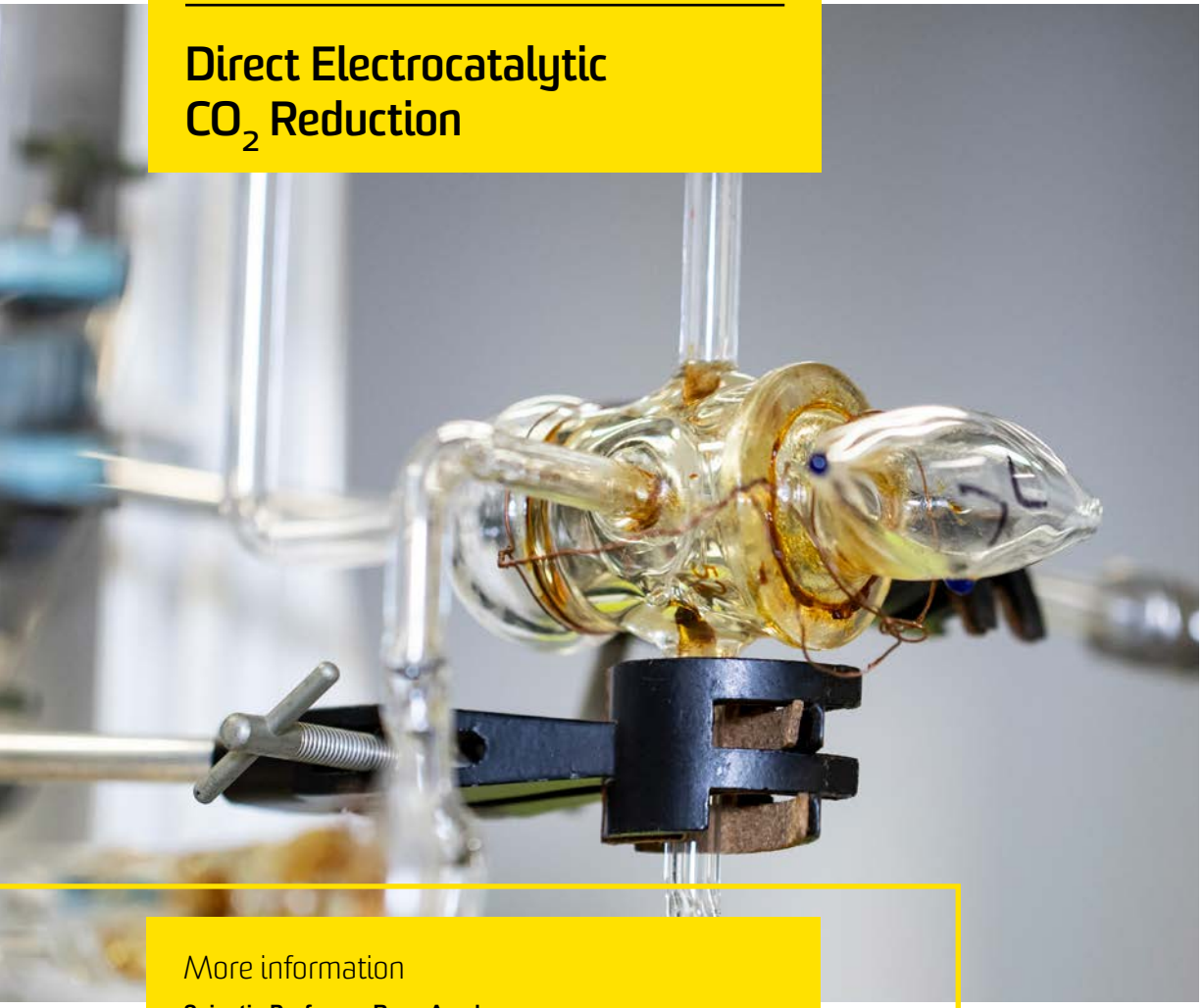
Direct Electrocatalytic CO_2 Reduction



Expertise in the direct conversion of carbon dioxide into high value liquid products, which is important for combating climate changes and energy efficiency challenges.

Competitive advantage

- The electrochemical CO_2 reduction reaction (CO_2RR) can be carried out at ambient conditions by applying an external bias
- Possibility to couple with electricity generated from renewable energy resources to close the carbon loop
- Simple, scalable and cost-effective catalysts for CO_2RR in the gas phase to deliver liquid products

Impact

- Alleviate global warming by direct conversion of CO_2 into high value liquid products
- Creation of a sustainable cycle of carbon-based fuel that will promote zero net CO_2 emissions

Successful applications

- Mesoporous tin oxide (SnO_2) electrocatalyst for large scale conversion of CO_2 to formate with high selectivity and current density

Capabilities and facilities

- Access to expertise and state-of-the-art facilities for electrocatalyst fabrication, characterisation and testing of performance

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Dry CO_2 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) which can be synthesised rapidly in a single step method, and is readily scalable
- High conversion of methane (up to 90%) is achievable at a relatively low operating temperature of 700°C
- Catalyst support (using SiO_2 and Al_2O_3) modification to enhance catalyst stability

Impact

- Alleviate global warming by conversion of CO_2 and methane into synthetic fuels
- Large scale production of active and stable catalyst

Successful applications

- The construction and commissioning of a Flame Spray Pyrolysis reactor to fabricate high surface area metal oxides and catalysts

Capabilities and facilities

- Access to expertise and state-of-the-art facilities for 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 CO_2 into Fuels and Chemicals

Developing electrochemical processes for conversion of the greenhouse gas, CO_2, 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 CO_2 reduction
- Understanding of the reaction mechanism for electrochemical CO_2 reduction

Impact

- A sustainable electrochemistry approach to producing valuable fuels that mitigates the energy issues
- Alleviating global warming by converting CO_2 into valuable products

Successful outcomes

- State-of-the-art nanoporous alloy catalysts for bifunctional CO_2 reduction to CO and formate
- Single-atom catalysts with an ultrahigh Faradic efficiency (>98%) for CO_2-to-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 NMR and solid-state NMR facilities

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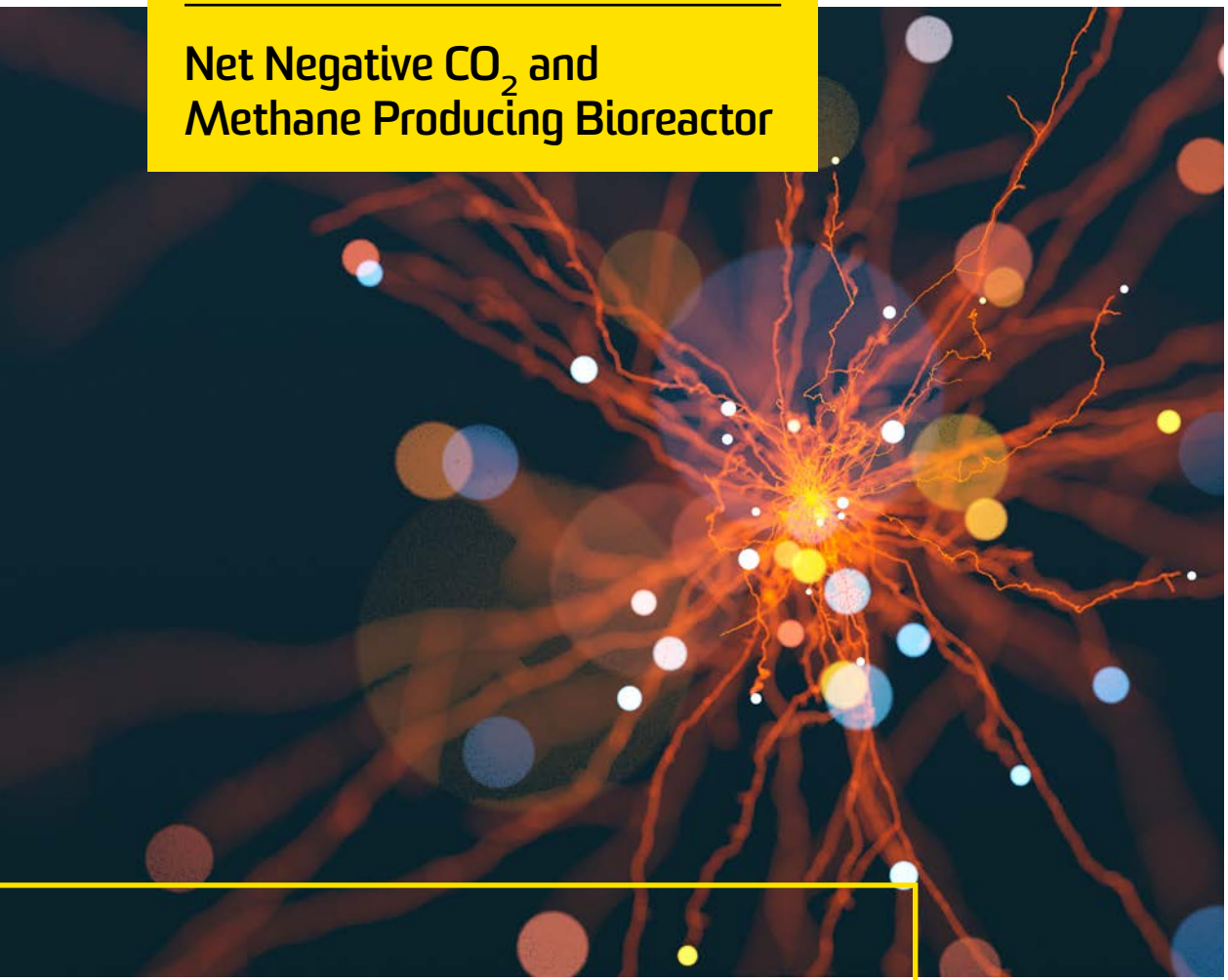
Net Negative CO_2 and Methane Producing Bioreactor



A bioreactor that uses sunlight and CO_2 dissolved in seawater to simultaneously generate methane from the decomposition of algae and sequester CO_2 in the coccoliths of growing algae.

Competitive advantage

CO_2 dissolved in sea water is at 20x the concentration atmospheric CO_2. Algae growing in seawater use sunlight and this CO_2 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 cocolyths are removed in a batch process and stored as sequestration of CO_2 (the precursors of limestone). The Biorector provides methane as a renewable fuel and sequests CO_2 as calcium carbonate or limestone.

- A bespoke bioreactor
- A combination of expertise to leverage existing technology in a combined approach to achieve net negative CO_2 production and produce a renewable energy source (methane) from solar energy

Impact

- Production of renewable fuel
- Capture of CO_2 to reduce the atmospheric concentration of greenhouse gases

Successful applications

- Design and commissioning of a bespoke bioreactor for net negative CO_2 and algal methane production
- Proven methane generation from methanogenic archaea decomposing algae and of CO_2 incorporation in algal coccoliths

Capabilities and facilities

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

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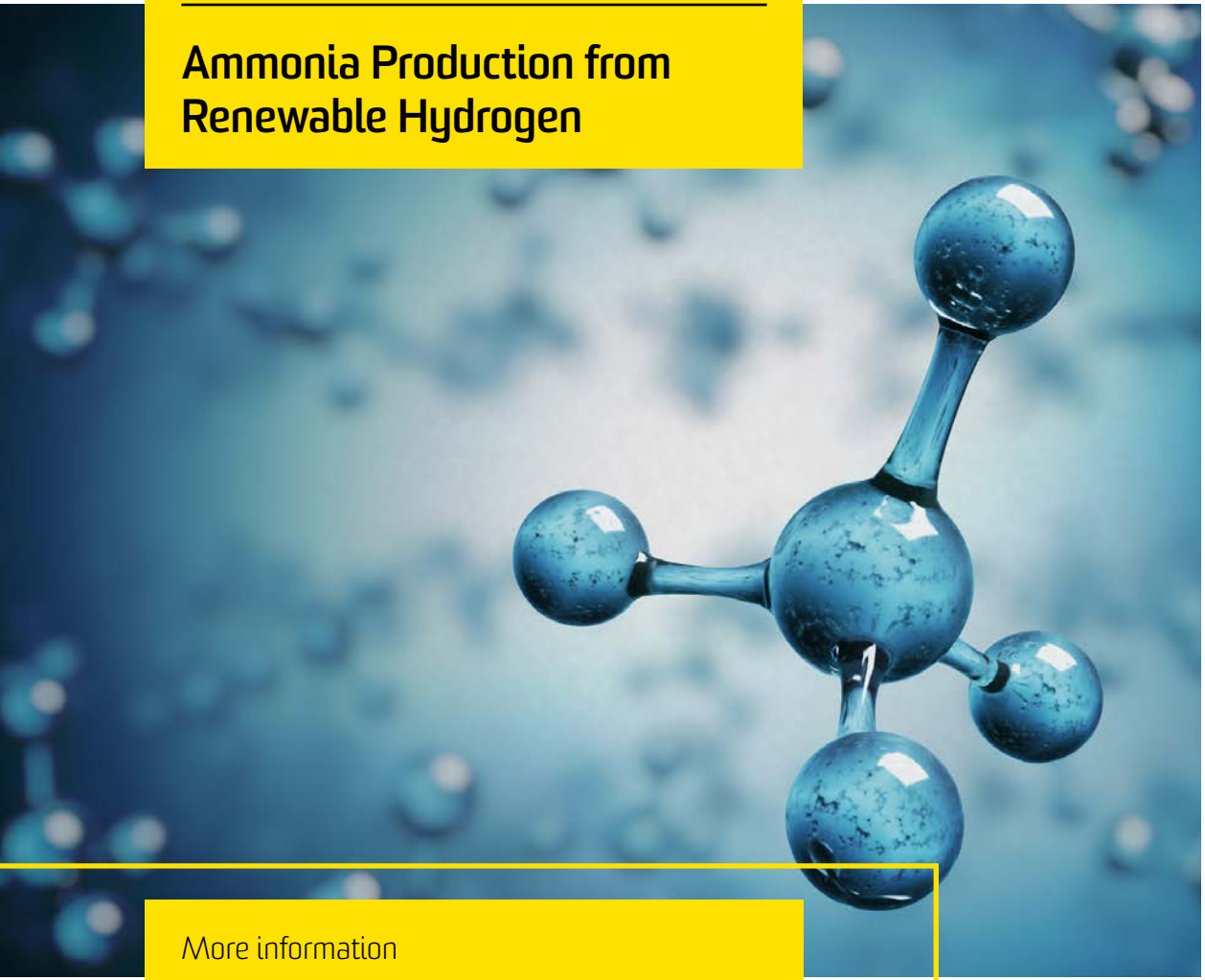
Ammonia Production from Renewable Hydrogen



Development of a high efficiency 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 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

- Cheaper and more energy efficient process for the production of ammonia

Successful applications

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

Capabilities and facilities

- Extensive lab facilities for PV electrolysis 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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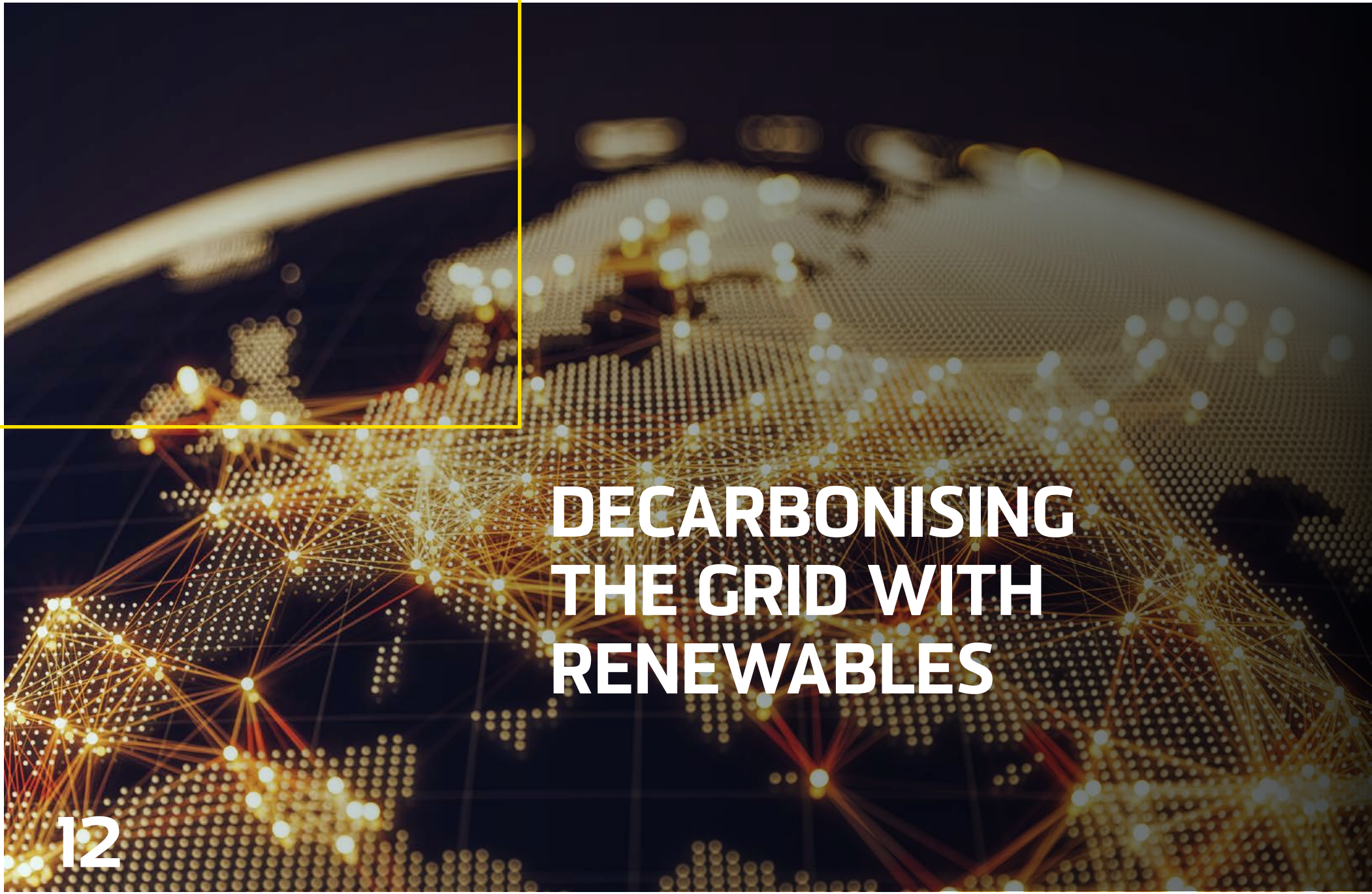
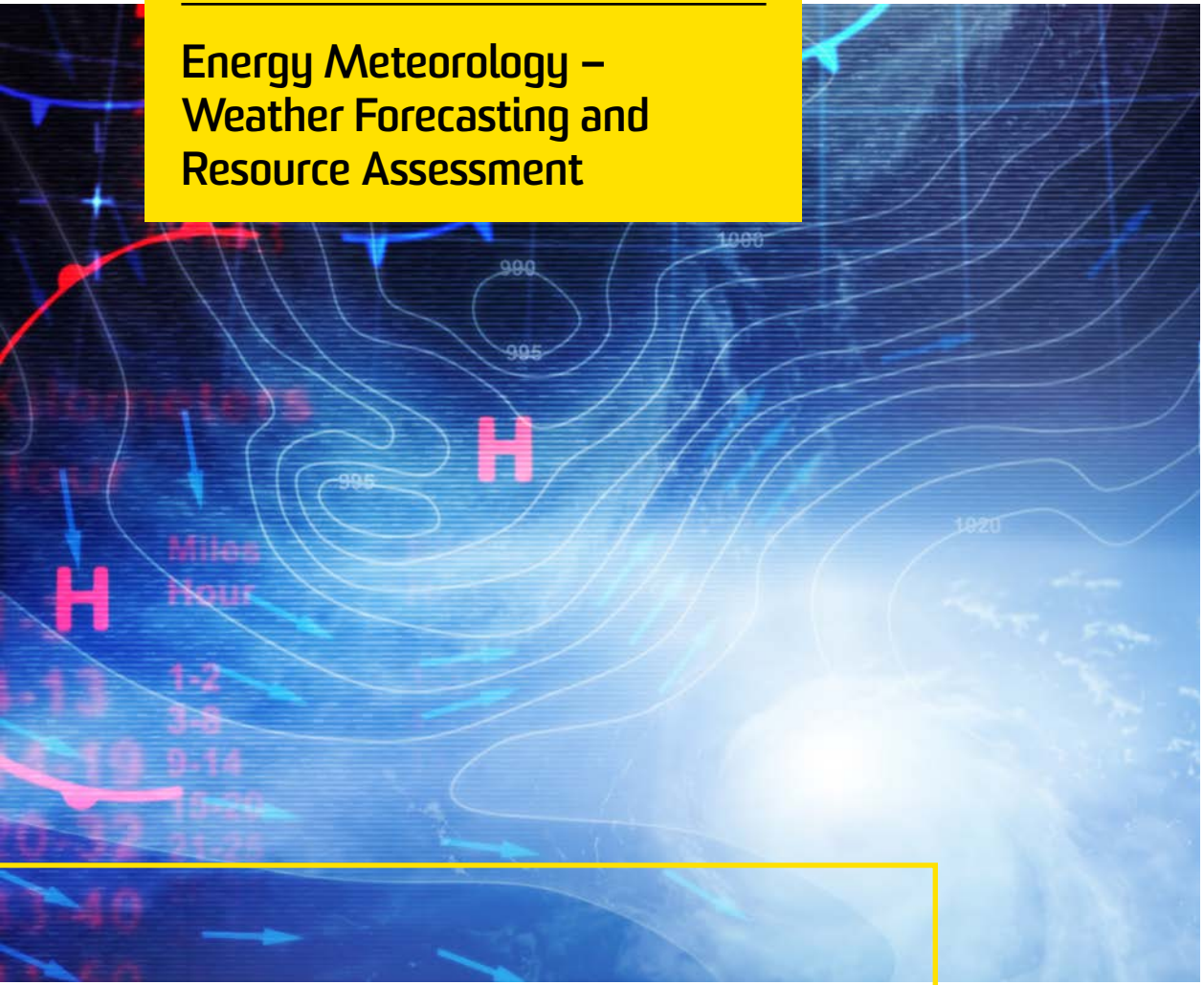


DECARBONISING THE GRID WITH RENEWABLES

Energy Meteorology – Weather Forecasting and Resource Assessment



Using the connection between energy and meteorology to develop models that lead to the promotion of cost-effective and sustainable weather and climate risk-management strategies for the energy industry.

Competitive advantage

- Cutting-edge short-term forecasting for different renewable technologies and hybrid renewable systems, using techniques ranging from running and evaluating Numerical Weather Prediction Models (NWP) to extraction of irradiance from satellite imagery
- Experience in producing weather and power forecasts at timescales that align line with the operation of the National Electricity Market
- Expertise at integrating new forecasting models with the latest insights on the impacts on output from grid events to allow charge/discharge regimes to be developed for energy storage in hybrid systems

Impact

Providing new understanding of the relationship between the weather and energy generation will lead to the development of novel approaches to energy storage control in hybrid renewable energy systems and the development of cost-effective strategies for siting and managing both distributed and large-scale renewable energy systems

Successful applications

- Optimisation of battery size and type for hybrid systems based on weather forecasting
- Identifying the key impacts of atmospheric aerosols such as dust on the output of solar technologies
- Improving weather forecasts for the wind energy sector
- Identifying the impact climate change will have on new wind farm developments

Capabilities and facilities

- Dedicated computation laboratories for advanced simulation modelling and associated facilities for validation studies
- Weather monitoring equipment for validation of modelling results

Our partners

- CSIRO
- Bureau of Meteorology
- NREL
- AEMO
- IMC

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Weather Forecasting for Optimising Energy Storage Systems

Renewable energy power plant performance is maximised using an advanced suite of weather and climate-based optimisation and control strategies for hybrid systems that incorporate energy storage. Risk mitigation strategies are developed that can be used by operators to ensure generation is secure and optimised and ensures maximum returns in the competitive energy market.

Competitive advantage

Extensive expertise in advance weather forecasting strategies across fundamental research to industrial-scale applications delivering:

- Integration of new forecasting models with the latest insights on the impacts on output from grid events and charge/discharge regimes for energy storage in hybrid systems
- Development of key insights into the impacts of weather events on wind and solar operation, particularly extreme weather events, as well the interplay of different battery technology performance in system response
- Interrogation, development and strategies and integration of new technologies into industrial-scale applications

Impact

Development of novel approaches to energy storage control in hybrid RE systems using a combination of weather forecasting and machine learning.

Successful outcomes

- Optimisation of battery size and type for hybrid systems based on weather forecasting

Capabilities and facilities

- 30 kW/130 kWh commercial VRB system in Tyree Building for energy storage and micro-grid research.
- Dedicated computation laboratories for advanced simulation modelling and associated facilities for validation studies.
- Climate controlled chambers for evaluating effects of environmental parameters on energy storage system performance.

Our partners

- Fraunhofer ICT

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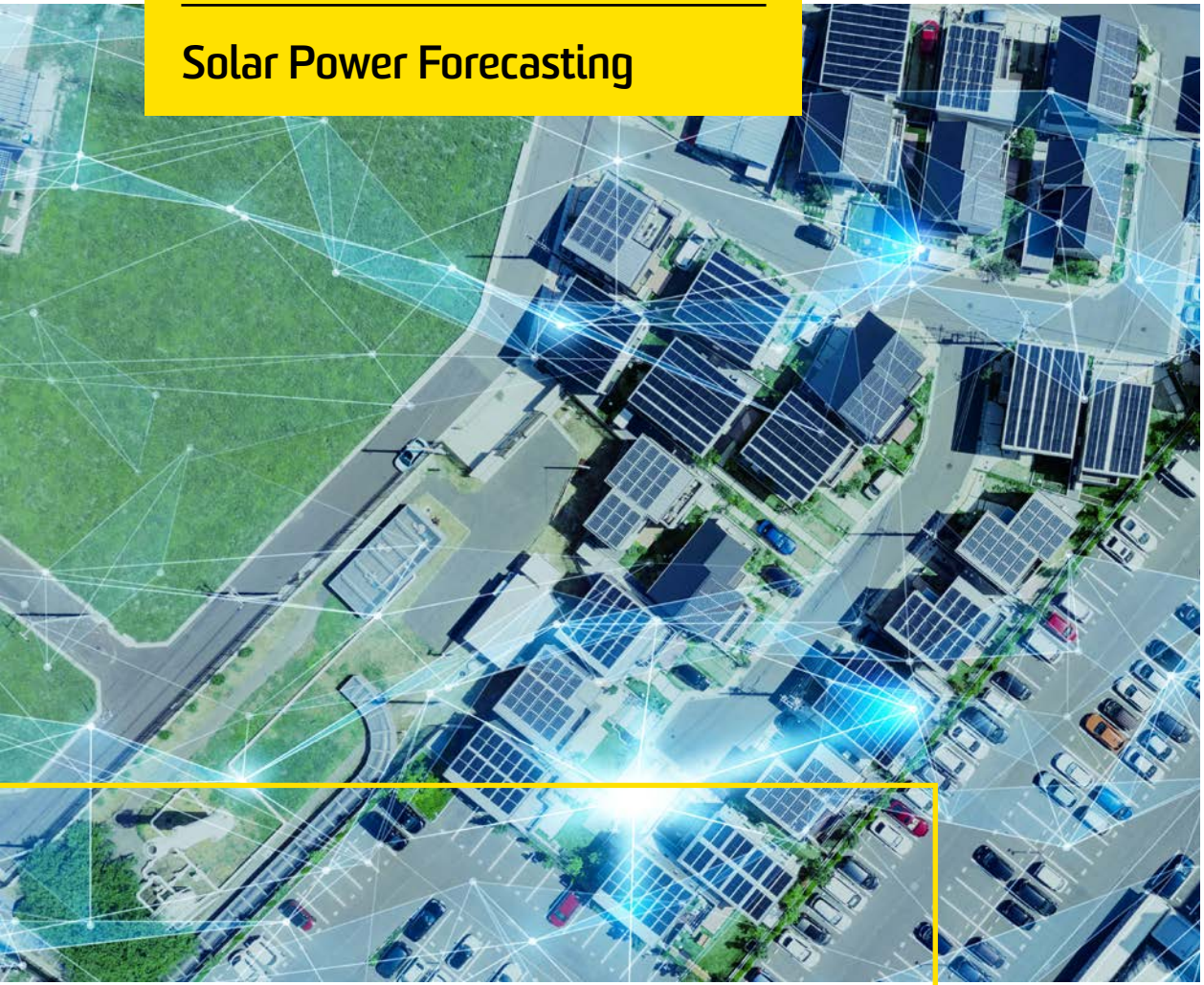
Solar Power Forecasting



Accurate solar forecasting is essential for managing and increasing adoption rates of grid-connected solar systems. Forecasts for regionally-distributed PV systems and individual solar power plants can be provided based on a proprietary PV system modelling methodology and expertise in combining Numerical Weather Prediction (NWP) and real-time observations with artificial intelligence techniques.

Competitive advantage

This capability can be provided as an API-based software-as-a-service (SaaS) product, which can:

- Optimise dispatch and operating reserve requirements for grid operators
- Meet compliance requirements and reduce risks for solar power plants
- Make energy-management system (EMS) smarter in micro-grid and storage systems

The product features:

- Sophisticated data processing with artificial intelligence methods, and
- Reliable and flexible data delivery through web services.

Impact

- Increased safety and efficiency of grid operation by facilitating grid operators to better optimise dispatch while managing the intermittency and ramp-rate of solar power plants
- Increased adoption rate of solar by overcoming the challenges from high penetration and reduced reserves
- Optimised storage management to reduce required battery sizes and increase battery lifetimes

Successful applications

The PV system modelling methodology has been used in evaluating and optimising new solar module designs for commercial partners. It has also been integrated into a commercial home battery storage product.

Capabilities and facilities

- Solar system forecasting
- Meteorological data processing
- Artificial intelligence
- Web service development

Our partners

- LONGi Green Energy Technology
- Hebei Sizhuo Photovoltaic Tech
- DSM Advanced Solar
- Energy Research Centre of the Netherlands (ECN)

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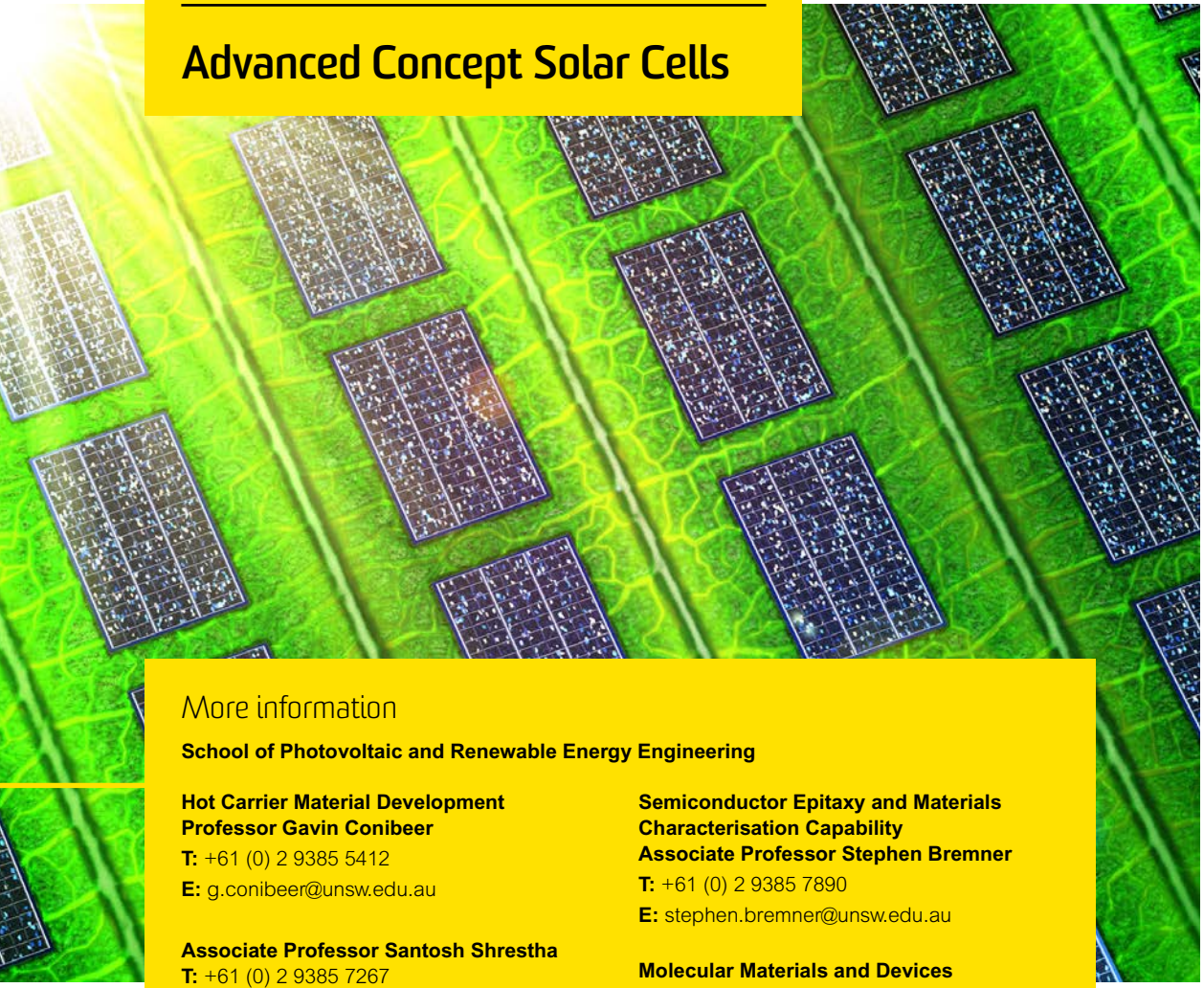
Advanced Concept Solar Cells



Seeking to demonstrate new, long-term approaches to photovoltaic power conversion that can fundamentally increase photovoltaic device efficiency.

Competitive advantage

- Deep conceptual understanding of the thermodynamic basis for solar power conversion
- World class semiconductor and molecular device fabrication and characterisation facilities

Impact

- Demonstrated the first hot carrier quantum well photovoltaic device
- Demonstrated a metallic hot carrier photovoltaic device where sunlight is extinguished in an 8nm layer of chromium

Successful applications

- Four patents on hot electron photovoltaic devices in collaboration with Toyota Motor Corporation
- One patent on hot electron photodetectors in collaboration with Sharp Corporation

Capabilities and facilities

- The SPECTRE Lab (SPECTroscopy for Renewable Energy) houses a suite of techniques that allow the measurement and development of advanced solar cell technologies using a tuneable femtosecond laser system
- Molecular approaches to spectral engineering to better utilize the solar spectrum. This includes the development of both optical and electrical devices
- Inorganic semiconductor based approaches to third generation photovoltaics including intermediate band solar cells and hot carrier solar cells
- Semiconductor Molecular Beam Epitaxy, capable of fabricating quantum heterostructure electronic devices with atomic layer control
- Atomic Layer Deposition of metal oxides

Our partners

- Toyota Motor Corporation
- Sharp Laboratories Europe

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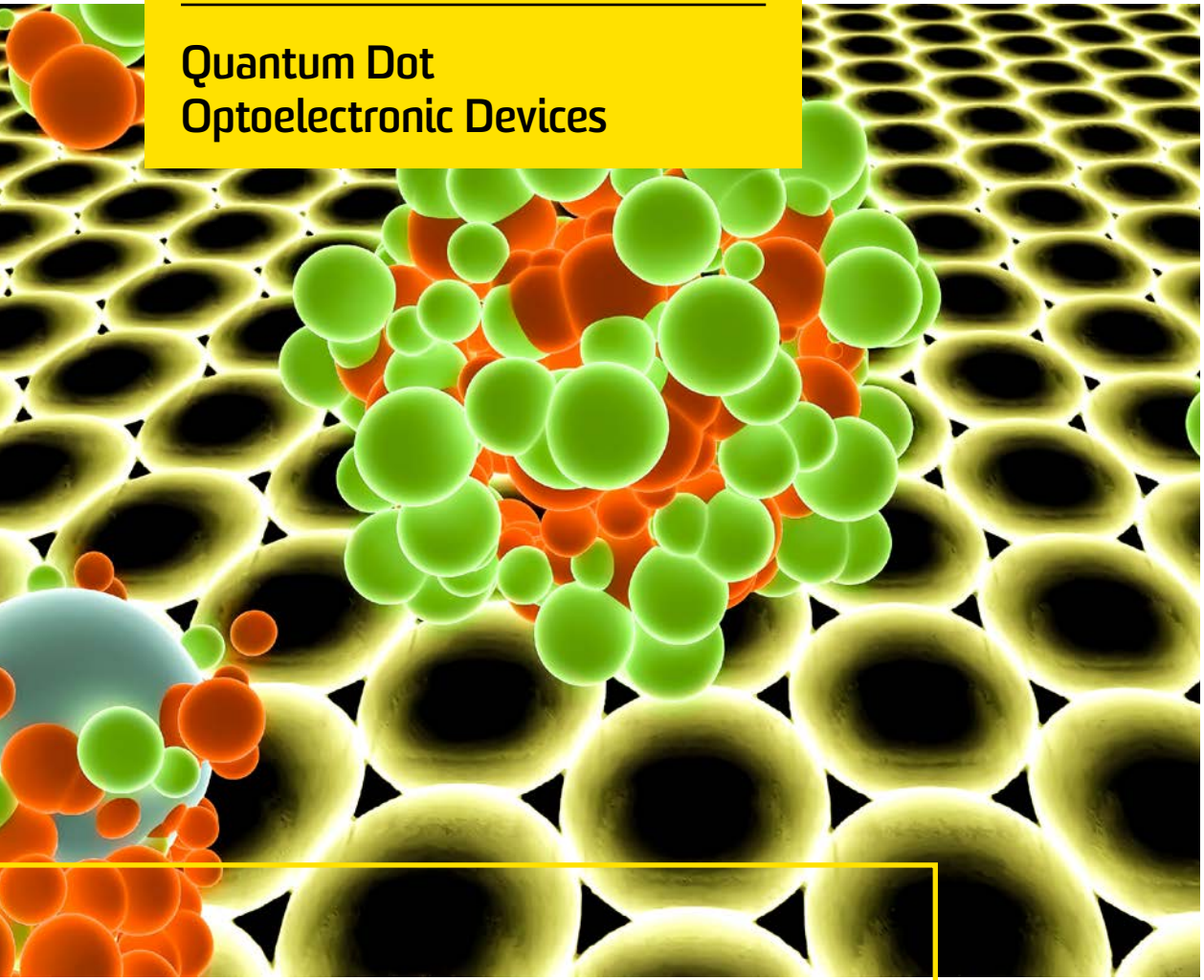
Quantum Dot Optoelectronic Devices



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High performance semiconducting devices are synthesised chemically from nanomaterial and quantum dot colloids. These nanomaterials have applications in solar cells, batteries, renewable fuels and luminescent solar concentrators.

Competitive advantage

- World-record semiconducting quantum dot thin film solar cells using PbS and PbSe
- Creation of highly fluorescent non-toxic nanoparticles, Zn:$CuInS_2$
- Vast experience working with and developing:
  - Low cost high efficiency chemically synthesized optoelectronic devices
  - A variety of oxide nanoparticles with good semiconducting properties
  - Tuneable surface chemistries in high performance nanoparticle systems
  - Inorganic Pb-halide perovskite nanoparticles with tuneable fluorescence across the visible spectrum
  - Magnetic nanoparticles, Fe_3O_4
  - 2D fluorescent and catalytic nanomaterials, MoS_2 and WS_2

Impact

Enables extraction of energy from light in easily implementable/scalable ways, to harvest energy in unconventional locations, e.g. windows. Improvements in electrochemical energy storage. Efficient energy extraction from biomass-derived cellulose, making inefficient bioethanol obsolete

Successful applications

- World leading quantum dot solar cells in PbS and PbSe
- Highest recorded photoluminescence quantum yield from PbS quantum dots (unpublished)
- Lab-scale luminescent solar concentrators, with good performance
- Improved manganese oxide battery electrodes using doped nanoparticles
- Breakdown of cellulose into value-added products

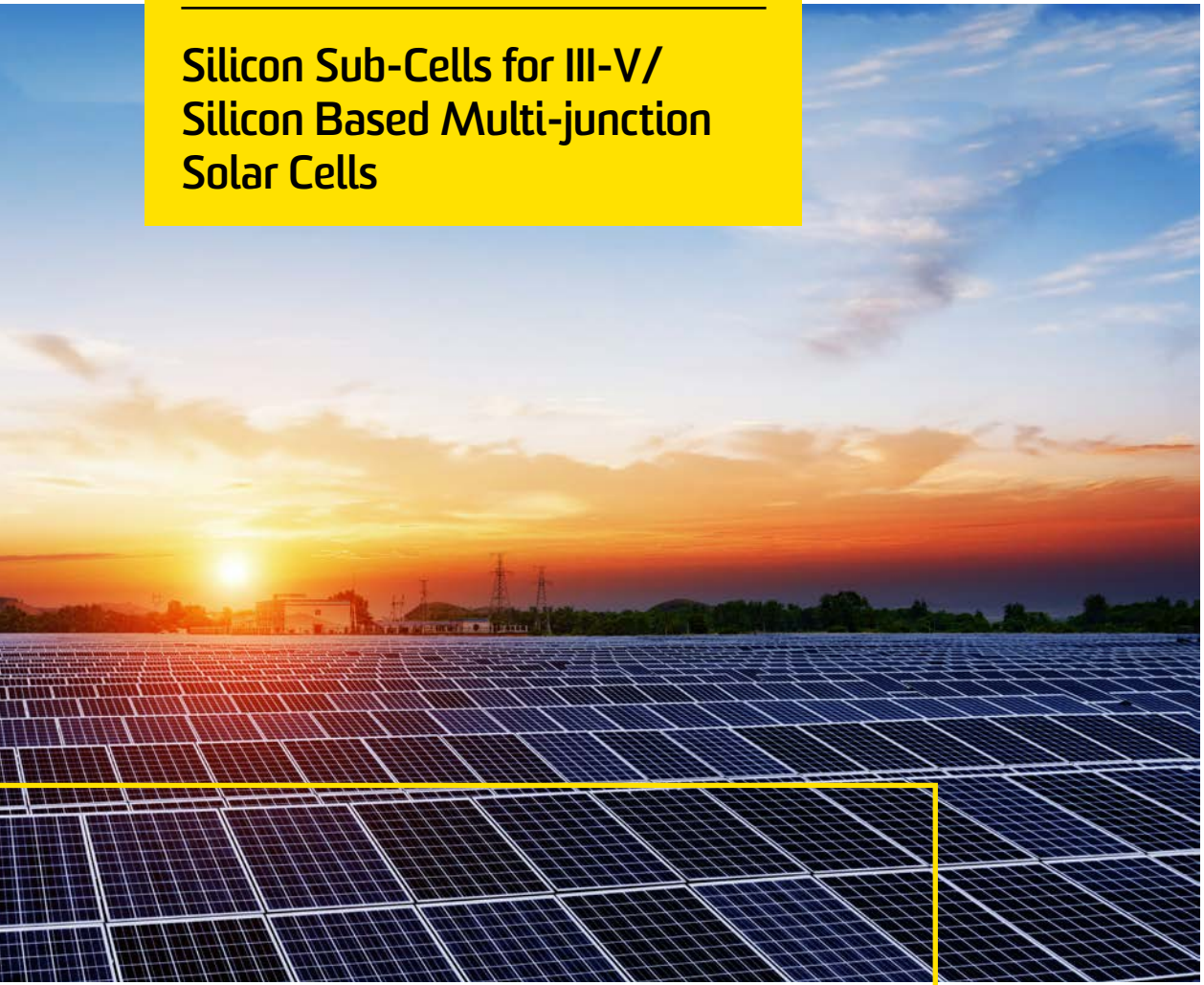
Capabilities and facilities

- 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 infra-red (approx. 400-1500 nm)

Our partners

- ClearVue Pty Ltd, Perth
- Natcore Inc, NY, USA
- Jinko Solar, China

Silicon Sub-Cells for III-V/ Silicon Based Multi-junction Solar Cells



Developing high performance silicon sub-cells for use in III-V/ silicon multi-junction solar cells and targeting final efficiencies in excess of the single junction limit of 33 percent.

Competitive advantage

- World-leading expertise in silicon solar cells
- Unique knowledge of Passivated Emitter Rear Local diffusion (PERL) and related silicon solar cell designs and processing requirements
- Expertise in the preparation of silicon structure for III-V growth processes preserving silicon performance
- Patented room temperature contacting technique to simplify processing
- Design and optimisation capability for silicon sub-cells including detailed device modelling, and expertise in additive optical path length enhancement techniques

Impact

- First group to investigate the design requirements for a silicon solar cell with grown III-V material as top junction
- Part of team that holds the current two junction III-V/silicon multi-junction world record for one sun illumination

Successful applications

- Successfully determined robust process for preserving silicon minority carrier lifetimes during III-V growth
- Used modelling and experimental work to determine the key device features to ensure high performance silicon sub-cells
- Produced the first III-V/silicon multi-junction solar cells with optical path length enhancement schemes integrated

Capabilities and facilities

- Full silicon solar cell processing capability including emitter and back surface diffusions, controlled surface texturing and advanced metallisation
- Additive optical path length enhancement techniques developed at UNSW
- Multi-junction solar cell characterisation including spectral response

Our partners

- SolAero, USA

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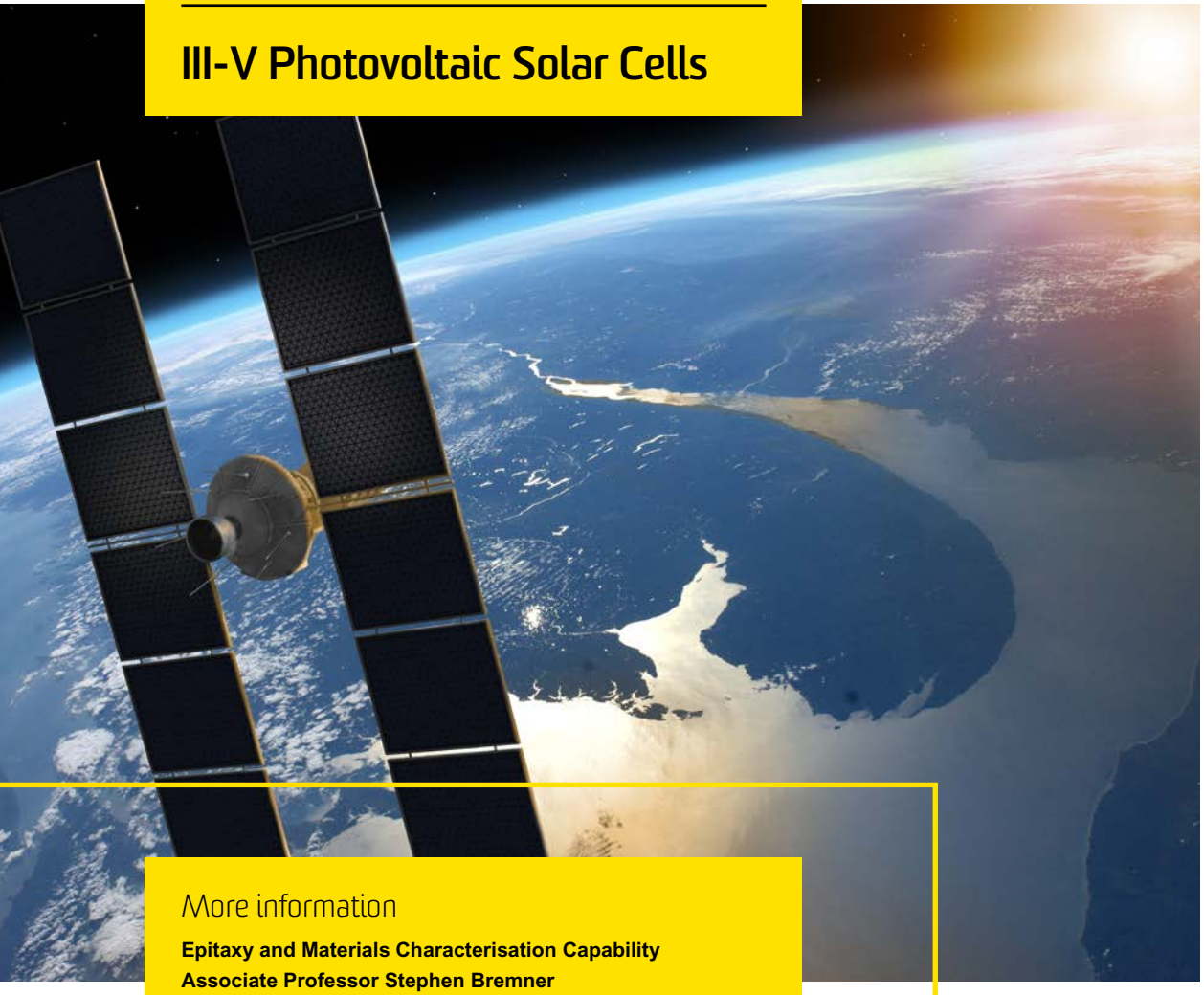
III-V Photovoltaic Solar Cells



Fabricating III-V PV solar cells—multi-junction solar cells made from III-V semiconductor alloys that are used in spacecraft and concentrator systems and are the most efficient available—from the epitaxial growth of high-quality III-V materials using molecular beam epitaxy to device processing and testing.

Competitive advantage

- Over twenty years' experience working on highly efficient III-V solar cells and associated photonic structures
- Only III-V molecular beam epitaxy capability in Australia with the rare ability to grow antimonide and bismide materials
- Full 3" III-V device growth, processing & characterisation on campus
- Rapid test and measurement capability, enabling IV, EQE and EL to be measured from 6" wafers automatically
- Experience in radiation testing of space solar cells

Impact

Demonstrated the highest efficiency nanostructured solar cell ever made with a spin-out company, Quantasol, achieving 28.3% using strain-balanced quantum well layers. It is a technology that has since been evaluated by all major space solar cell manufacturers worldwide.

Successful applications

- Quantasol spin-out traversed the life-cycle from university lab to acquisition by JDSU (now Lumentum), a major optoelectronic device manufacturer
- Selective light confinement in multi-junction solar cells demonstrated in partnership with the US Naval Research laboratory

Capabilities and facilities

- Gen930 molecular beam epitaxy system, consisting of 7 growth sources and three doping ports. This allows for the growth of Arsenides, Antimonides and Bismide compounds
- Access to full cleanroom for III-V device processing, photolithography, wet and dry etching and metallisation
- Full materials characterisation available including high-resolution X-ray diffraction, AFM, SEM, TEM, photoluminescence
- III-V photovoltaic characterisation available, including light I-V, suns-Voc, EQE and multi-junction EQE

Our partners

- IQE PLC
- US Airforce
- US Naval research laboratory

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Organic and Perovskite Solar Cells

Development and fabrication of high-efficiency semitransparent organic and tandem solar cells for window applications. Optimising the device structure design of tandem devices to improve the device efficiency toward a theoretical efficiency of 40 percent.

Competitive advantage

- The skills to develop semi-transparent organic solar cells of 7 percent efficiency, with average visible transmittance (AVT) of 25 percent for window applications
- Patented technology

Impact

Organic and perovskite photovoltaics are extremely attractive candidates for use in next-generation solar cell technologies as they offer affordable solution-based manufacturing processes, light-weight, mechanical flexibility, clean, and renewable energy. The development of solution processed tandem fabrication techniques will significantly reduce the cost of electricity generation for commercial applications. It will also establish an Australian tandem cell processing capability that would eventually make the country a global leader in the commercialisation of tandem solar cells

Successful applications

Developed solution processed single junction organic and perovskite solar cells with maximum efficiency ~ 14.5 percent and ~19 percent, respectively, under 1-sun illumination.

Capabilities and facilities

- New laboratory for research on organic and perovskite materials and devices, equipped and geared towards the development of world-class research facilities
- Access to world-class laboratories for material and device characterization, such as microscopy (TEM, SEM, AFM), XRD and XPS, and micro-Raman. The advanced optical/spectroscopy laboratory can provide the spectral measurements required, including absorption, PL, and FTIR

Our partners

- Huawei - Transparent organic photovoltaic devices
- Dyesol
- Future Solar Pty. Ltd.
- Other world-leading researchers

More information

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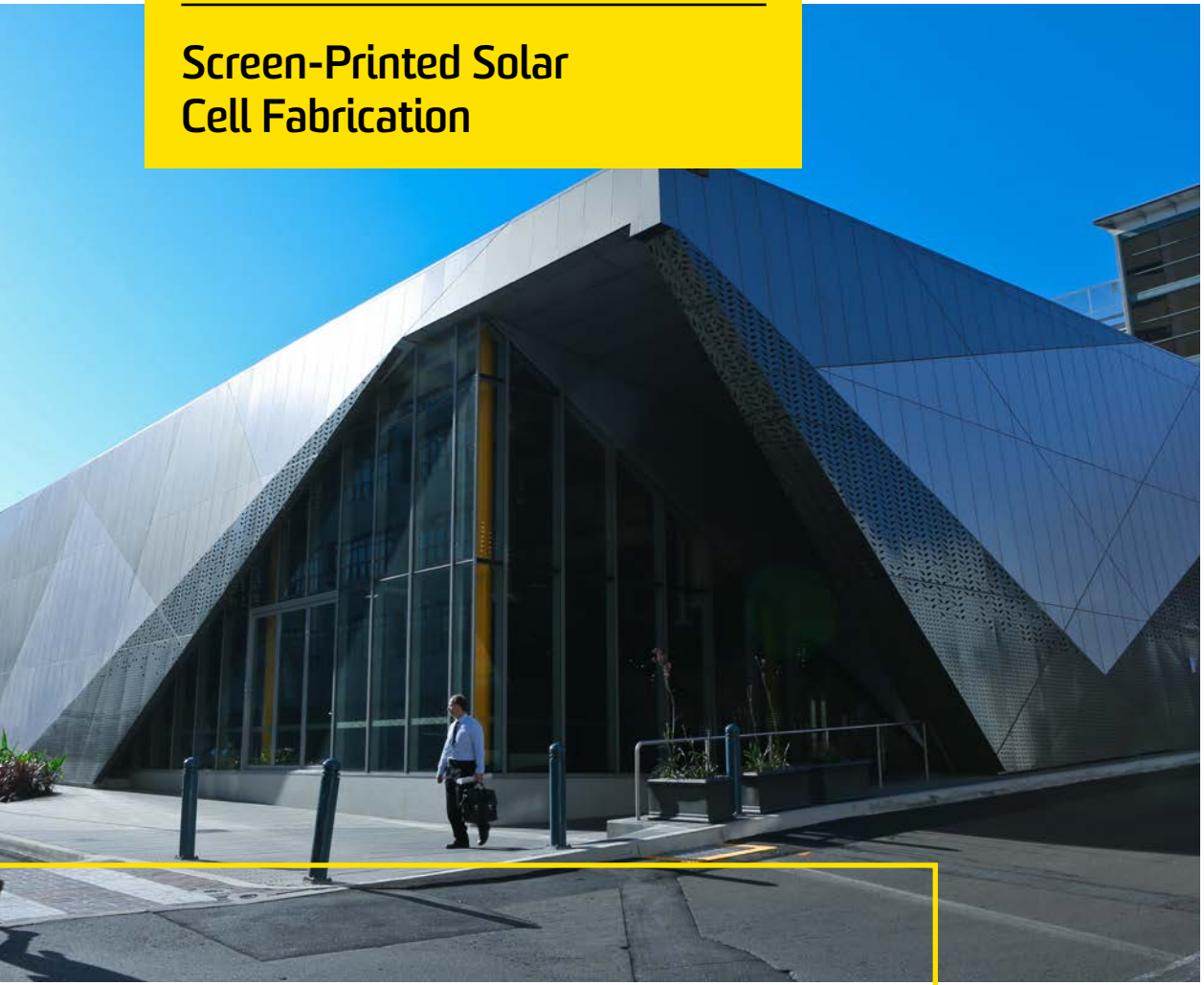
Screen-Printed Solar Cell Fabrication



The fabrication of full industrial-size screen-printed solar cells, from raw silicon wafers through to working devices with screen-printed metal contacts, and encapsulated photovoltaic modules.

Competitive advantage

- Full end-to-end fabrication of screen-printed solar cells
- State-of-the-art characterisation facilities for industrial solar cells
- Decades of expertise in silicon solar cell fabrication and characterisation

Impact

Reducing light- and temperature-induced degradation increases the performance of industrial screen-printed solar cells

Successful applications

- Commercialisation of advanced hydrogenation processes for eliminating light-induced degradation and light- and elevated temperature-induced degradation in silicon solar cells

Capabilities and facilities

- Complete screen-printed solar cell fabrication in the Solar Industrial Research Facility

Our partners

- LONGi
- Suntech
- Canadian Solar
- SAS Sunrise
- LG Electronics
- China Sunergy
- CEC Energy
- Phono Solar
- Tongwei
- Nanjing Sunport
- Tianwei
- Jinko
- Meyer Burger
- Schmid
- DR Laser
- Asia Neo Tech
- Ke Long Wei

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Sprayable and Paintable Solar Cells and Tandem Solar Cells

Research into high-efficiency silicon solar cells, tandem solar cells, perovskite solar cells, manufacturing cost analysis and integration of photovoltaics for a wide range of applications, e.g. buildings, portable devices and vehicles.

Competitive advantage

World records for energy conversion efficiencies of

- large area perovskite solar cells (2016)
- large area monolithic perovskite/Si(homo-junction) tandem solar cells (2018)
- GaAsP/Si monolithic tandem solar cells

Successful outcomes

- Hermetic Encapsulated Perovskite Solar Cells for Thermally Insulated Glazings

Capabilities and facilities

- Fabrication and characterisation of high efficiency and large area perovskite solar cells

Our partners

- Suntech Power
- Trina Solar
- Greatcell Solar Materials
- Microquanta

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

Cutting-edge research into a range of topics related to improved, lower cost solar photovoltaic energy conversion including; Tandem, Reduced Operating Temperature, High-Efficiency and Vehicle-Integrated Solar Photovoltaics.

Competitive advantage

- Hold the world record of 25% for highest efficiency PERC (passivated emitter and rear) silicon solar cell, a cell structure invented at UNSW and now accounting for most of the world's commercial production
- Hold the world record for the most efficient solar module at 40.6% energy conversion efficiency, a multi-cell stack involving 4 cells, each responding to a different range of solar wavelengths

Impact

- Over US$20 billion of UNSW-invented and -developed PERC cell modules sold worldwide in 2018
- Former team members responsible for successful diversification of manufacturing industry into China which resulted in a tenfold solar module price reduction in the years from 2008 to 2018

Successful applications

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

Capabilities and facilities

- Laboratory for fabrication of high-efficiency solar cells
- Solar Industrial Research Facility for evaluating full-sized wafers at pilot production level

Our partners

- BP Solar
- Suntech Power
- Trina Solar
- Jinko Solar
- Longi Solar

More information

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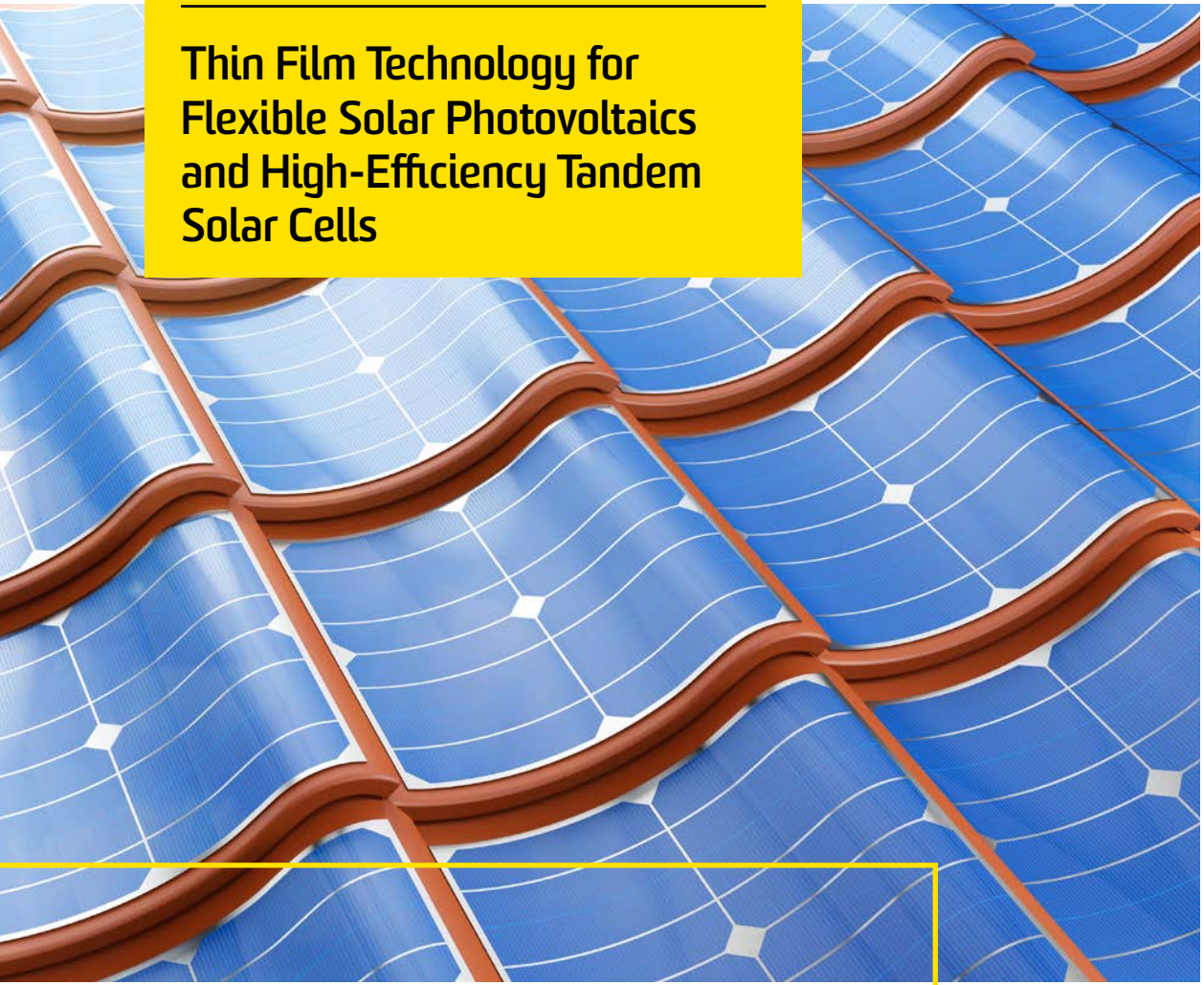
Thin Film Technology for Flexible Solar Photovoltaics and High-Efficiency Tandem Solar Cells



Work on a range of thin film solar cell technologies to offer a renewable solution to generate electricity. 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 world record of 11% for highest efficiency high bandgap pure sulphide Keserite CZTS (Cu2ZnSnS4) solar cells and have established 4 world records for this photovoltaic technology
- Developed 21% efficient low-temperature (<200 °C) processed planar perovskite solar cells with improved stability without encapsulation
- Developed above 30% efficiency III-V/Si tandem solar cells
- Designing and developing new PV materials that are made from environmentally-friendly and earth-abundant materials for Silicon based tandem cells

Impact

- The aim is to make solar photovoltaic more efficient, cost-effective and competitive for the energy market and for their applications in various aspects of our life such as building- and vehicles-integrated PV, and portable power sources
- The breakthroughs in kesterite represent a major advance in developing solar cells that are flexible, stable, cheap and non-toxic

Successful outcomes

- 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 for fabrication of 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 pilot production level of tandem cells
- Advanced characterization tools for thin film photovoltaic materials and devices

Our partners

- Trina Solar
- Longi Solar
- Jinko Solar
- Baosteel

More information

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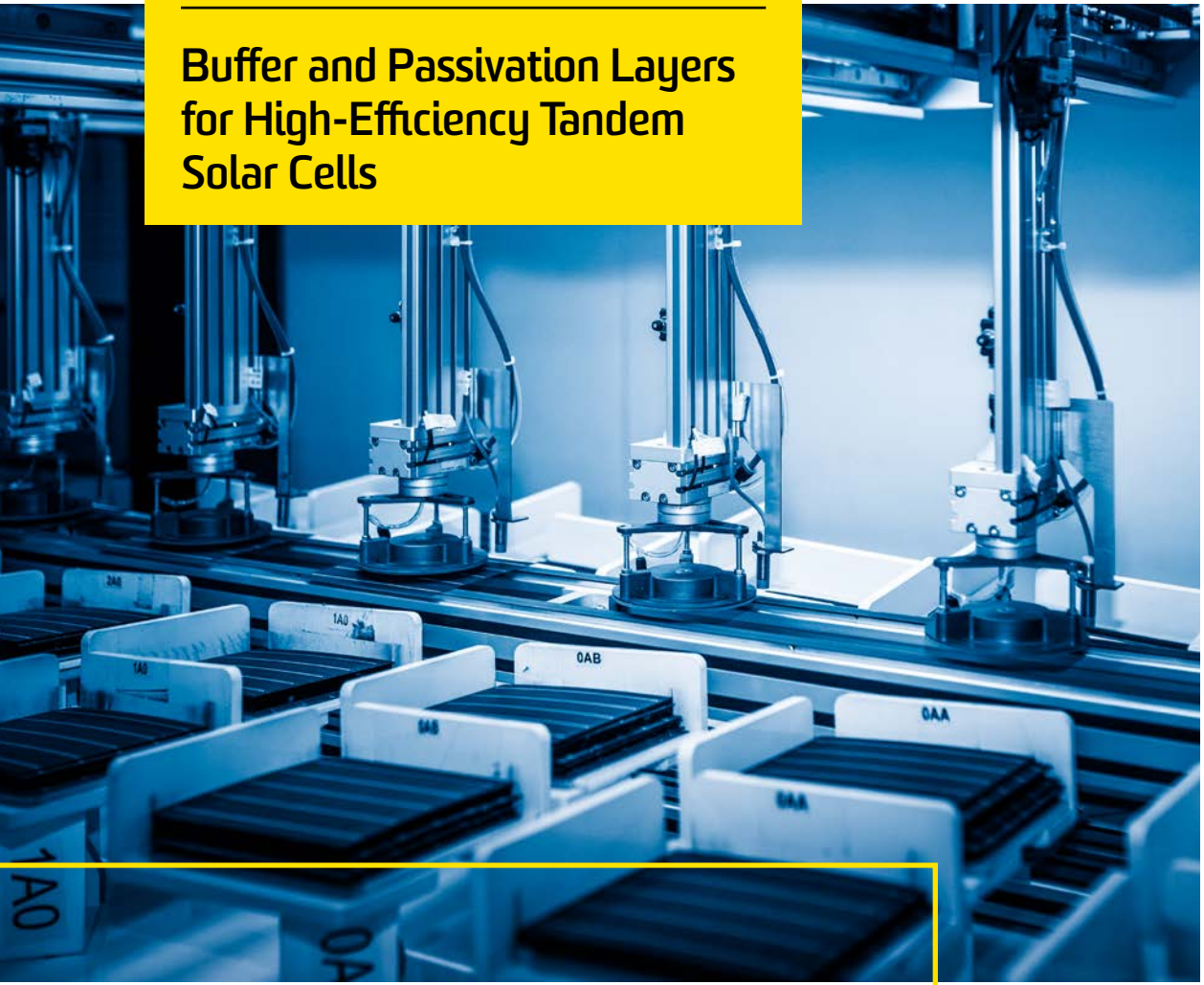
Buffer and Passivation Layers for High-Efficiency Tandem Solar Cells



It is quite well accepted that tandem solar cells are the most promising way to achieve a solar cell efficiency in excess of 30%. If these are to be silicon based, they will require both buffer and surface passivation layers in order to maximise their performance.

Competitive advantage

- The only laboratory in Australia that has an atomic layer deposition reactor with real-time feedback on the synthesised material, offering unprecedented advantages in terms of process optimisation and device integration
- Use of an advanced, computational material science approach to identify the most promising materials before synthesising them
- Ability 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 outcomes

- 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 process from low- to high-technology readiness level
- Access to both lab-scale as well a pilot-scale thin film deposition equipment for swift transfer from the laboratory to the factory

Our partners

- Working together with various leading worldwide research groups to test thin films at the solar cell device level

More information

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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

- World-class understanding of device-relevant fundamentals
- Capability to synthesise a wide range of surface passivation materials/ stacks in-house
- Field-leading characterisation capabilities
- The first to develop a method for extracting the quantity of charge in dielectrics on doped silicon surfaces

Impact

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

Successful outcomes

- One of the main pioneers 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 and experience in state-of-the-art device simulation tools
- In-house laboratory and pilot-scale thin film fabrication capabilities for a wide range of surface passivation films

Our partners

- Leadmicro, a leading equipment manufacturer from China
- A number of non-disclosed solar cell manufacturers

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Carrier Selective Contacts for Silicon Solar Cells

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

Competitive advantage

- The only laboratory in Australia that has an atomic layer deposition reactor with real-time feedback on the synthesised material, offering unprecedented advantages in terms of process optimisation and device integration
- Cutting-edge device optimisation informed by a high-level understanding of device fundamentals
- Real-time insight and control of thin film growth and its correlation to final device performance
- Ability to perform atomic-scale engineering using atomic layer deposition
- Using an advanced, computational material science approach to identify the most promising materials before synthesising them

Impact

A process to lower the contact resistance of screen-printed contacts was successfully transferred to high-volume manufacturing in less than 2 years after first demonstration at the 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 in PECVD and PVD equipment

Capabilities and facilities

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

Our partners

- Leadmicro, a leading equipment manufacturer from China
- A number of non-disclosed solar cell manufacturers

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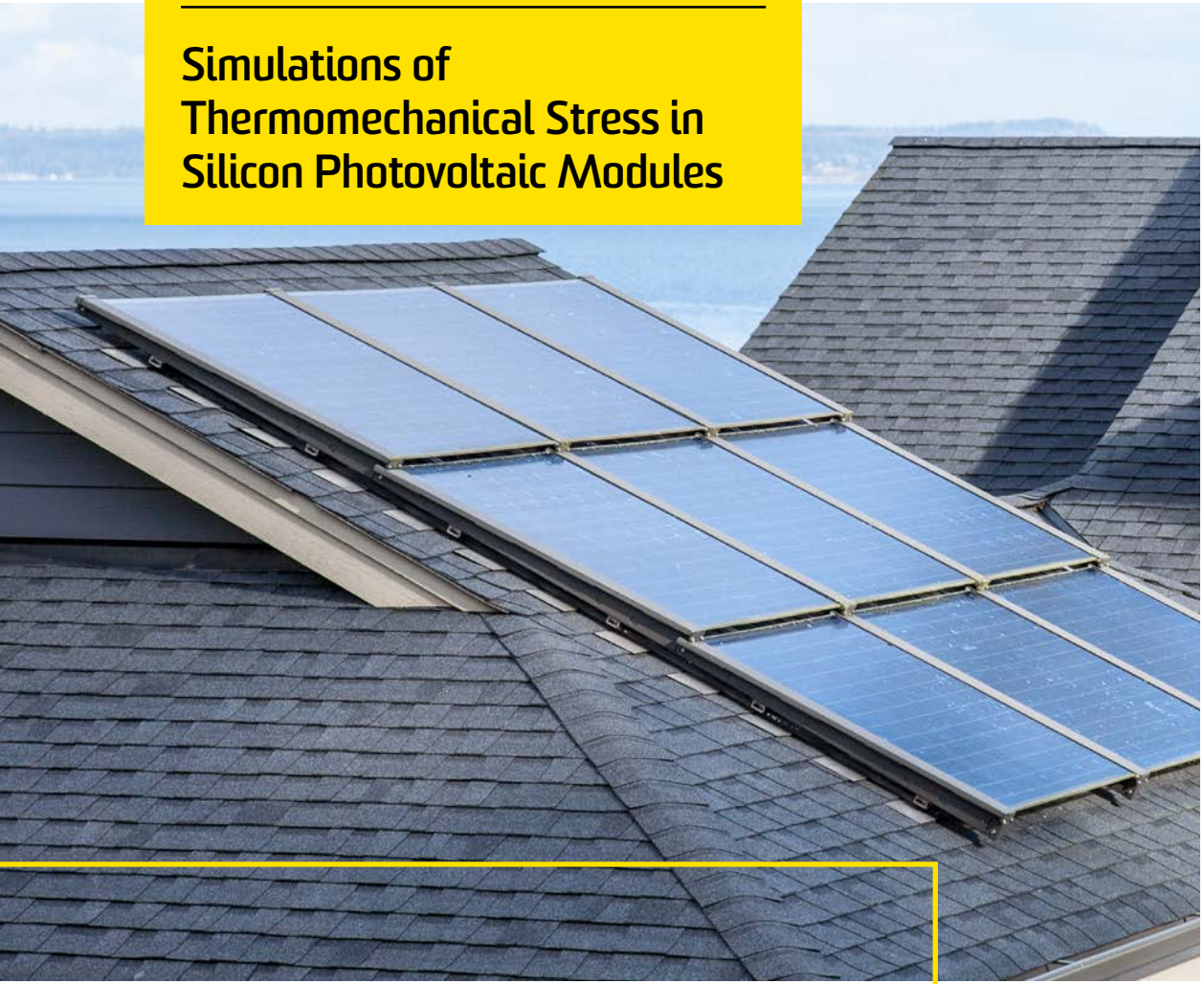
Simulations of Thermomechanical Stress in Silicon Photovoltaic Modules



The use of simulations to predict how wafer firing, cell interconnection and module lamination processes affect the induced stress in silicon wafers that can cause cracks, which limit production yield and module durability.

Competitive advantage

- Expertise in finite element modelling of thermomechanical stress in mixed material systems
- Pending patents for methods of reducing the induced thermomechanical stress in silicon wafers through use of interconnection geometry
- Ability to identify regions of high stress induced by different interconnection methods for wafers of varying thickness

Impact

Can be combined with optical simulations of electricity yield to identify module configuration that maximises optical and electrical performance whilst ensuring improved durability.

Successful outcomes

- Identified patterns of thermomechanical stress in silicon photovoltaic modules interconnected with soldered ribbons and wires
- Identified impact of interconnection geometry on stress evolution

Capabilities and facilities

- Silicon photovoltaic module fabrication and testing facilities

Our partners

- LONGi Solar
- Sizhuo PVTech Hebei
- 3M
- DSM
- ECN (part of TNO)

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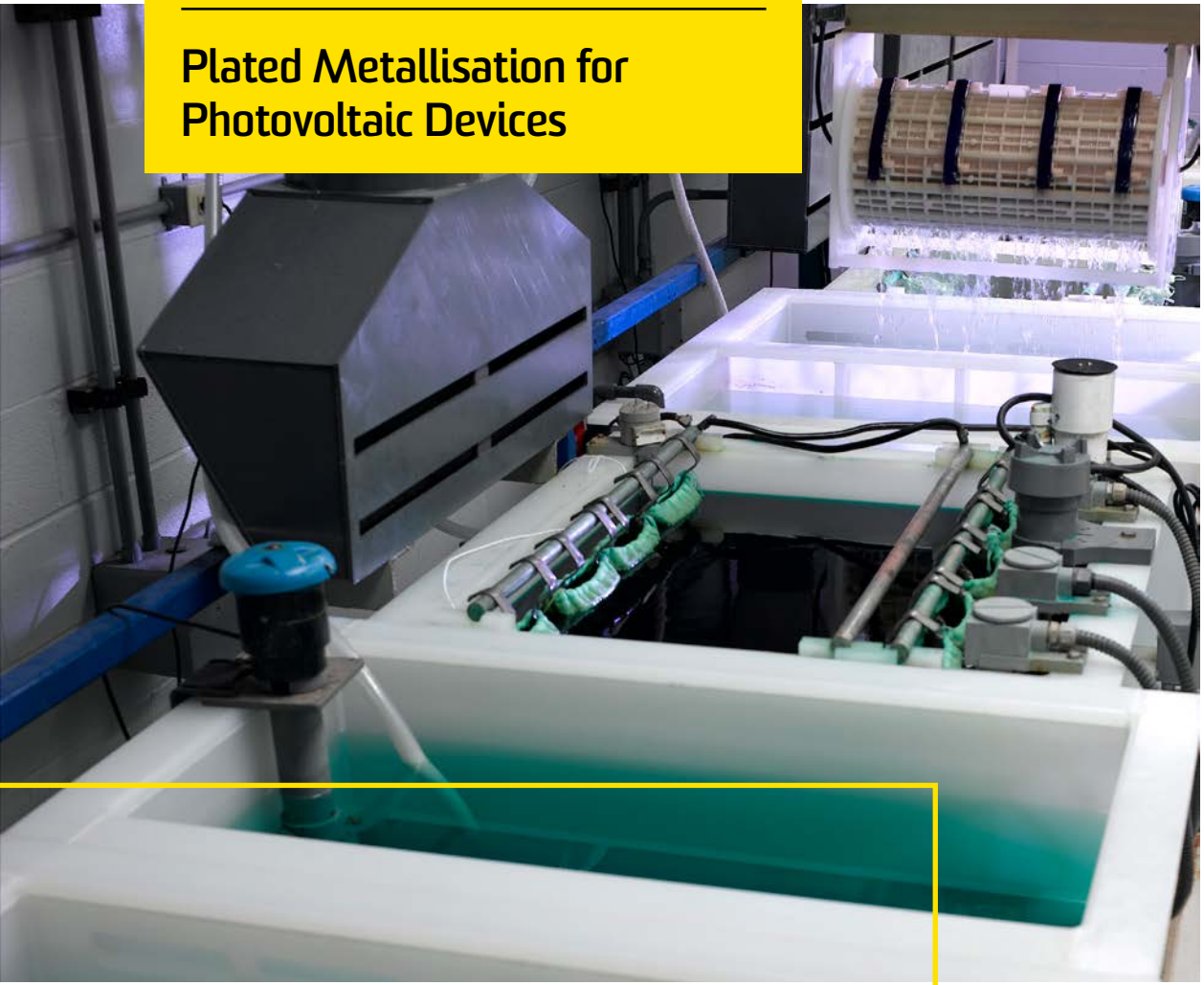
Plated Metallisation for Photovoltaic Devices



Copper plated electrical contacts to solar cells can provide the advantages of high conductivity and low cost, however copper plating processes can present challenges in terms of equipment availability, process control, durability and waste management.

Competitive advantage

- Extensive experience in copper plating processes including light-induced plating and forward-bias plating of industrial silicon solar cells
- World-class facilities for adhesion testing of solar cells and durability testing of modules

Impact

- Demonstrated copper plated p-type PERC cells with strong finger adhesion
- Several patented patterning methods for contact region definition

Successful applications

- Nickel/copper/silver plating of ps-laser ablated p-type PERC solar cells
- Nickel/copper/silver plating of n-type PERT solar cells
- Copper plated bifacial silicon heterojunction cells

Capabilities and facilities

- Nickel/copper/silver plating processes and equipment for p-type and n-type Si solar cells
- Contact formation using 266 nm ps laser ablation
- Light-induced and forward-biased plating processes for silicon solar cells
- Immersion plating processes for seed and capping layers
- Sputtered amorphous seed layers for plated contacts
- Grid designs for copper plated solar cells
- Finger and busbar adhesion measurements
- Patterning and copper plating processes and equipment for silicon heterojunction cells
- Copper plating and equipment for GaAs solar cells
- Environmental testing of copper-plated Si photovoltaic modules
- Analysis and detection of copper diffusion in silicon
- Cross-sectional analysis of modules using plasma FIB to determine physics of failure mechanisms arising from environmental testing of modules

Our partners

- Suntech Power
- Trina Solar

More information

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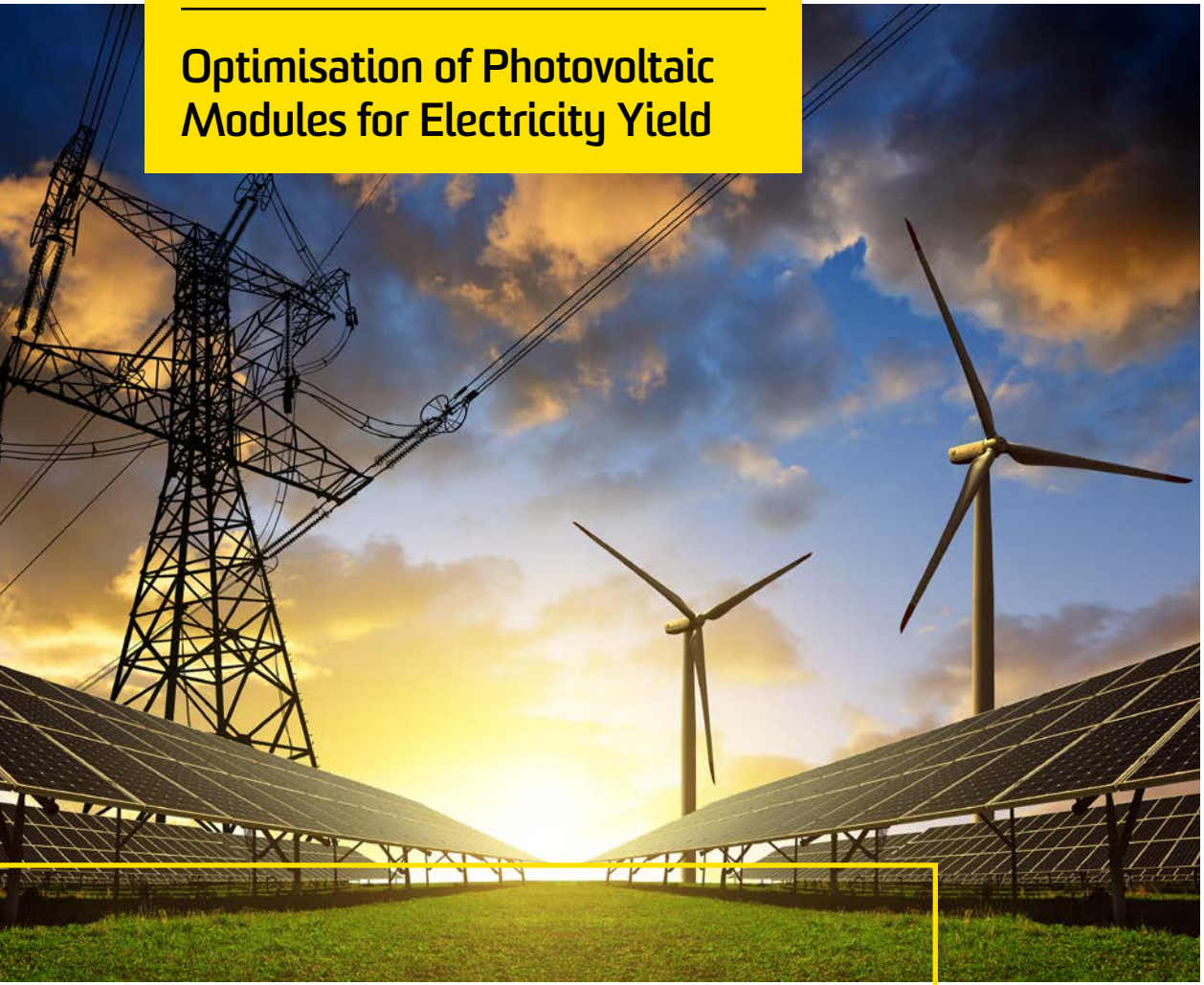
Optimisation of Photovoltaic Modules for Electricity Yield



Using simulations to identify interconnection and light structuring approaches that maximise electricity yield, which is a more useful determinant of the levelised cost of electricity for a location than standard test conditions.

Competitive advantage

- Expertise and software in optical simulation that allows for efficient matrix-based computation of electricity yield at particular locations
- Up-to-date knowledge of state-of-the-art interconnection designs for silicon photovoltaic modules

Impact

- Reduced LCOE by optimisation of photovoltaic modules for increased electricity yield

Successful outcomes

- Predictions of both power and electricity yield gains for modules interconnected with wires and ribbons with light redirecting films
- New interconnector geometries that can enhance the optical performance of photovoltaic modules
- Collaborations with leading photovoltaic module manufacturers and producers of interconnection ribbons and light re-directing films
- Demonstrated results identifying optical benefits of different interconnection methods (e.g. Smartwire, MultiBB, ribbons with light redirecting films)

Capabilities and facilities

- Optical modelling software and expertise
- Facilities for fabricating and testing modules under STC and angular illumination

Our partners

- LONGi Solar
- Sizhuo PVTech Hebei
- 3M
- DSM
- ECN (part of TNO)

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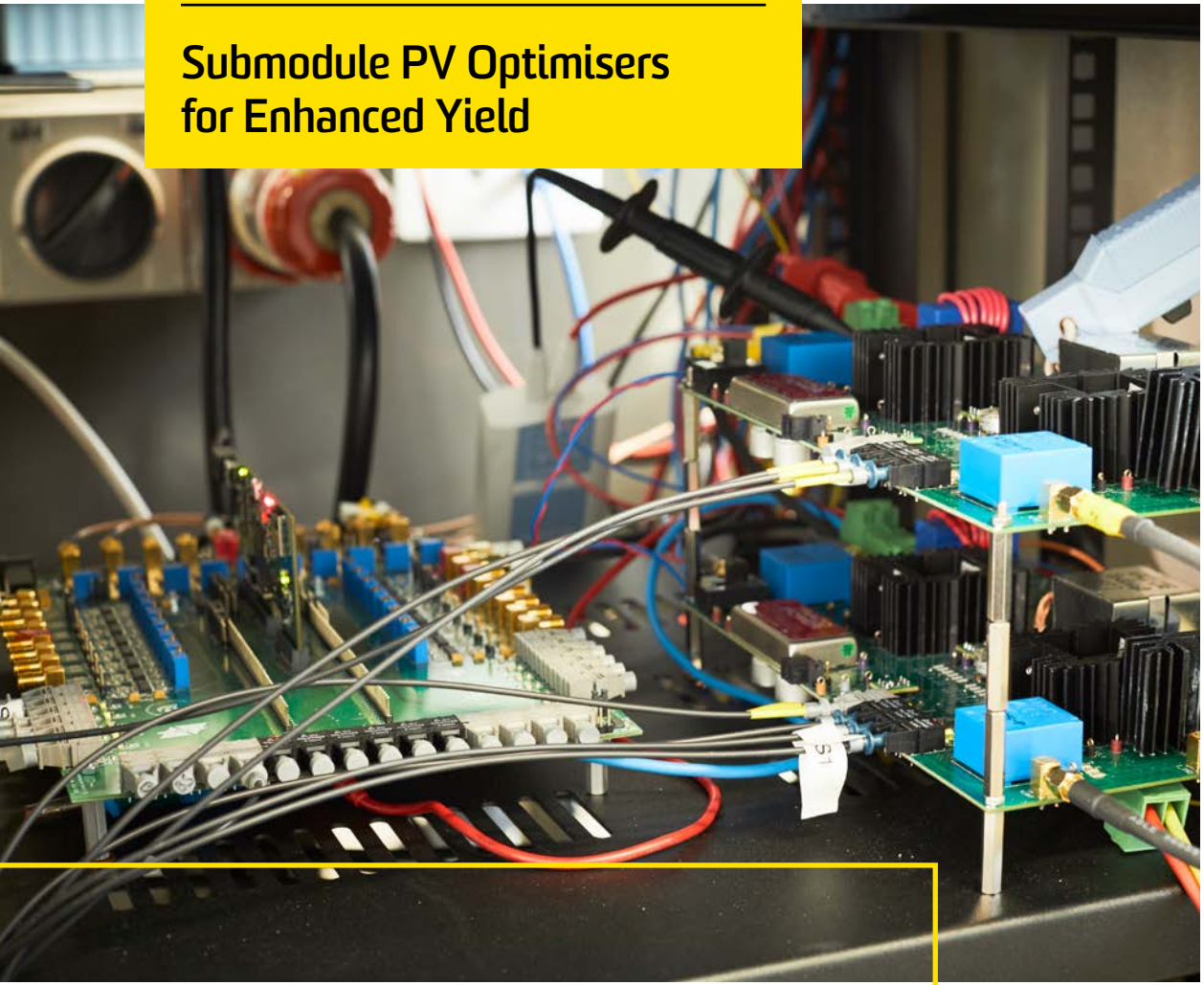
Submodule PV Optimisers for Enhanced Yield



Developing power electronic-based optimiser circuits that maximise the energy output, in real time, from photovoltaic panels that have become shaded, hot or are deteriorating. Doing so attacks the costs and benefits of PV systems from two significant directions, improves the yield and enhances the return on investment.

Competitive advantage

- Use of state-of-the-art high power-density circuitry in the design of lower cost optimiser circuits
- Demonstrated ability to improve the yield of new and existing installations by up to 30%

Impact

- Improving the energy yield from sub-optimally located and positioned PV panels
- Lowering the costs by focusing on sub-module and individual tiles
- Reducing the power rating of the optimiser power electronics

Successful outcomes

- Differential power processor prototype has been verified by PV simulators

Capabilities and facilities

- High-quality test and measurement systems for assessment and verification of circuitry
- Environmental chamber testing for accelerated life assessment
- Advanced power electronics converter testing platform
- Hardware-in-the-loop simulation platform
- PV simulators

Our partners

- Hi-Vis Group
- Hyperion

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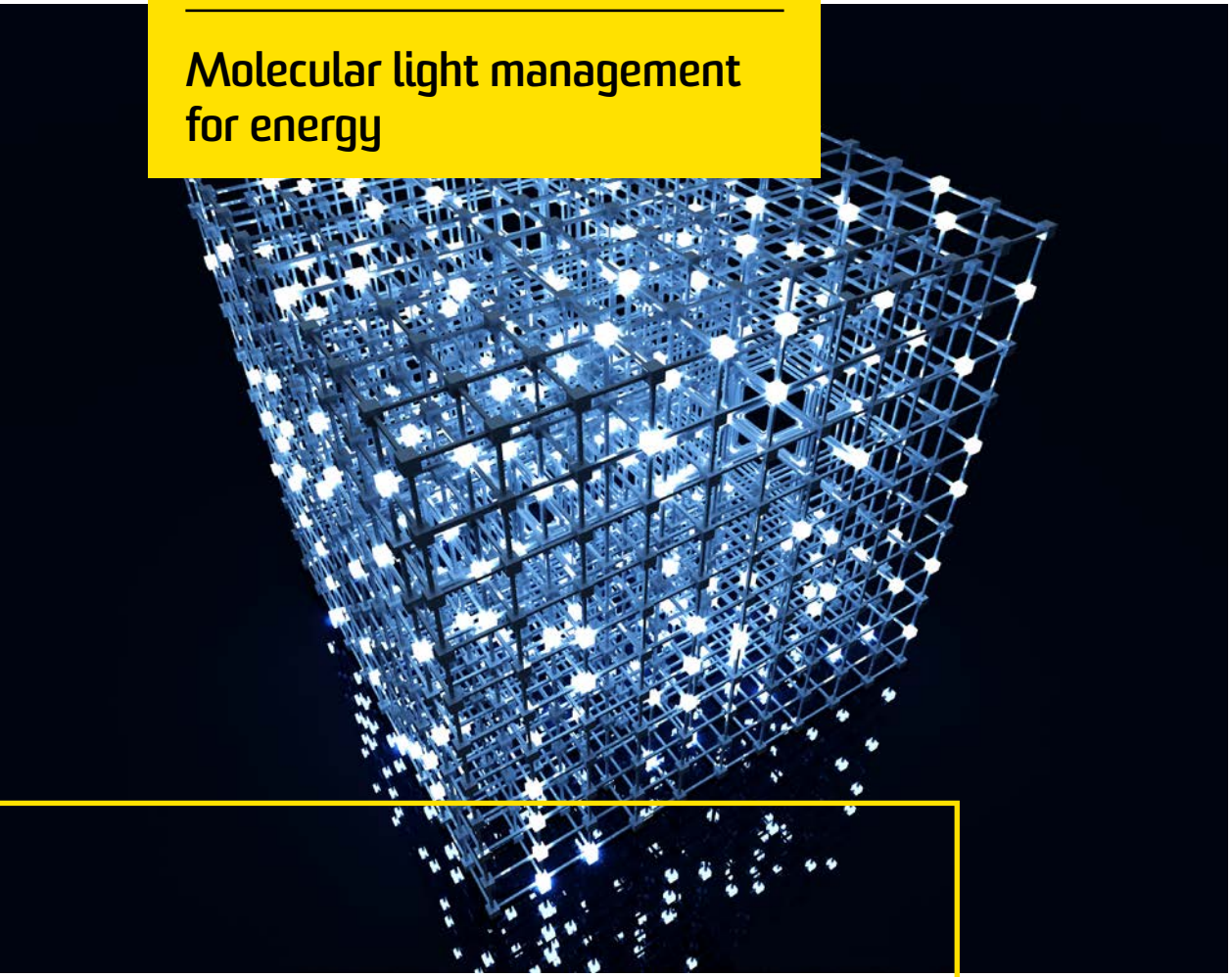
Molecular light management for energy



Using a range of different molecules to manipulate light for more efficient energy applications. Laboratories specialising in the characterisation and application of several molecular technologies. Leading expertise in spectral manipulation and exciton management using photochemical upconversion and singlet fission, and concentrating light using molecular luminescence.

Competitive advantage

- Decade of experience and world leaders in photochemical upconversion
- Only laboratory using photochemical upconversion to convert light from below the silicon bandgap
- Can analyse 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 characterisations facilities: ultrafast optical, THz and Raman, time-resolved electron spin resonance
- Material synthesis and fabrication of oxygen-sensitive devices

Our partners

- HiVis Pty Ltd – A manufacturer of road safety signs
- Through ACEx – CSIRO, RBA and DSTG

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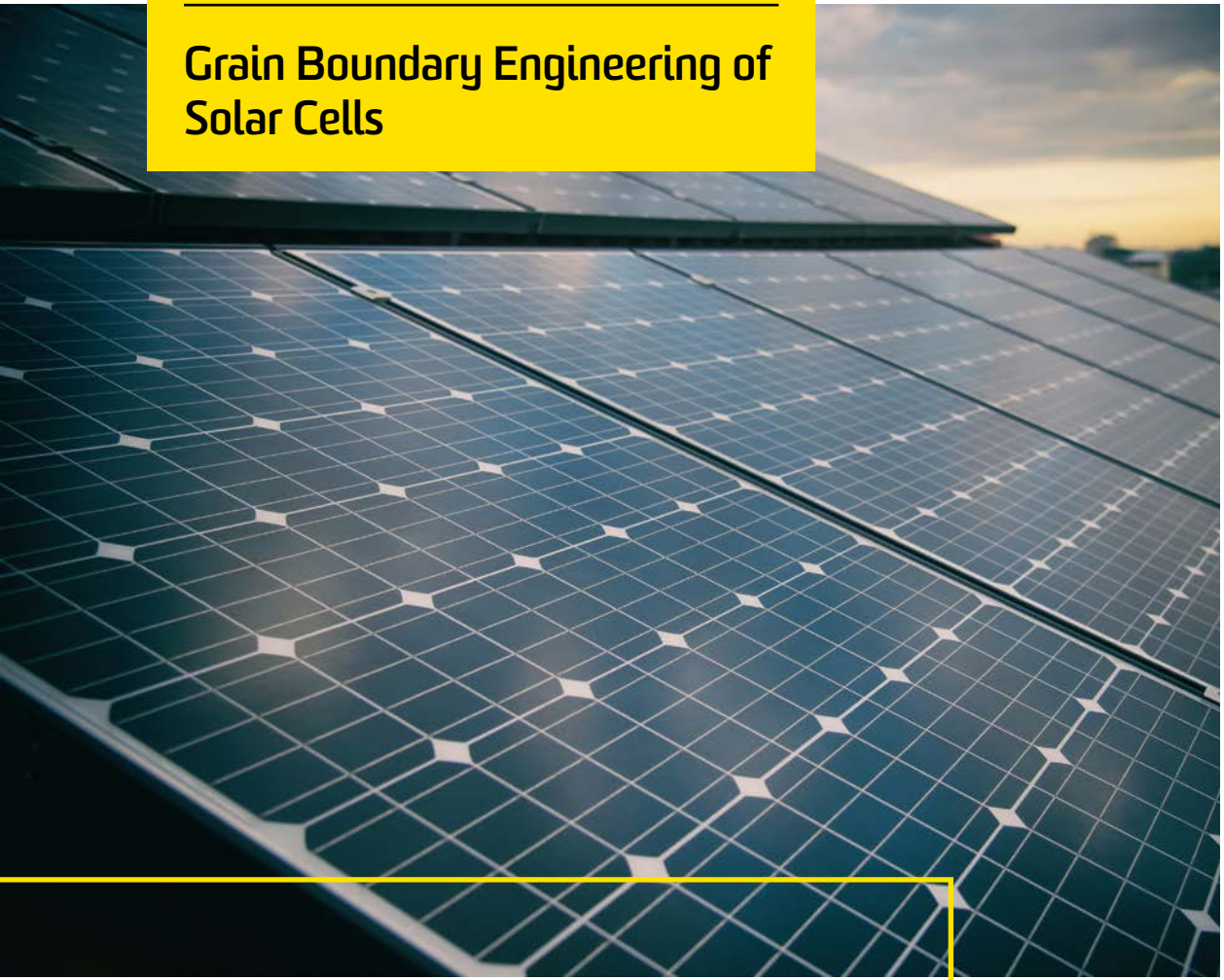
Grain Boundary Engineering of Solar Cells



Using various forms of advanced scanning probe microscopy to characterise the properties of grain boundaries, and other material interfaces, with nanometre lateral resolution under light illumination.

Competitive advantage

- Exclusive scanning probe microscopy platform, developed inhouse and not available commercially
- Material properties can be assessed with nanometre resolution
- Ability to test 6-inch wafers

Impact

Creating a better understanding of the properties of materials at nanoscale.

Successful outcomes

- Technology has been applied 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, changes upon chemical treatment, quantum efficiency of grain boundaries and other interfaces in solar cells and photovoltaic devices

Our partners

- Lawrence Berkeley National Laboratory

More information

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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 to gain deeper insight, is superbly suited for this purpose.

Competitive advantage

- World-class functional scanning probe microscope technique that has an advantage over other bulk characterisation techniques in providing spatial resolution to nanoscale breadths
- The ability to measure the structure as well as the functional data, which better brings out the correlation between the structure and characteristics
- Unique scanning probe microscopy setup that is not available anywhere else in the world

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 CZTS, GaAs, and Si
- Investigate nanoscale properties of semiconductors for indoor solar cells

Capabilities and facilities

- The scanning probe microscopy setup comprises all the necessary functions for in-depth study such as:
  - Tuneable wavelength laser source (400-8500nm)
  - Environmental control (vacuum, O2, N2), heating, cooling stage (-120ºC to 300ºC)
  - High sensitive current sensor (1 pA to 10μA).

Our partners

- Daeyon C&I (Korea, indoor solar cell development)

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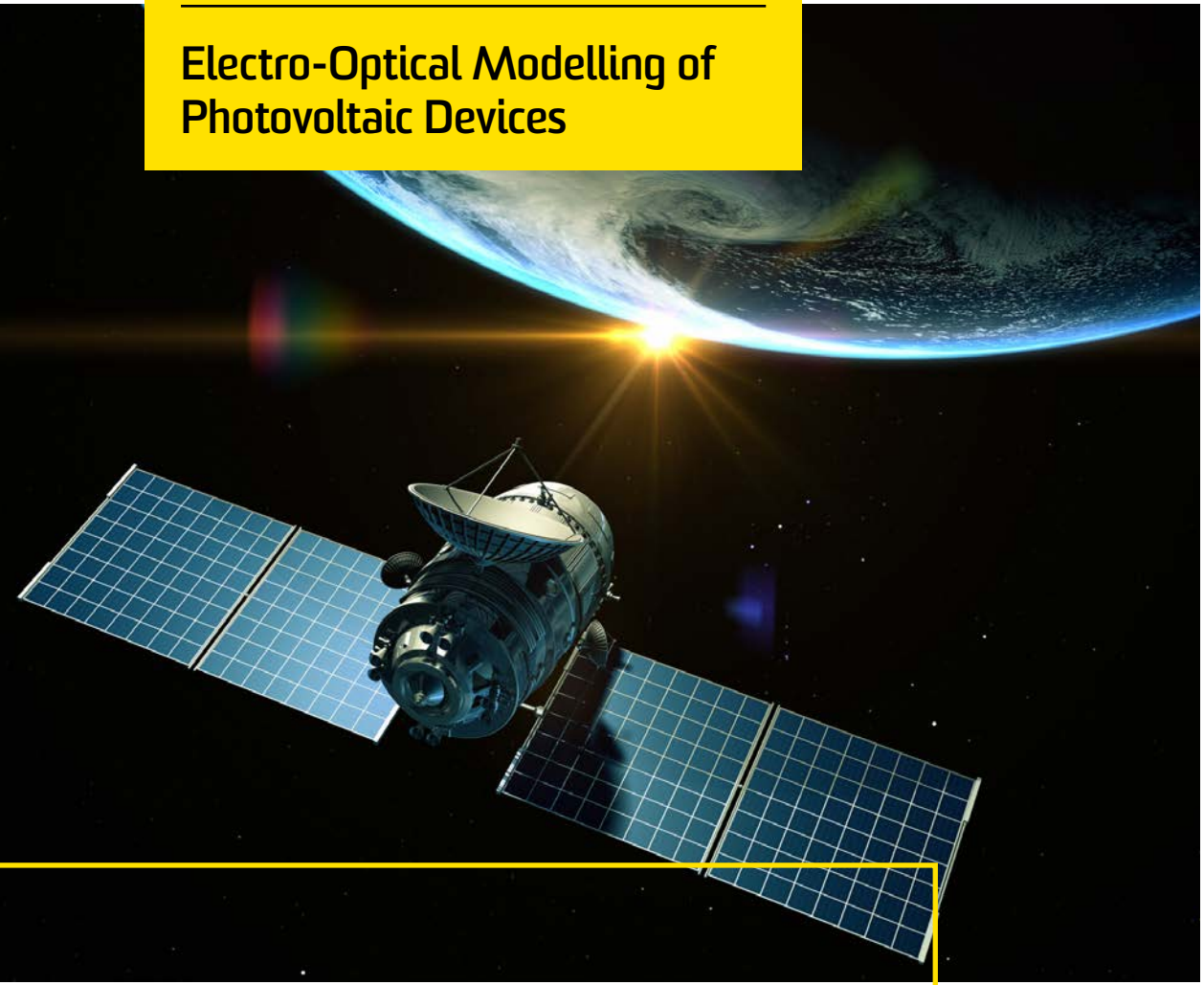
Electro-Optical Modelling of Photovoltaic Devices



Developing and releasing open-source codes specifically designed to model the electronic and optical response of inorganic solar cells, notably III-V solar cells and silicon tandem solar cells, to a high level of accuracy using computer simulations.

Competitive advantage

- Ideally suited for III-V thin-film solar cells and silicon tandem architectures
- Code is scriptable and scalable, allowing applications from CAD for individual solar cells through to estimating energy yield from PV systems
- Integrated optical constant and semiconductor parameter database
- Python has been used as the base programming language making the code multi-platform
- All codes are open source, allowing collaborators to run the simulation freely

Impact

- Software released publicly on a dedicated website
- Sourcecode available on the GitHub repository
  - SolCore PV device model
  - RayFlare PV optics model

Successful outcomes

- A 28.3% single junction concentrator solar cell was designed using the SolCore code in conjunction with a spin-out company, Quantasol
- The energy yield from a commercial triple-junction solar concentrator system was calculated using SolCore code and used to identify atmospheric effects on the seasonal electricity output
- The absorption in two types of silicon solar cell (Al-BSF and Heterojucntion) was calculated from the UV to mid-IR, enabling sub-gap losses to be determined and the thermal emissivity
- The absorption in each layer of a perovskite/silicon tandem cell was calculated using RayFlare

Capabilities and facilities

- The code runs on standard desktop PCs using the Python3 language
- The code is under active development as an open-source project with international partners and users

Our partners

- Imperial College London
- IQE PLC
- Naked Energy Ltd
- US Airforce
- US Naval Research Laboratories

More information

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Advanced Characterisation of Wafers, Cells and Modules

Advanced inspection systems and characterisation methods have been developed that cover the entire photovoltaic chain of wafers, cell and modules. These unique techniques are then used to investigate defects and degradation mechanisms at any level of a photovoltaic system.

Competitive advantage

- World-best lifetime tester for silicon wafers developed
- Developed machine learning applications for photovoltaics that include identification of defects and degradation mechanisms based on lifetime measurements or luminescence images
- The first and only contactless outdoor luminescence imaging system for photovoltaic modules in the field

Impact

Helping to meet the ICCP report target of 8-10 TW peak power of installed photovoltaic by 2030, through developing novel methods to quantify and identify the nature of defects in silicon wafers and developing methods for early detection of degradation mechanisms across the entire photovoltaic chain. These developments will lead to lower production costs, higher efficiency cells and more reliable systems.

Successful outcomes

- Determination of the parameters of the defect 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 photovoltaics

Capabilities and facilities

- Lifetime measurements at a wide temperature range (80 – 680 K)
- Lifetime measurements of metallised samples
- Current-voltage measurements at a wide temperature range (80 – 680 K)
- Optical and spectral measurements at a wide temperature range (80 – 680 K)
- Photoluminescence measurements at uniform excess carrier concentration
- Contactless outdoor photoluminescence imaging

Our partners

- Sinton Instruments
- BT Imaging
- Meyer Burger
- SunRise
- Jinko Solar
- Shamash Australia

More information

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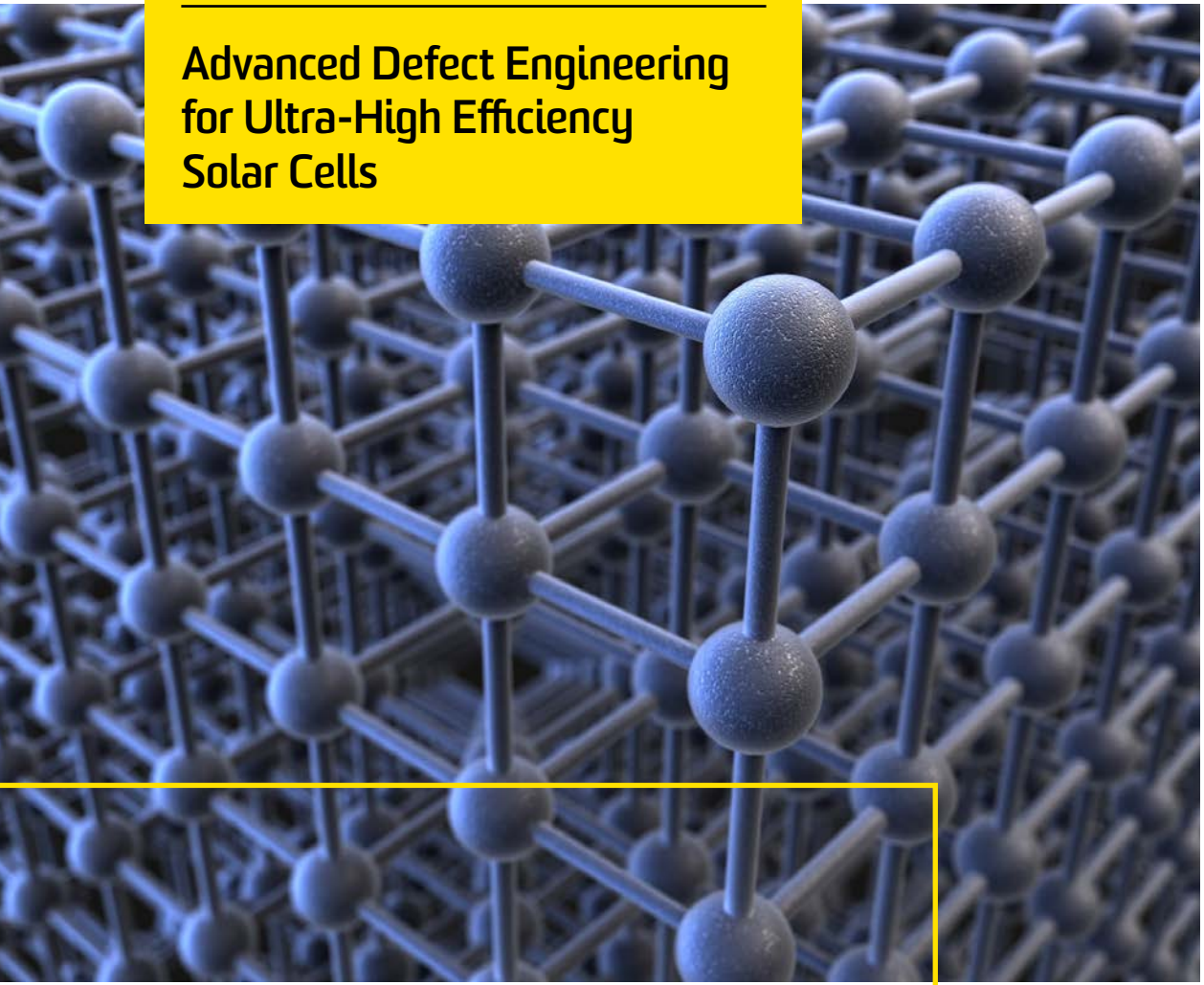
Advanced Defect Engineering for Ultra-High Efficiency Solar Cells



Unravelling the defects grown during the processing of state-of-the-art silicon solar cells to ensure high quality and high efficiency.

Competitive advantage

- World-leaders in unravelling the physics of defects in high-efficiency devices
- Successfully developed a wide range of processes to remove defects in solar cells and improve their efficiency
- Processes that are tailored to the specific needs of the industry, and the wafers and ingots they use

Impact

Improving the efficiency of silicon solar cells by identifying defects and developing processes to reduce them.

Successful applications

- Ring defect removals
- Metals gettering
- Defect hydrogenation
- Defect dissolution

Capabilities and facilities

- Tabula rasa, oxygen precipitates dissolution
- Defect thermal deactivation
- Advanced intrinsic and extrinsic gettering
- Vacancy-defect dissociation
- Hydrogenation processes

Our partners

- Industry leaders in monocrystalline silicon solar cell fabrication

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Stability Testing for Silicon Solar Cells

Testing the stability of silicon solar cells, including accelerated degradation testing of susceptibility to light-induced degradation and the recently identified light- and elevated temperature-induced degradation mechanisms.

Competitive advantage

- Accelerated degradation capabilities to obtain susceptibility to light-induced degradation
- Expertise in the development of R&D tools for accelerated stability testing of silicon solar cells
- Experience in developing processes to mitigate light-induced degradation in silicon solar cells

Successful applications

- Rapid testing of light-induced degradation susceptibility in silicon solar cells
- Commercialisation of advanced hydrogenation processes for eliminating light-induced degradation and light- and elevated temperature-induced degradation in silicon solar cells

Capabilities and facilities

- Tools for accelerated stability testing of laboratory size and industrial silicon solar cells with high-intensity illumination
- Tools for conventional stability testing of silicon solar cells
- Suitable for cell sizes up to industrial silicon solar cell dimensions

Our partners

- LONGi
- Suntech
- Canadian Solar
- SAS Sunrise
- LG Electronics
- China Sunergy
- CEC Energy
- Phono Solar
- Tongwei
- Nanjing Sunport
- Tianwei
- Jinko
- Meyer Burger
- Schmid
- DR Laser
- Asia Neo Tech
- Ke Long Wei

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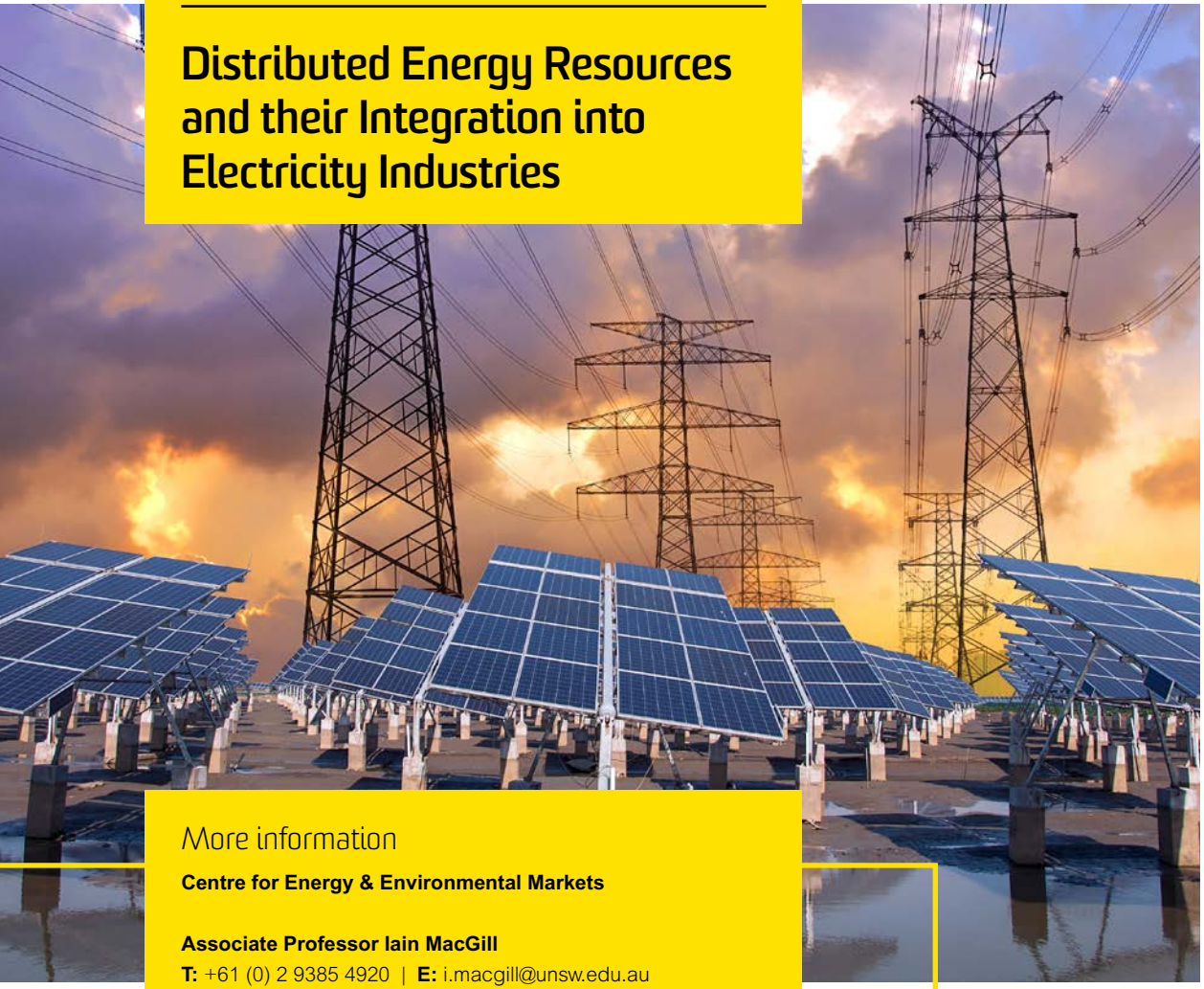
Distributed Energy Resources and their Integration into Electricity Industries



High penetrations of Distributed Energy Resources (DERs) can have a range of impacts. Successful integration of DER will be critical to managing system cost and reliability. This involves managing a range of technical and financial impacts, which in turns involves public participation, regulatory development and appropriate business models.

Competitive advantage

Leading research group on restructured electricity industries, encompassing Engineering, Business, Social Sciences and Law. Expertise in assessing and managing the technical impacts of DER, and in market design, regulations and policy development..

Impact

Increase the understanding of the role of DERs and improve their integration into electricity industries and market

Successful applications

- Detailed assessments of the real-world voltage and frequency impacts of DER
- Analysis of impacts and value of distributed PV, storage and demand response on networks and power systems, over a range of timeframes
- Integration between electricity market and distributed energy modelling
- Temporal and spatial characterisation of distributed PV and demand response profiles
- Open source tools including tariff design, distributed energy sharing and aggregation models
- Rooftop solar potential spatial analysis
- Analysis of public participation in governing electricity data
- Interdisciplinary frameworks for policy, market and regulatory assessment and design
- Assessment of the potential and value of DERs for integration of variable renewable energy
- Submissions to regulatory and market rule change processes

Capabilities and facilities

- Expertise in market and DER modelling, data science and developing open source tools
- Access to high performance computing facilities on campus, and at the National Computational Infrastructure

Our partners

Extensive links with key electricity sector stakeholders including all levels of Government; NEM institutions; network businesses; industry associations; NGOs; consultants; energy developers; DER businesses and startups.

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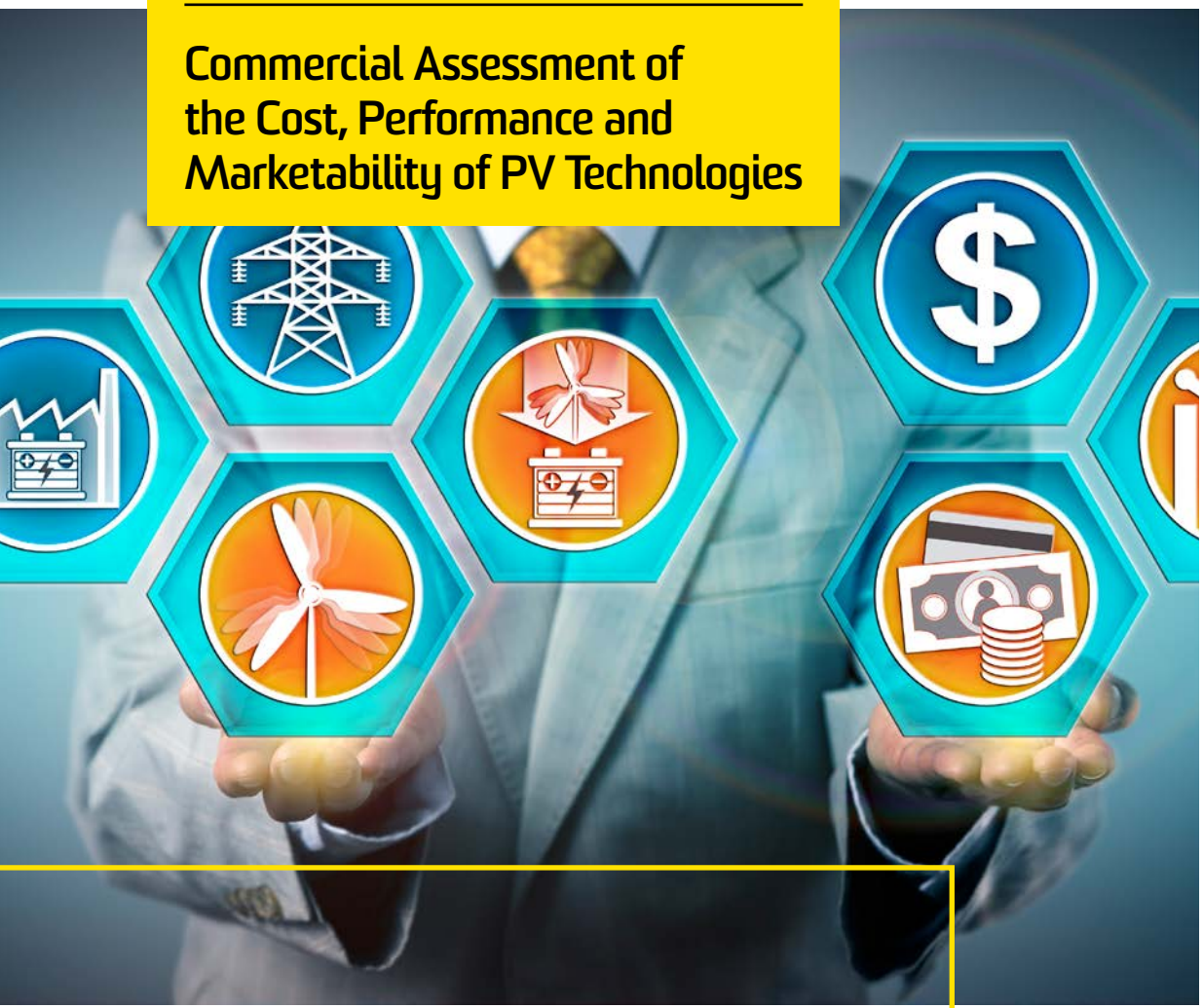
Commercial Assessment of the Cost, Performance and Marketability of PV Technologies



Industry and academic experience in commercial assessment of photovoltaic technologies from a combined cost, performance and market perspective.

Competitive advantage

- Cost and uncertainty model that can be applied to a wide range of low- to medium-technology readiness level (TRL) technologies, unlike conventional approaches that are most applicable to high TRL technologies
- Iterative analysis method that identifies and then focuses on the key uncertainties and allows assessment to be completed with a minimum of time and effort
- Methodology has been developed so that it can be used by researchers without access to highly detailed cost input data

Impact

- Results can be used by researchers to engage positively with industry
- Analysis can be used to guide research directions into the most promising avenues for future commercialisation
- Analysis outcomes can be used to set technical and cost-related research targets

Successful applications

- Analysis of low TRL perovskite photovoltaics – single junction cells on glass and flexible substrates as well as in tandem structures with silicon
- Using analysis to identify the cost and performance drivers of more mature photovoltaic c-Si technologies – laser doped selective emitter, advanced hydrogenation, silicon heterojunction cell on p-type wafers
- Technoeconomic analysis of PV module recycling methods and their outlook

Capabilities and facilities

- Validated techno-economic analysis methodology with track-record of application to PV technologies
- Established online database tools to enable wide collaboration with Australian and international institutes

Our partners

- National Renewable Energy Labs (NREL), USA
- CSIRO

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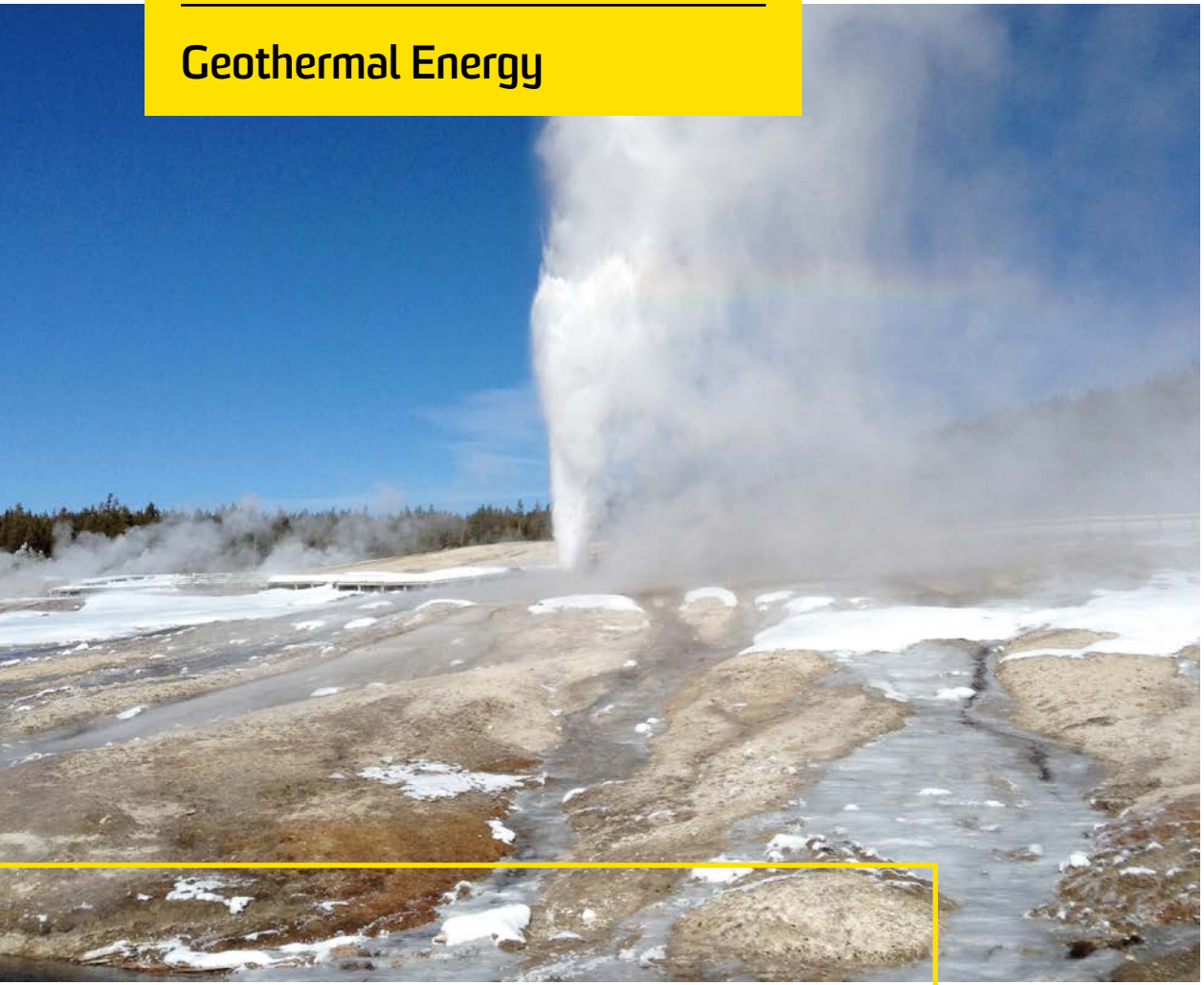
Geothermal Energy



Geothermal energy can provide the cheapest, cleanest and most abundant source of baseload power. Innovative solutions for cascaded heat use and direct heat applications are scalable and can provide clean power for industrial and domestic applications.

Competitive advantage

- International expertise in geothermal energy
- Experience in coordinating geothermal initiatives in Germany, New Zealand and Australia
- Providing innovative solutions for cascaded heat use and direct heat applications
- Enhanced geothermal stimulation strategies for high temperatures
- Novel drilling technologies for hard basement rocks
- Patented technology in desalination, advanced geothermal cooling technology and low temperature geothermal refrigeration

Impact

- Cheap and abundant baseload power

Successful outcomes

- Implementation of novel groundwater heat rejection concept for cooling a supercomputer
- Innovative geothermal solutions for developing countries
- Lithium co-production from geothermal brines

Capabilities and facilities

- Advanced rock characterisation laboratory
- High temperature/high pressure triaxial geomechanics testing facilities
- Thermal infrared laboratory

Our partners

- Green Rock Energy Limited
- Geodynamics Limited

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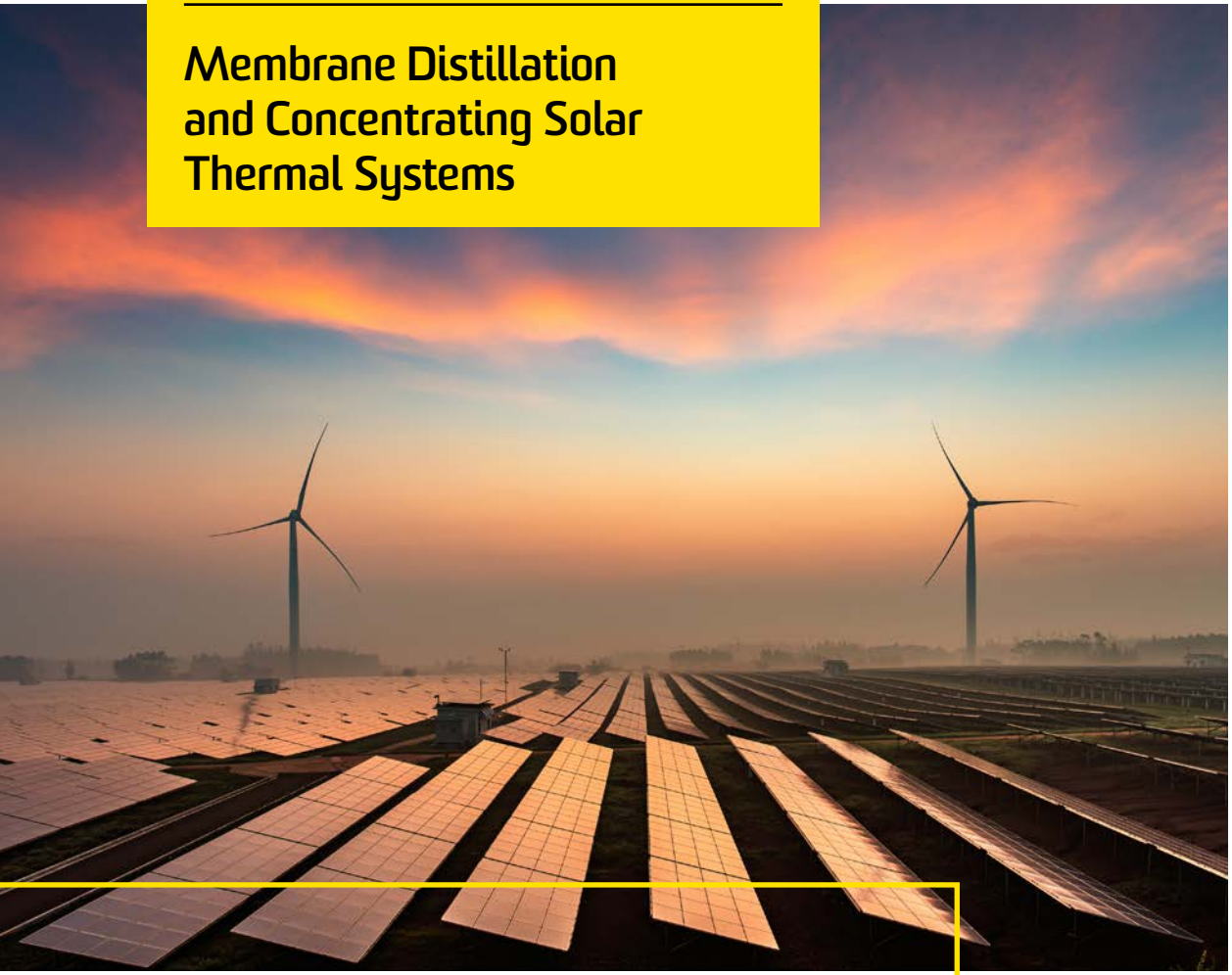
Membrane Distillation and Concentrating Solar Thermal Systems



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

Competitive advantage

- Wide-ranging expertise in areas from membrane materials development to CST plant optimisation
- Innovators in the design of modules and materials such as hydrophobic coatings and 3D printed parts, and skilled at determining how best to incorporate them into solar thermal systems

Impact

Remote locations in Australia and the Middle East and North Africa are blessed with abundant solar resources and increasing levels of development but burdened by access to reliable drinking water and electricity generation facilities. Enabling the co-production of water and electricity will open up significant possibilities for these areas.

Successful applications

- Production of prototype membrane distillation modules which can utilise the exhaust from thermal power plants
- A techno-economic analysis of the potential for this technology has been conducted
- 4 research outputs have been published

Capabilities and facilities

The facilities to produce and test new modules and materials at laboratory and pilot scale.

Our partners

- Vast Solar
- Origin Water

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Marine Energy – Making Waves

The Water Research Laboratory (WRL) is a world-leading fundamental and applied research organisation that tackles some of the world's most challenging water engineering problems. It offers laboratory facilities to test waves and currents in 2D and 3D, at scales appropriate for coastal engineering, device and array testing.

Competitive advantage

- The largest and most comprehensive hydraulic laboratories in Australia, including 2D and 3D wave-making facilities, and high flow-rate flumes
- Among the best coastal physical modelling facilities in the southern hemisphere
- Over 60 years' experience conducting marine energy field-measurement campaigns across the world
- State-of-the-art facilities, equipment and some of the world's most creative problem solvers in this area of research
- Being NATA certified for Quality Assurance guarantees that commercial activities are executed with strict regard to quality, time, budget, and delivered in accordance with authorised contractual agreements

Impact

The ability to physically model and test marine devices allows design optimisation and extreme load measurement to ensure the safety and efficiency of foundations and subsea cables.

Capabilities and resources

- Large 3D Wave Basin with segmented wave-making capability, 2 deep wave flumes (with combined wave/current capability), open channel flumes
- Extensive suite of laboratory sensors including wave probes, current meters, LIDAR, 3D FARO, submersible load cells and pressure sensors
- Large range of offshore and marine field measurement equipment

More information

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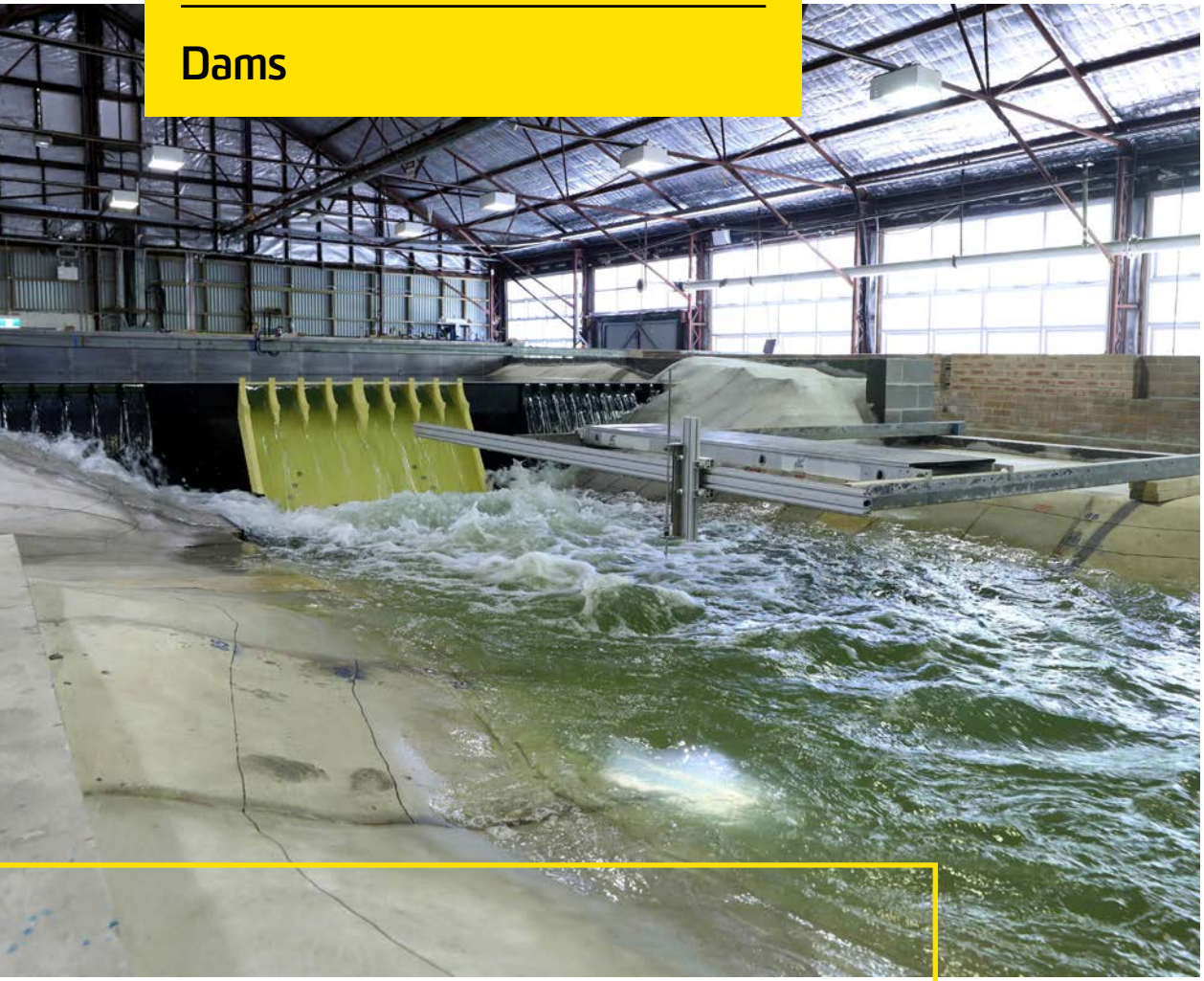
Dams



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

- Largest and most comprehensive hydraulic laboratories in Australia with over 5,000m^2 of floor space, as well as high flow-rate flumes
- Extensive experience in conducting performance assessment of hydraulic structures such as dam outlet works, spillways and hydro power stations

Impact

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

Successful applications

- World's 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

- 5 fully-equipped physical laboratories
- 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

Our partners

- GoldWind Wind Farm
- CSIRO
- Ausgrid
- Aurecon

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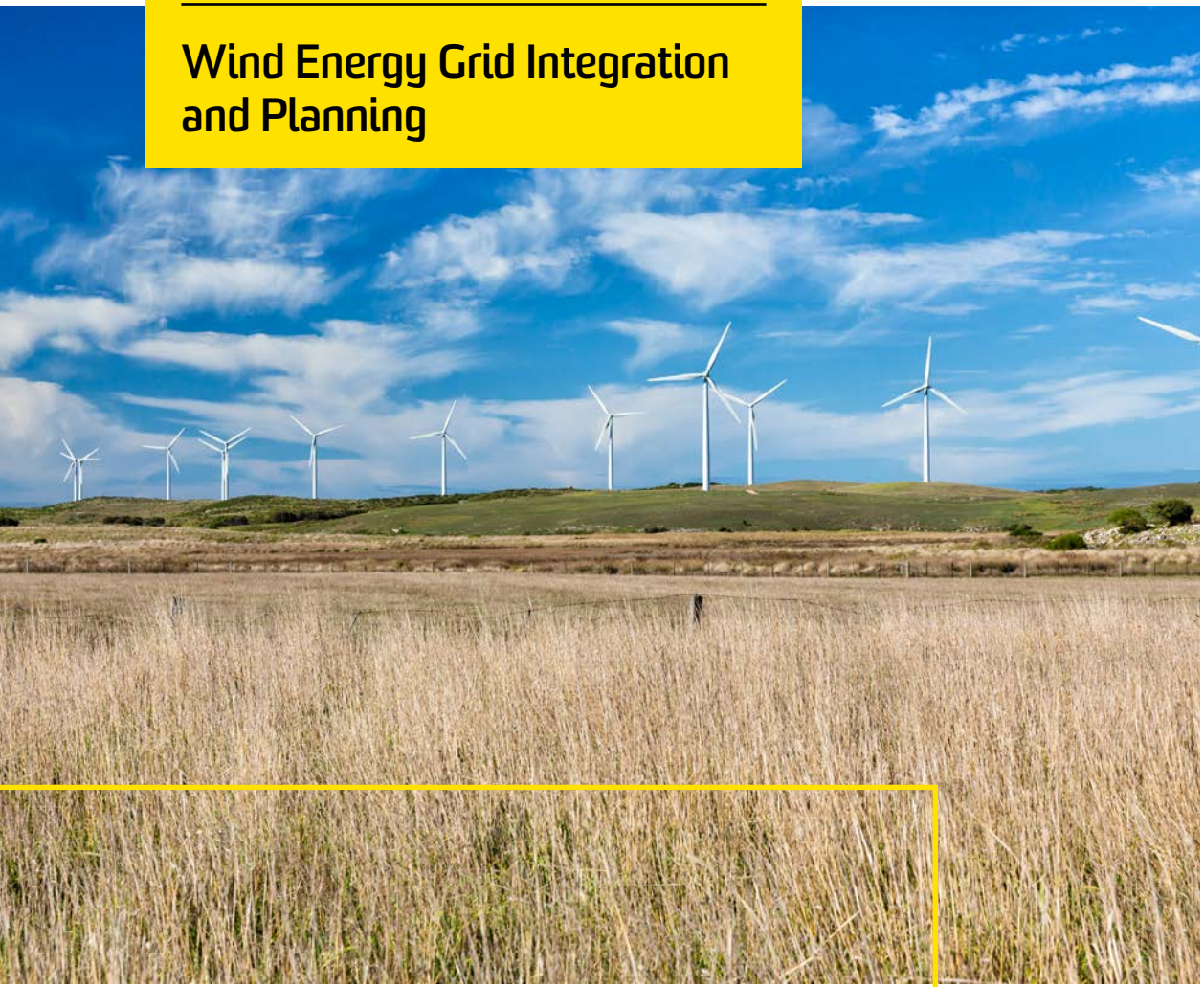
Wind Energy Grid Integration and Planning



Research into wind technologies to analyse the impact wind energy has on electricity markets, develop models, and assess the technical impacts of integrating it into the grid.

Competitive advantage

- World-leading improvements in the understanding the impacts of different loads, generation sources and energy storage on system security
- Expertise in the optimal planning of offshore wind farm electrical layout
- Innovative optimal dispatching tool for wind energy integration through multi-terminal VSC-HVDC grids
- Experience in grid planning and co-optimisation of electricity and gas networks
- Expertise in industrial standard software and in-house tools

Impact

- The creation of advanced planning and operating tools to ensure a stable and reliable power supply, and defer capital investment
- Large-scale wind farms with energy storage will allow increased use of renewable generation within the network

Successful applications

- Future Grid project aiming to develop the nation's capacity to plan and design the most efficient, low-emission electricity grid for Australia
- Hongkong Electric Company's off-shore wind farm design project that covers wind resource modelling, prediction, grid impact studies, dispatch and energy storage options

Capabilities and facilities

- Cross-platform modelling tools for grid studies of the impacts of loads, generation sources and energy storage on system security
- Grid planning and operations incorporating wind, solar and storage
- Hardware-in-the-Loop testing bed for energy storage systems with programmable grid simulations on real time digital simulators (RTDS)

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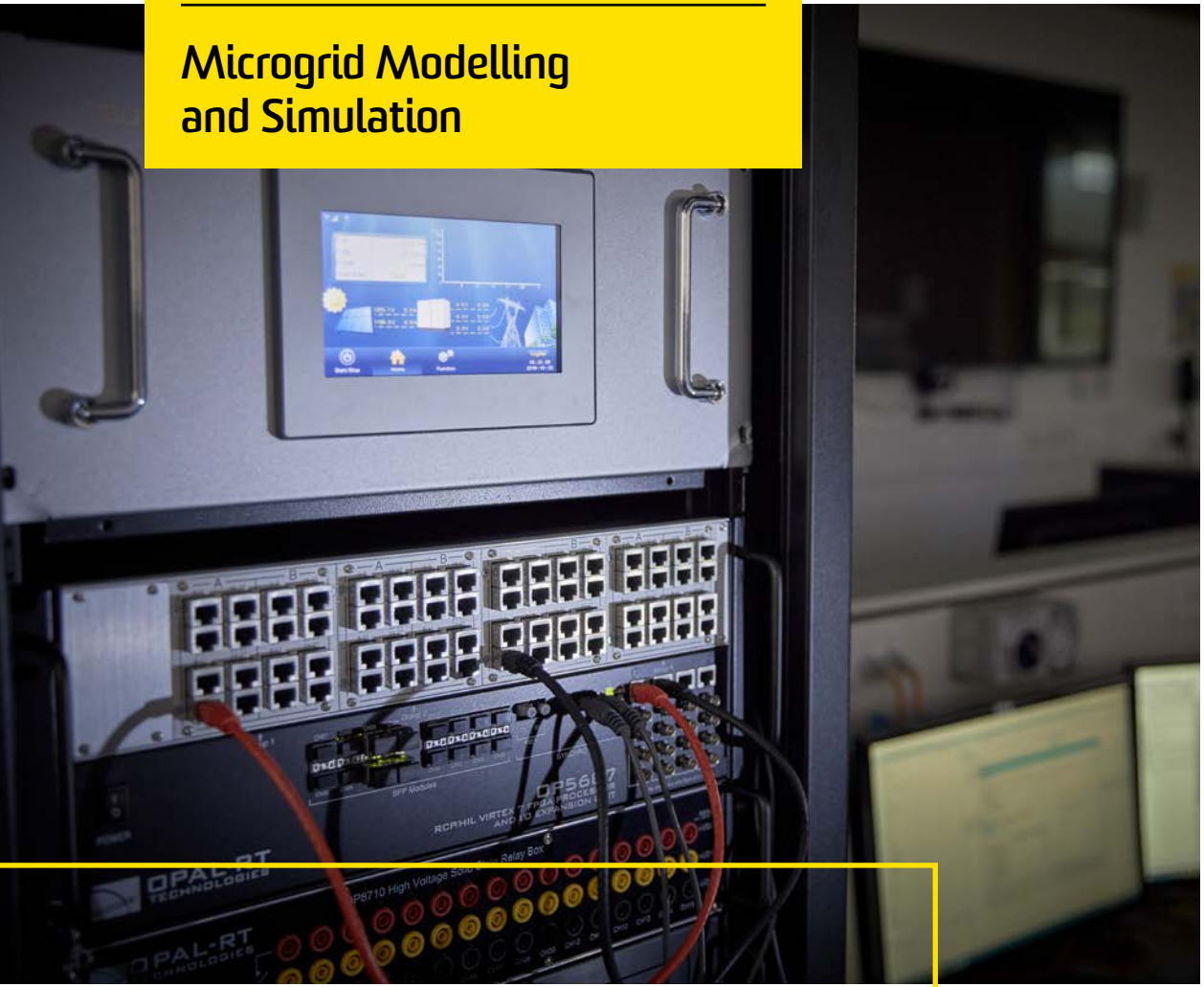
Microgrid Modelling and Simulation



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

Competitive advantage

- At the forefront of research into, and the development of, microgrids using a wide-range of inverter control systems, conventional rotational generation, and energy storage
- A wide array of 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

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

Successful outcomes

When the Asian Development Bank conducted a project for LECO, the electrical distribution operator in Colombo, Sri Lanka, it used UNSW microgrid simulation and modelling techniques.

Capabilities and facilities

- A state-of-the-art inverter and microgrid test platform
- An 18-rack RTDS real-time simulator
- An OPAL-RT system for high-speed power electronics simulation in real time

Our partners

- ARENA
- Electranet
- Tasnetworks
- AEMO
- Empower
- Sungrow

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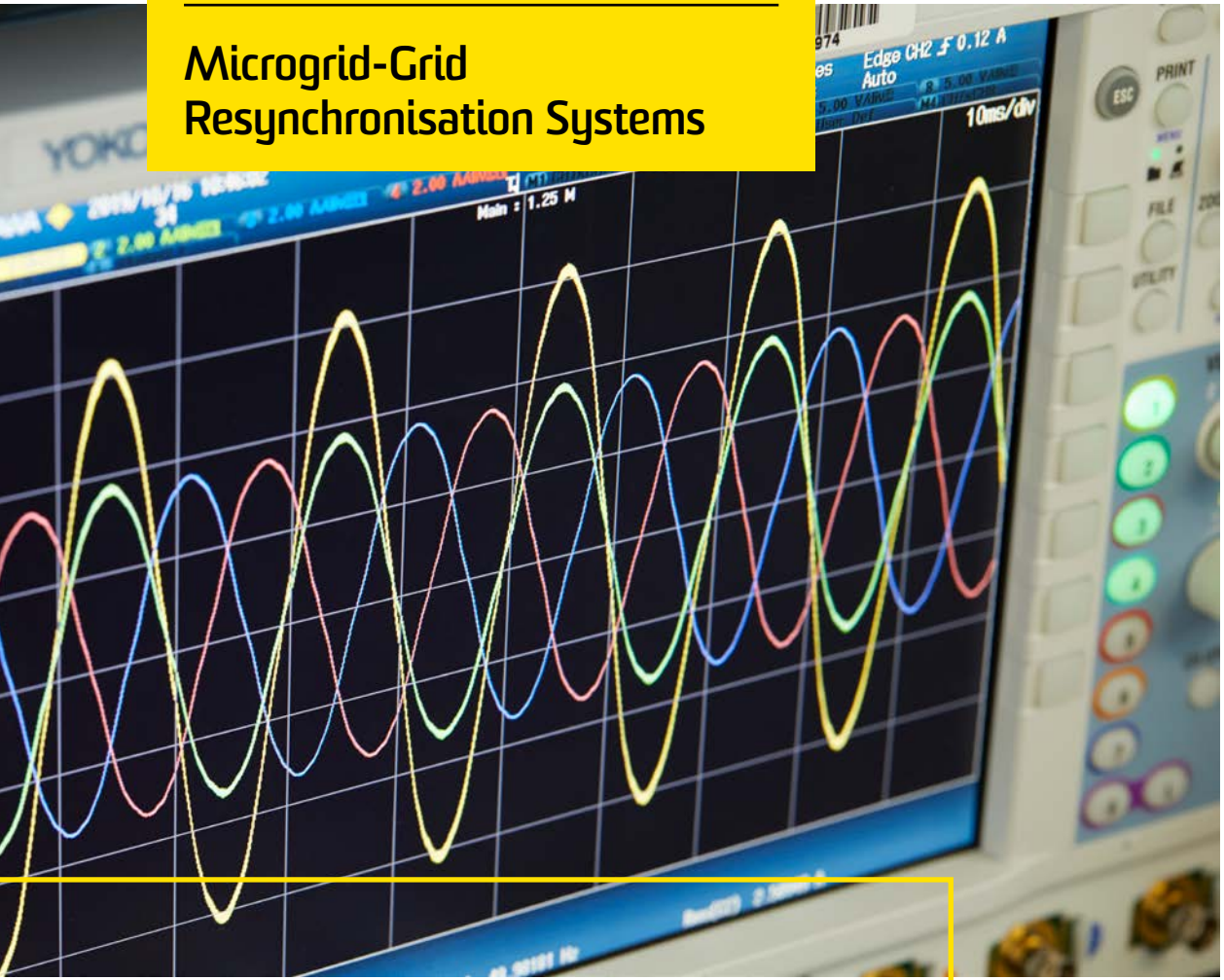
Microgrid-Grid Resynchronisation Systems



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
- 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 needed to resynchronise the microgrid, based on the estimate of load and generation types.

Successful outcomes

- 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 partners

- A. W. Tyree Foundation
- ARENA
- Asian Development Bank

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Microgrid Inverter Technologies

The development of 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
- Being suitable to use with small-scale microgrids and portable, mobile systems, makes these technologies suitable for use in disaster relief and other rapid deployment needs

Successful outcomes

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

Capabilities and facilities

- A state-of-the-art 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 partners

- The A. W. Tyree Foundation
- Australian Research Council
- AEMO
- ARENA
- Empower
- Sungrow

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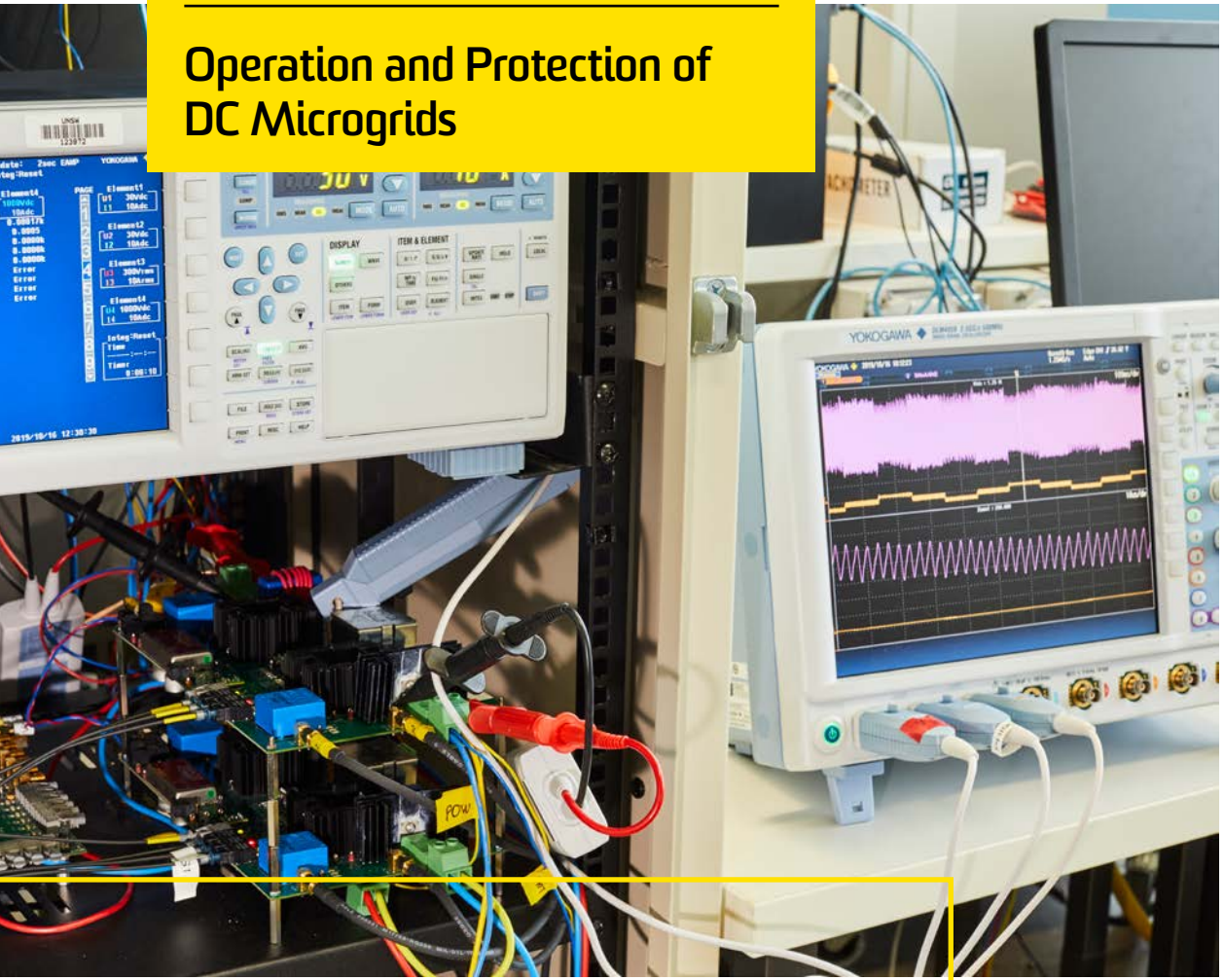
Operation and Protection of DC Microgrids



The use of DC microgrids is a potential growth area with a range of platforms including vehicles, aerospace, marine and rail. There is a need for developing tools, techniques and models to back up serious experimental work on hardware prototypes, and is working on protection devices and systems.

Competitive advantage

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 outcomes

- Tyree microgrid project
- Marine platforms
- Road-side signage
- Water treatment plants

Capabilities and facilities

Access to state-of-the-art 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 partners

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

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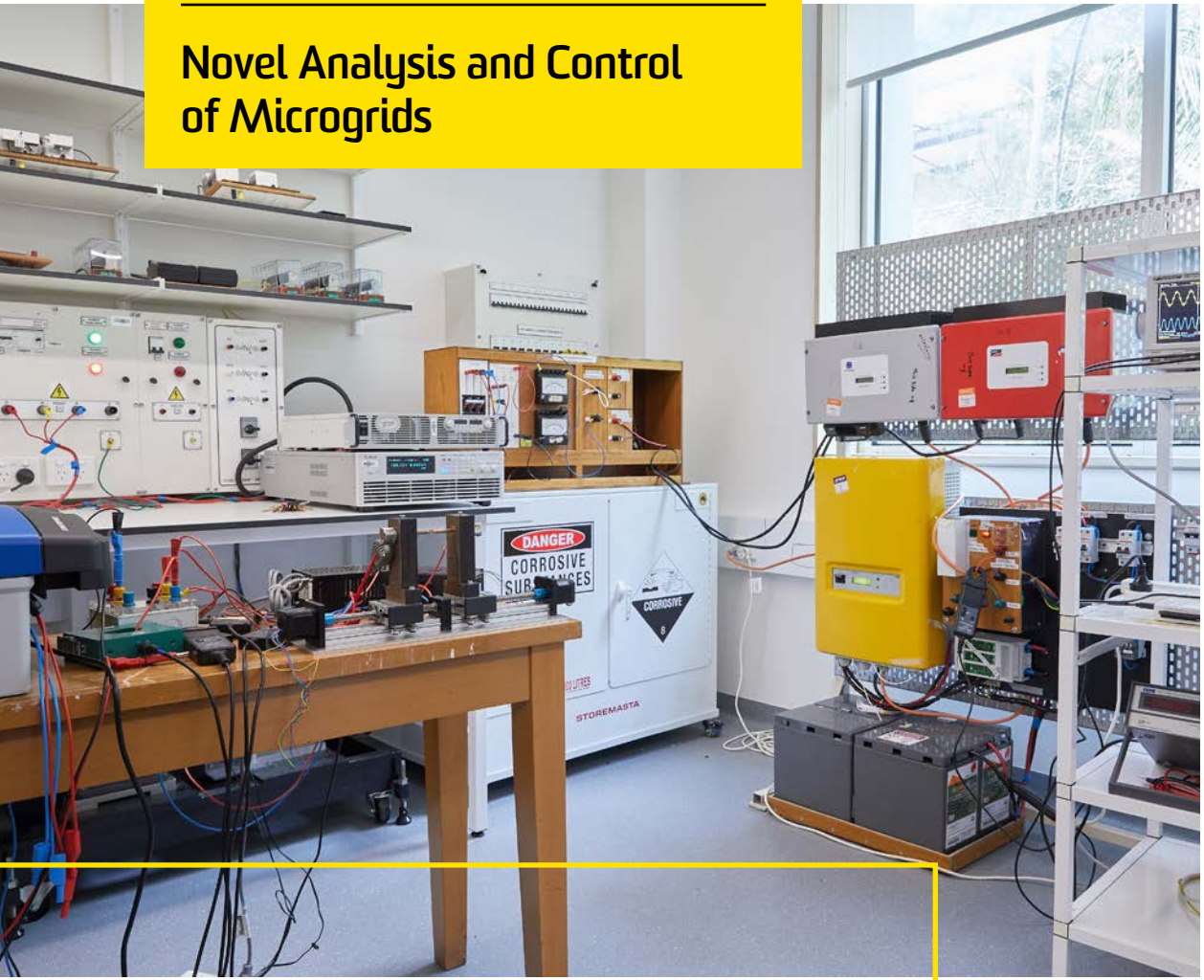
Novel Analysis and Control of Microgrids



Using expertise in 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 approaches to:
  - detection and classification of disturbances in islanded microgrids
  - fault location
  - regulating frequency through demand response
- Improved load-shedding techniques

Impact

- Appliance level data analysis and control
- Integration of electric vehicles
- Power demand management
- Novel controllers under unbalanced voltage conditions

Successful applications

- Reliable microgrids for remote communities with a communication-based control architecture - Sri William Tyree Foundation Research Fund – 1.5m – 2017-2019
- Analysis and control of DFIG in microgrids – Transfield foundation – 45K – 2013-20
- Micro generation test facility for the assessment of power quality and hybrid system control - Australian Power Institute – 103k – 2011-20

Capabilities and facilities

- Single-phase microgrid test facility in Electrical Engineering Building
- Three-phase microgrid in Tyree Energy Technologies Building
- Software tools for analysis

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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 from there design non-linear control systems
- An experienced interdisciplinary research team with a significant collaborative track record in the 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 rigorously establish the stability of single-phase microgrids using proportional and resonant controllers and 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
- A state-of-the-art laboratory microgrid facility (Tyree Energy Technology Building)
- State-of-the-art real-time digital simulation facilities for hardware-in-the-loop testing

Our partners

- A.W. Tyree Foundation
- AEMO
- Sungrow

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Off-Grid Renewable Energy Based Active Distribution Networks

Designing controls for flexible, off-grid electricity networks that can interconnect small renewable resources and loads in the same way as the main electricity grid.

Competitive advantage

- The 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 in India for a rural community

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
- A world-class distribution energy resources laboratory, in partnership with the ANU and power distribution companies, with capability to interconnect new generation resources and perform experiments to test control and modelling for dynamic control

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Solid-State Transformers for Microgrids and Battery Charging

Solid-state transformers (SSTs) are poised for widespread use in connecting renewable energy sources to the utility grid, replacing traditional 50 Hz transformers in the distribution and higher voltage grid, microgrids and battery-changing installations.

Competitive advantage

- Demonstrated capability in the design converters and controllers for SSTs with 20 kHz transformer
- Modular design capability to cater to higher power
- Supervision to completion of a PhD student who investigated, built and tested a 2kW SST at UNSW in 2018

Impact

The world-wide market for SSTs at present is estimated at $100b, and rising fast. This is because of their inherent ability for fast protection and control of power-flow in both directions, high efficiency and much smaller footprint (implying high power density).

Successful outcomes

- SST development is currently undergoing intense research in several universities in Europe, USA and Japan, in conjunction with industries

Our partners

- Ultima Capital Partners
- Defence Innovations, Melbourne

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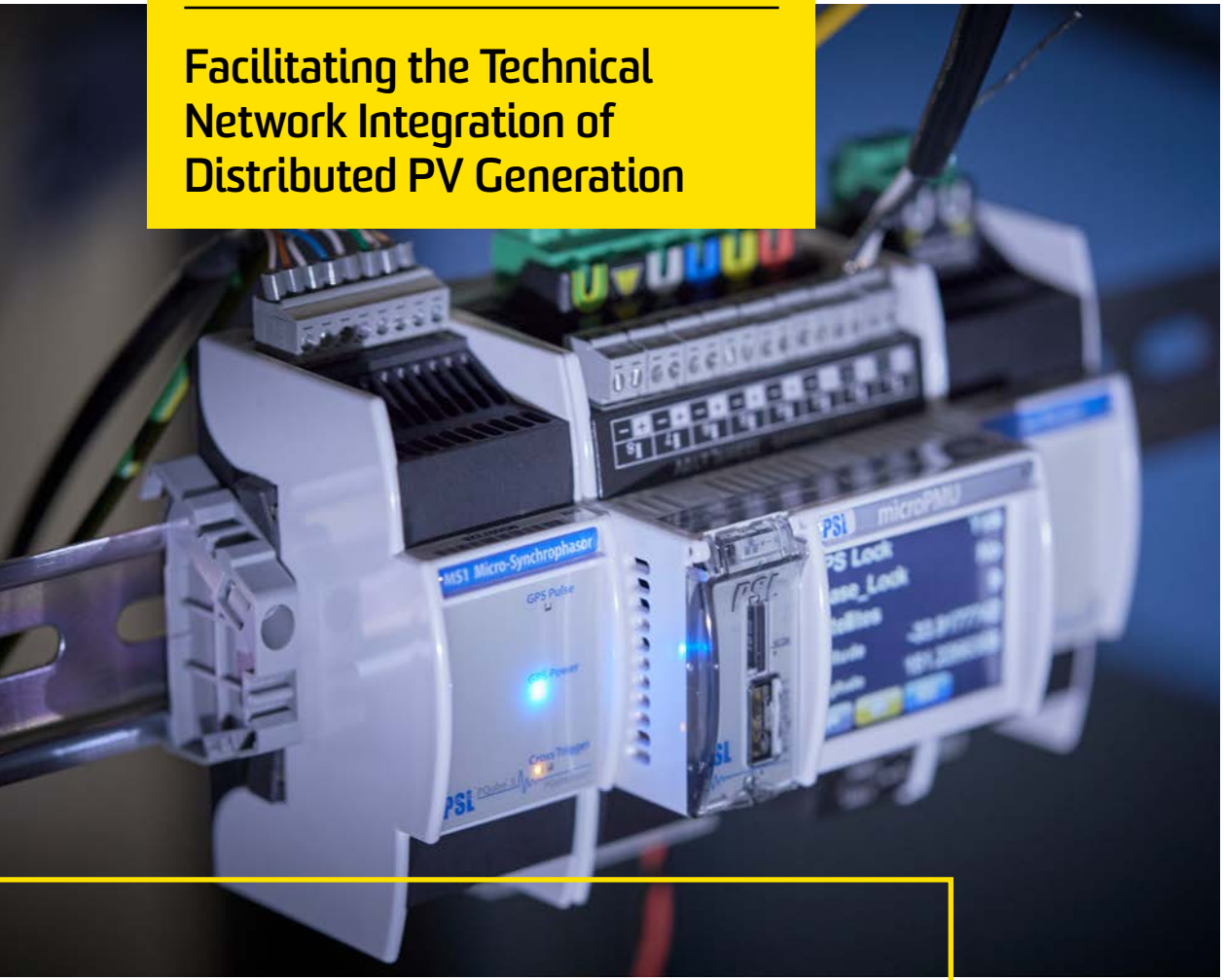
Facilitating the Technical Network Integration of Distributed PV Generation



Addressing the characterisation of photovoltaic (PV) generation variability to help network operators to plan appropriately for high penetration of distributed PV. A method for estimating the amount a low-voltage feeder can accommodate without exceeding upper voltage limits has been developed, along with methods to manage distribution voltage levels.

Competitive advantage

- Comprehensive characterisation which describes the behaviour of PV generation variability over the course of the day and over the course of the year
- The 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

Impact

- Simple and efficient methods for estimating maximum distributed generation capacity of a feeder that require no new communication infrastructure and are shown to be more efficient and equitable than similar methods currently proposed
- A tool through 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 voltage levels, upper and lower, are maintained within regulation limits

Successful outcomes

- Feeder modelling for distribution operators

Capabilities and facilities

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

Our partners

- APVI
- Endeavour Energy
- ARENA

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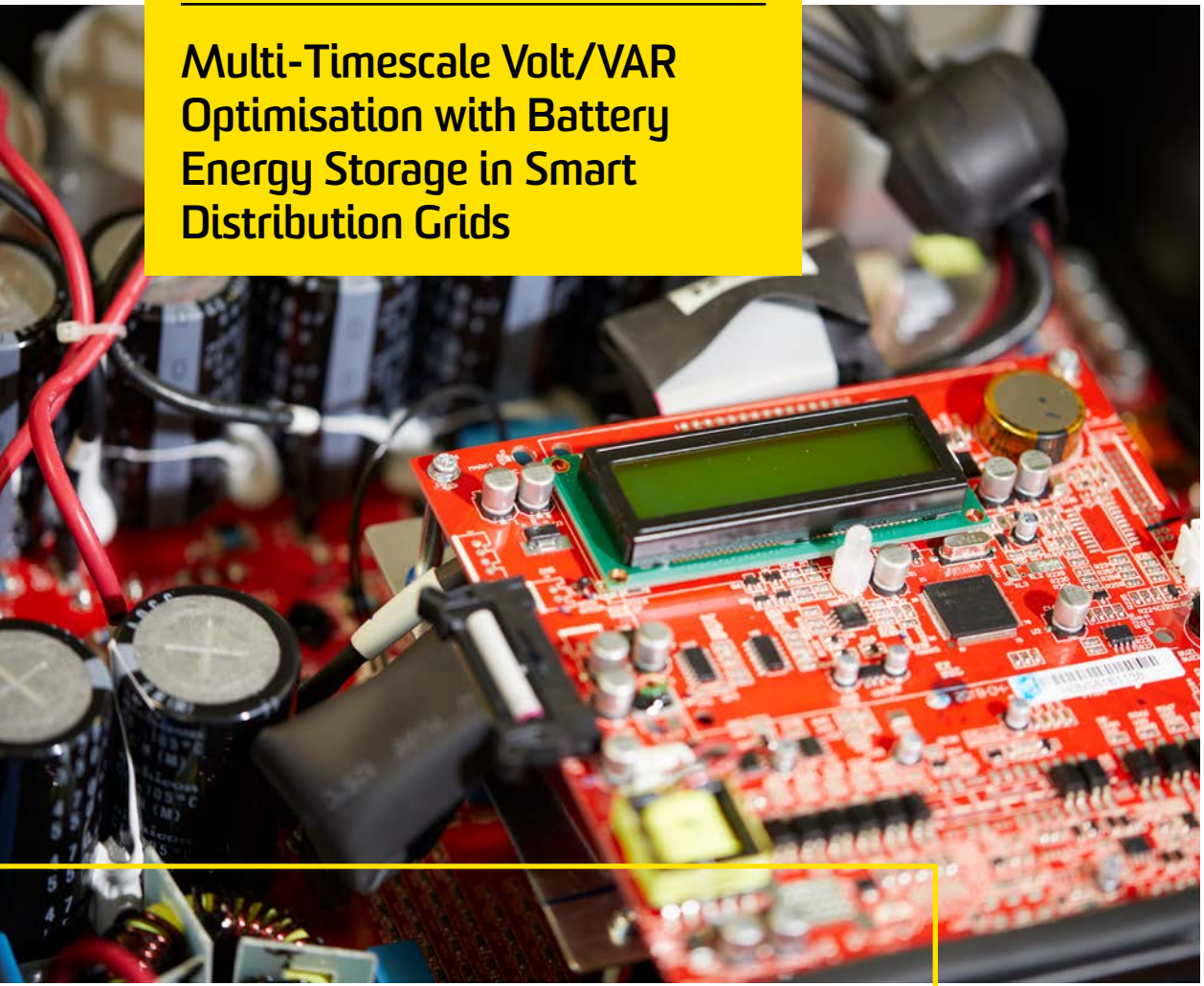
Multi-Timescale Volt/VAR Optimisation with Battery Energy Storage in Smart Distribution Grids



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

Competitive advantage

- Providing predictive control where there are forecasting uncertainties. Slow and fast timescale controls are coordinated using two-stage stochastic programming
- Expertise in this multi-dimensional optimisation area

Impact

The rapid increase in the integration of intermittent renewable energy sources into existing distribution grids has brought 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, and improves the steady-state stability of distribution grids.

Successful outcomes

- Proven advantages on simulated distribution feeders including IEEE benchmarks

Capabilities and facilities

- Tools, software and real-time simulation capability

Our partners

- A. W. Tyree Foundation

More information

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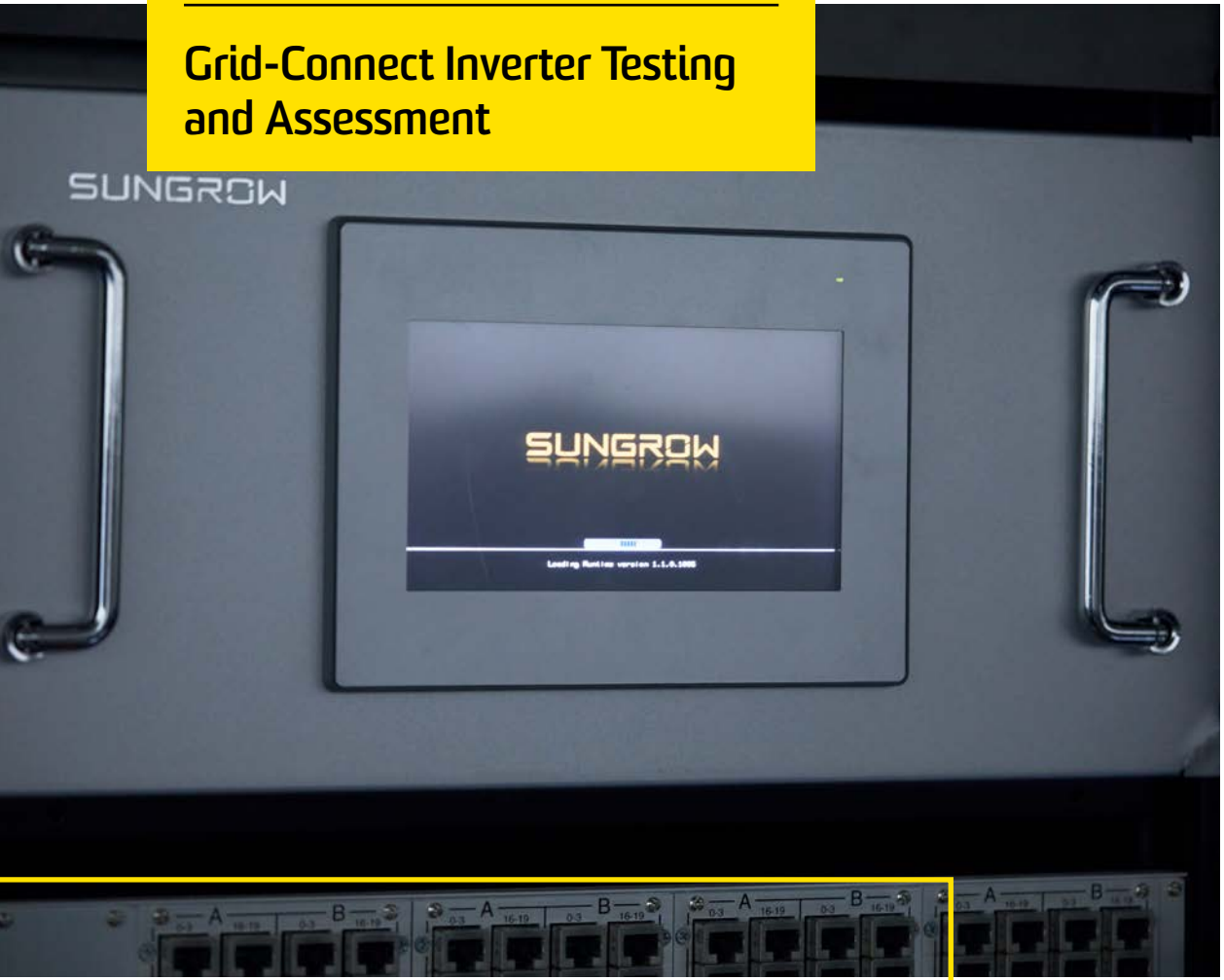
Grid-Connect Inverter Testing and Assessment



A comprehensive test set-up that can accommodate inverter capacities between 1kVA and 50kVA has been developed. It 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 wide experience of testing a variety of inverter types, makes and models
- Specialist knowledge and experience allows the identification of inverter vulnerability to grid disturbances which may cause unexpected behaviour in inverter makes and models. This is particularly important for Virtual Power Plant solutions and microgrid providers.

Impact

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

Successful outcomes

- Over 15 makes and models of inverter 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 including grid simulators, load emulation, feeder impedances, rotational generation and rotational loads.
- Fine-tuning of critical subsystems such as synchronising algorithms (PLL, FPLL, SOGI, Virtual Synchronous Generators), current mode control, voltage-source forming and fault characteristics.

Our partners

- ARENA
- Electranet
- Tasnetworks
- AEMO
- Empower
- Sungrow

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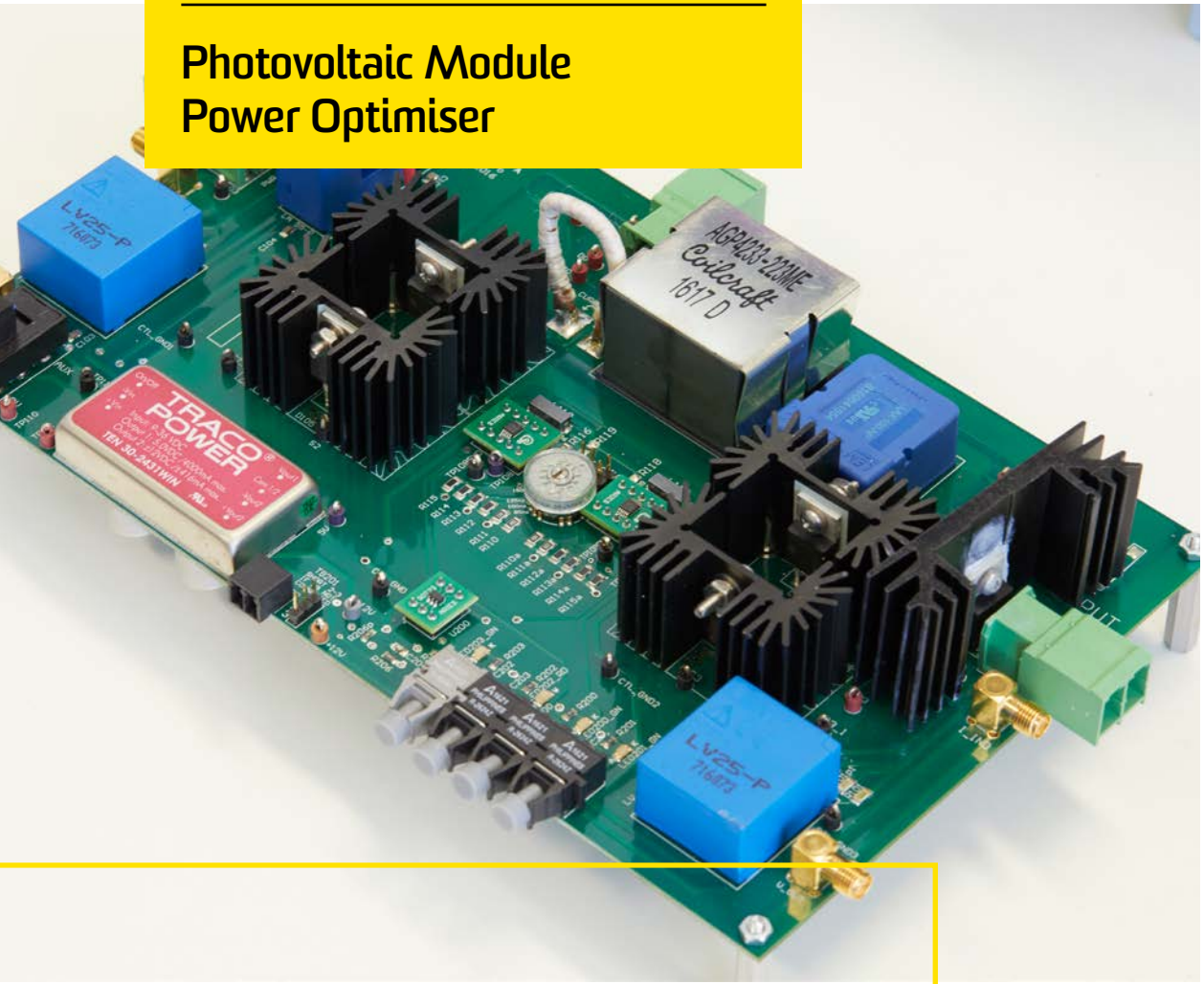
Photovoltaic Module Power Optimiser



A low-cost universal converter that can act as either a power optimiser or a micro-inverter for photovoltaic (PV) modules would maximise the energy output of photovoltaic systems by constantly extracting the maximum power from each photovoltaic 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 longer strings and strings of different lengths to design optimal solar PV systems

Impact

- More efficient photovoltaic 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
- Realtime simulation

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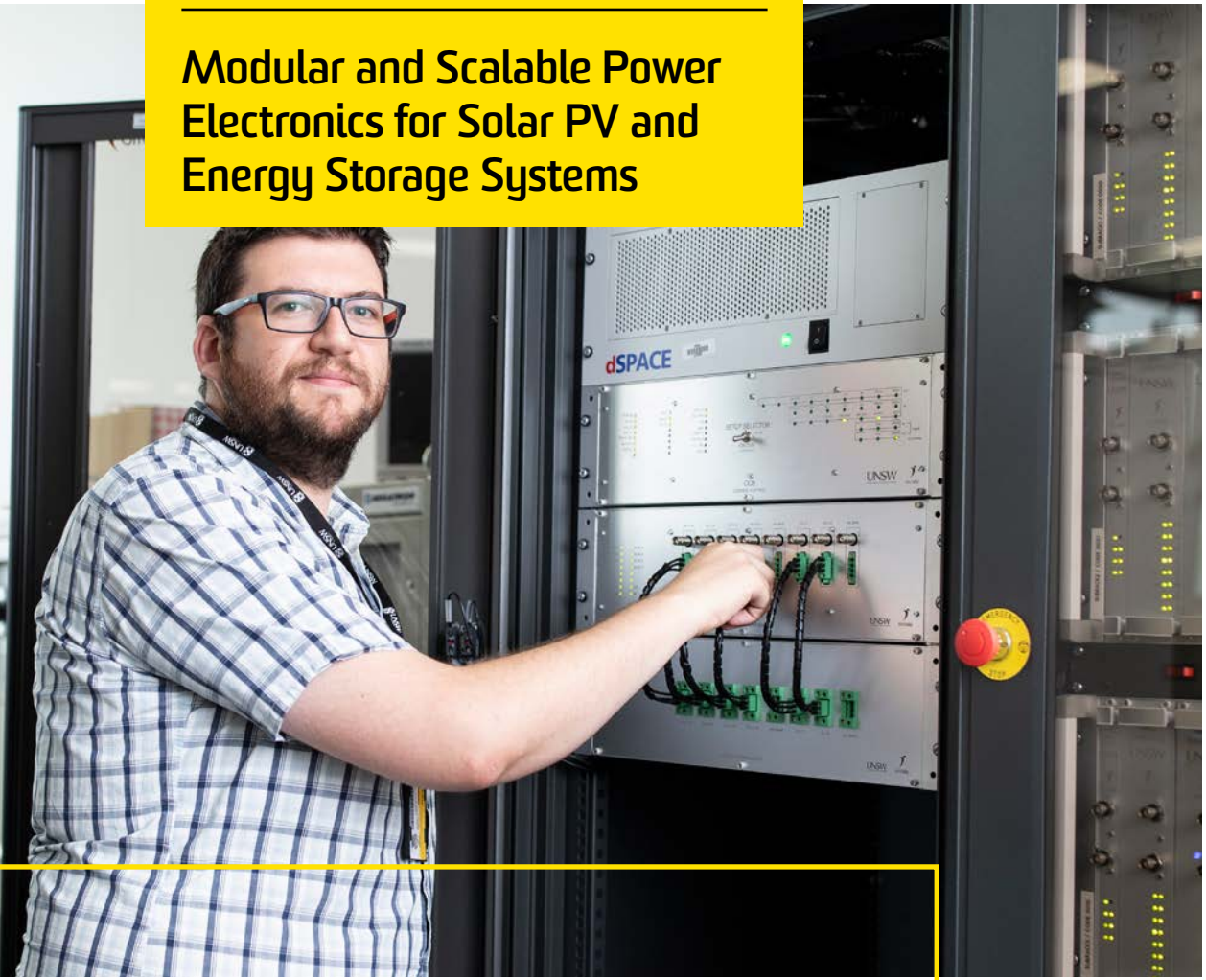
Modular and Scalable Power Electronics for Solar PV and Energy Storage Systems



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
- State-of-the-art real-time simulation for grid-integration validation, hardware and controller testing

More information

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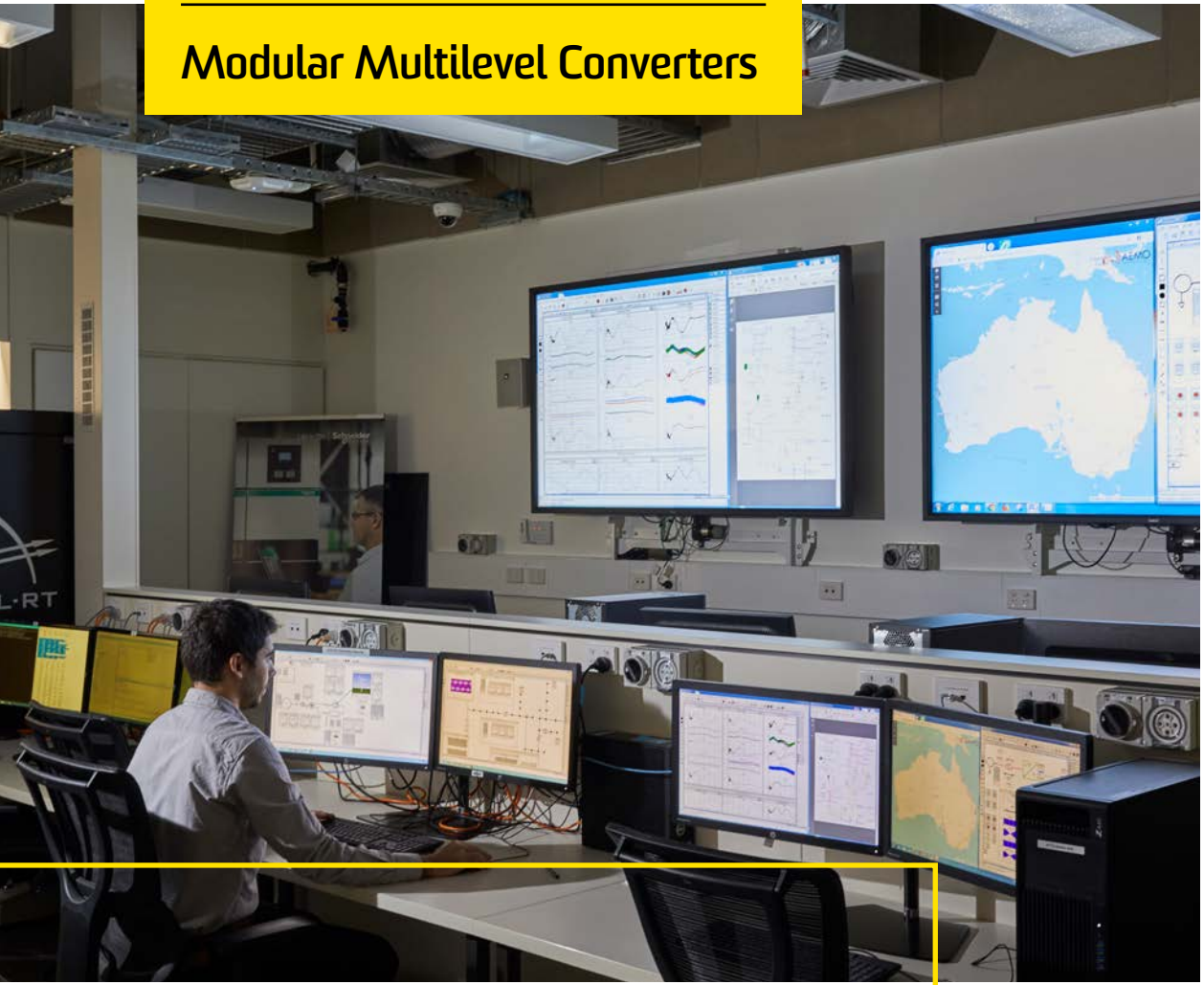
Modular Multilevel Converters



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 when it comes to high-power power-electronics conversion.

Competitive advantage

- World-leading analytical tools and modelling capabilities
- More than 10 years of research experience in developing topologies, hardware and control for modular multilevel converters

Impact

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

Successful outcomes

- 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 partners

- Tecnalia Energy, Spain

More information

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Cyber Security of Power System Control Systems

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 urgently required to rapidly and accurately detect attacks and protect control systems.

Competitive advantage

- Advanced, 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 system control systems
- An experienced interdisciplinary research team with a significant collaborative track record in the fusion of electrical power engineering and advanced control techniques
- Broad applicability to conventional central grids as well as grid-connected and islanded microgrids

Impact

- A control theory approach to assessing cyber security threats reduces uncertainty

Capabilities and facilities

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

Our partners

- Network operators
- Equipment manufacturers

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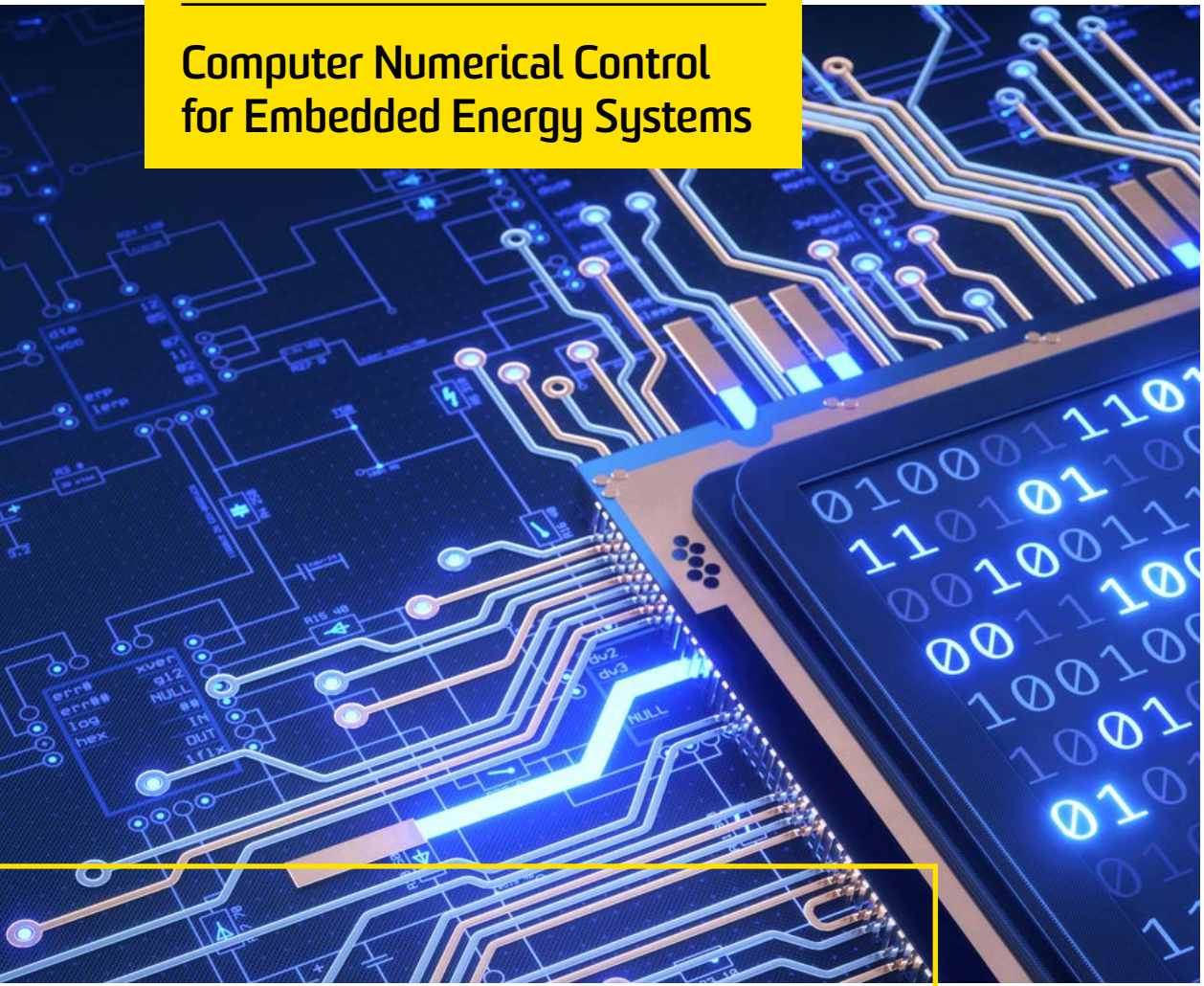
Computer Numerical Control for Embedded Energy Systems



Expertise in embedded system design for various systems, including computer numerical control (CNC) systems, wireless sensor networks, and high performance, low energy embedded systems.

Competitive advantage

Expertise in:

- Lifetime-aware wireless sensor networks
- Secure wireless sensor networks
- High performance CNC systems
- High performance, low energy, fully predictable embedded systems

Impact

- Embedded systems with better performance and greater security

Successful applications

- Aerospace I CNC system—core technology for founding Wuhan Huazhong Numerical Control Co Ltd (HNC), one of the world's leading CNC providers
- Lifetime-aware data collection in wireless sensor networks
- Secure data collection and distribution in wireless sensor networks
- Energy-aware task scheduling on MPSoC-based embedded systems
- Optimizing compilers for clustered VILW processor-based embedded systems
- Integrating cache locking and task scheduling for fully predicable embedded systems

Our partners

- Wuhan Huazhong Numerical Control Co Ltd

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Cooperative Distributed Energy Storage Systems

Massive penetration of energy storage systems presents new opportunities for power network operators and individual customers. Innovative cooperation of distributed energy storage systems can improve power quality while bringing additional capacity, flexibility and redundancy into power networks. It can also avoid costly power network upgrades and increase power-supply security.

Competitive advantage

Expertise in developing distributed multi-agent control strategies for energy storage systems. Distributed multi-agent control strategies provide improved performance compared with decentralised control strategies and have advantages in terms of robustness, scalability, security and flexibility over centralised control strategies.

Impact

The best approach to brain/machine interfaces suffers from serious limitations, in that their signal/noise degrades as the density of electrodes increases. An embeddable, conformal optics chip will provide a step-change in both clinical and research environments and enable the control of machines through the brain or the enhancement of human abilities.

Successful outcomes

Development of multi-agent control strategies for both homogeneous and heterogeneous distributed energy storage systems that allow:

- cooperative state-of-charge balancing with no circulating currents
- plug-and-play capability
- monotonic charging/discharging, and
- network topology independent dynamic optimal power flow.

Capabilities and facilities

UNSW houses one of the largest Real Time Digital Simulators (RTDS) in academic and research institutions globally.

- RTDS allows hardware-in-the-loop simulation, which is the final step before field verification.
- This presents the 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.

Our partners

- ABB Corporate Research, Sweden

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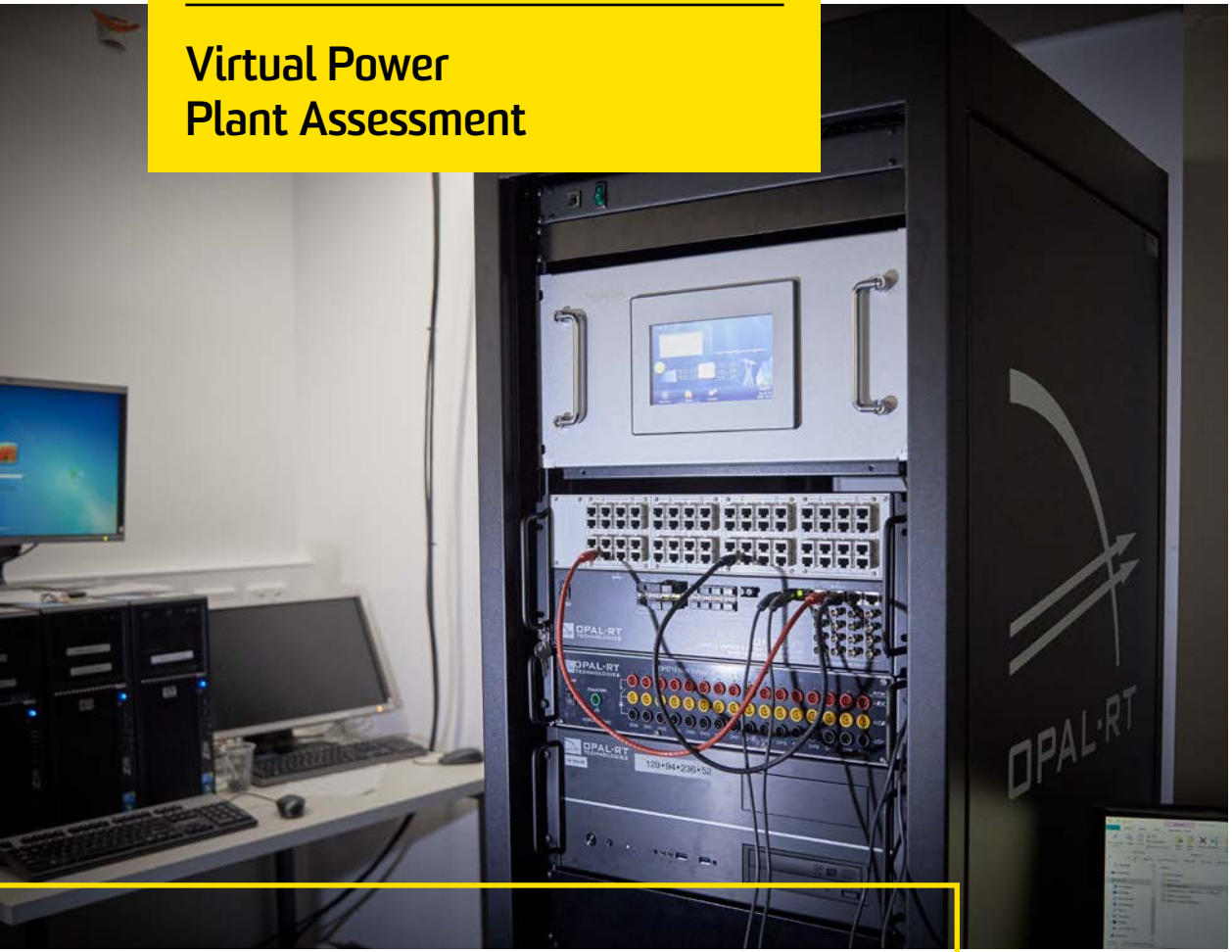
Virtual Power Plant Assessment



Assessing Virtual Power Plant (VPP) hardware and online optimisation strategies, and the potential that these systems can play in the energy transition and subsequent electrification of energy use.

Competitive advantage

- Leading expertise in hardware-in-the-loop testing and assessment of virtual power plant systems
- 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 investments and threats to assets from VPP aggregation
- Avoidance of large-scale disruption to VPP based on inverter performances

Successful applications

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

Capabilities and facilities

Access to state-of-the-art experimental facilities including:

- 10kVA experimental DC microgrid with diverse set of loads and generators
- 18-rack RTDS capable of modelling distribution and transmission networks
- OPAL-RT real-time simulator

Our partners

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

More information

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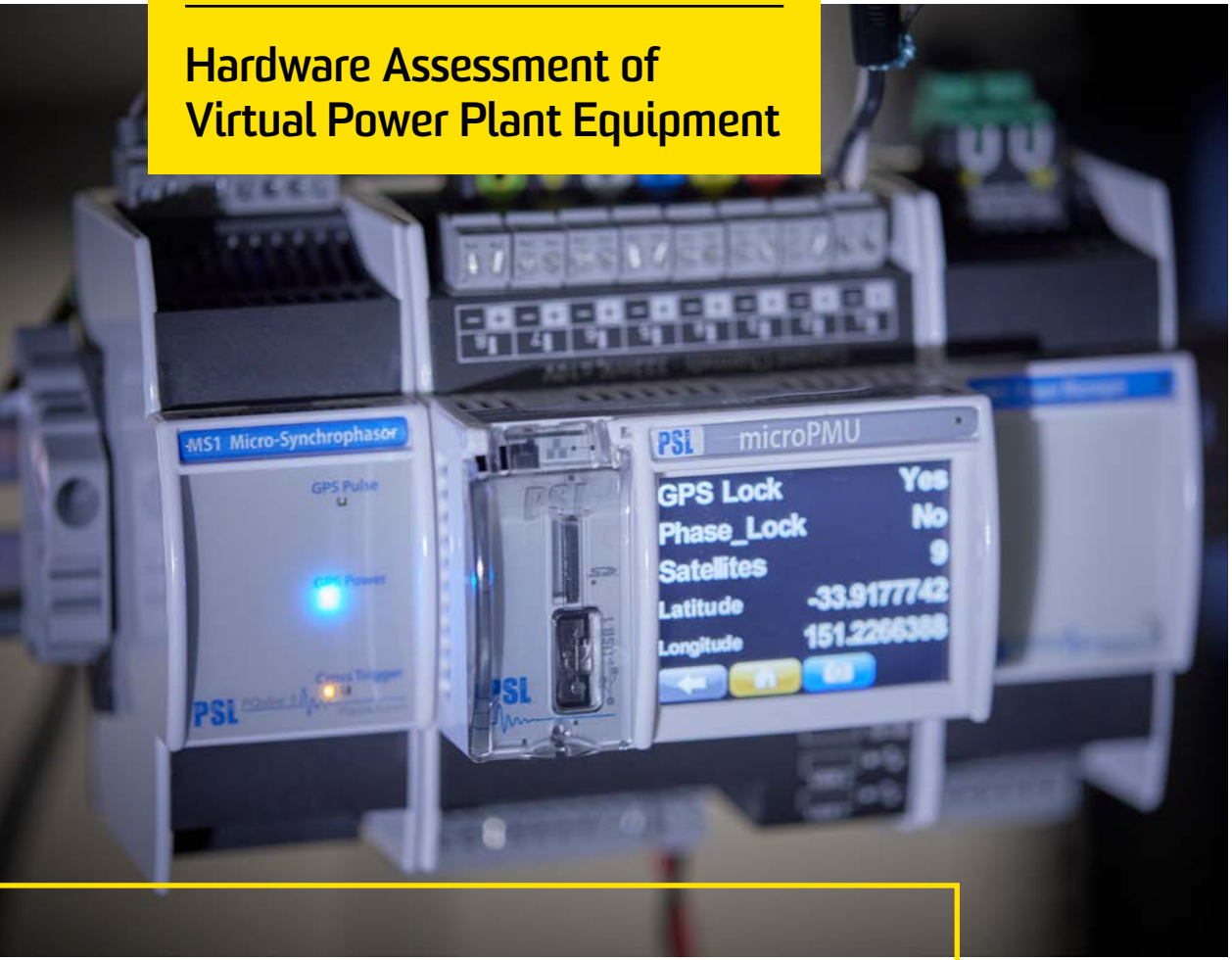
Hardware Assessment of Virtual Power Plant Equipment



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.

Competitive advantage

- Unique database of inverter behaviours and disturbance reactions
- Innovative models verified through experimental assessment
- Leading expertise in hardware-in-the-loop testing and assessment of virtual power plants
- Rapid modelling and simulation capability

Impact

- De-risk VPP investments and optimise VPP performance
- Proof of concept hardware and software assessment

Successful outcomes

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

Capabilities and facilities

Access to state-of-the-art experimental facilities including:

- A fleet of current inverter makes and models
- 18-rack RTDS capable of modelling VPP systems
- OPAL-RT real-time simulator for high-resolution simulations

Our partners

- Sungrow
- A. W. Tyree Foundation

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Condition Monitoring System (CMS) for Power Equipment Based on IoT Technology

Condition Monitoring aims to detect abnormality as it happens during the operation of power equipment and systems, diagnosing the type and causes for the abnormal condition and identifying the location of the possible failure based on a wireless sensing network.

SWER system monitoring is the most cost-effective choice for a distribution system of microgrids. However, due to the principle of SWER, the issue of voltage imbalance and instability has remained a serious issue for the past 20 years and fault detection is difficult due to the high impedance of the network.

Competitive advantage

- Unique, remote monitoring solution
- State-of the art, contactless sensing and wireless network based on IoT technology

Impact

- The ability to monitor a system remotely provides an economical solution to detect and identify the location of abnormalities
- This contactless sensing and wireless network collects data to present various features of a running equipment or system, with which performance, status and potential risks of the equipment or system can be identified

Successful applications

- Condition monitoring technology has been applied to a 100km SWER system that monitors the distribution system of a microgrid in a remote area. It is based on IoT technology and has proved to be able to communicate independently, without the support of the 3G/4G network
- Successfully tested in monitoring the condition of a specific component (bearing) of rotating machinery. The test has proved that the method can accurately identify the location and type of an abnormal condition in the machinery

Capabilities and facilities

- Remote SWER system monitoring for Microgrids
- Power Equipment Condition Monitoring based on contactless sensing and wireless network

More information

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Toward Ubiquitous Monitoring of the Grid

Photonics technologies developed at UNSW promise to greatly enhance the ability to cost-effectively monitor power at strategic network locations, in order to address the challenges of new grid architecture.

Competitive advantage

- Cutting-edge, affordable, scalable and intrinsically safe monitoring technology that can be applied to all aspects of the electricity grid
- World-class photonics that are adaptable to all current voltage ranges and to hazardous environments like mines, refineries and smelters
- Know-how and intellectual property related to design, fabrication and production

Impact

The successful in-situ implementation of the technology would provide a powerful tool to enable preventive monitoring of the grid and address topical issues such as system strength, dynamic line rating and other important issues related to the changing nature of the grid. All of these are vital to help the grid adapt to the steady, ongoing development of renewable energy sources and the emergence of new network architectures.

Successful outcomes

- The technology is currently in use in the University's high-voltage laboratory
- It has also been applied in other areas such as mine and ocean monitoring

Capabilities and facilities

- Access to UNSW high-voltage laboratory
- Access to UNSW node of the Australian National Fabrication Facility
- Access to commercially-ready, patented technology

Our partners

- Zedelef Pty Ltd
- Tyree Transformers (through their Foundation)
- Ampcontrol
- Schneider Electric

More information

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Intelligent Monitoring of Electricity Grids

The electricity grid delivers electrical energy from diverse generation sources to end users. It is a complex, continuously-evolving and dynamic system. Advances in sensing devices, digital technologies and communications make it possible to engineer systems for accurate, online, real-time monitoring of the grid and intelligent, automated control of its operation.

Competitive advantage

- Expertise in HV AC and DC transmission systems, equipment, components and devices
- Leaders in smart-grid monitoring systems with embedded intelligence, e.g. novel sensing devices, signal processing, data analytics, to provide on-line monitoring of power flow, power quality, losses/efficiency and network transients
- Novel diagnostic techniques for insulation assessment—e.g. ultra-high frequency detection of partial discharges, dielectric spectroscopy and frequency response analysis
- Expertise in novel dielectric materials for electro-technology—e.g. high-k dielectrics for energy storage capacitors, polymeric nanocomposites and biodegradable insulating liquids

Impact

- Making electricity supply systems more reliable and better managed

Successful applications

- Development of intelligent, robust online condition monitoring for electricity substations and other strategic assets of high-voltage electricity grids
- Online partial discharge monitoring in cables and transformers
- Distributed online monitoring of SWER networks and detection of high-impedance arcing faults

Capabilities and facilities

- High Voltage laboratory with various HV sources available for testing: impulse, 50 Hz AC, DC, VLF, variable frequency
- Wide range of state-of-the-art measurement instruments for dielectric insulation study—sensors, partial discharge, dielectric dissipation factor, space charge, time and frequency domain spectroscopy, thermal imaging, and fast data acquisition systems

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Solar Powered Remote Sensors for the IoT

Solar powered hybrid devices with on-board energy storage can enable compact remote sensing devices that collect and transmit field data to the cloud to support 24/7 monitoring and surveying applications.

Competitive advantage

- Expertise in photovoltaics and energy storage
- Practical experience in fabrication of hybrid devices
- Expertise in durable device encapsulation
- Circuit and device modelling/simulation expertise

Impact

- Self-powered sensors and devices to enable monitoring and/or survey data to be collected from remote areas and assimilated via cloud computing into historical and/or predictive models
- Hybrid photovoltaic and storage functionality for solar-powered devices and tools, and medical implants

Successful applications

- Demonstrated hybrid device based on a commercially-produced silicon solar cell

Capabilities and facilities

- Extensive expertise in both photovoltaics and energy storage research
- State-of-the-art laboratory facilities for both photovoltaics and energy storage research and fabrication of hybrid devices

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Fault Ride Through Testing Facility to Support Grid Stability

A facility to test the ability of non-synchronous power plants to maintain continuous uninterrupted operation when a power system is subjected to a voltage disturbance. This is a fundamental requirement to maintain system security and prevent wider frequency collapse.

Competitive advantage

- Full suite of low voltage ride-through (LVRT) and high voltage ride-through (HVRT) testing services
- Ability to simulate different depths of voltage dips and rises, ranging from 0% to 140% with a step of 1% of the rated voltage, lasting from 1000 ms to 3000 ms
- Ability to simulate different grid faults, including line to line (L-L), double line to ground (LL-G), and line to line to line (L-L-L)
- Test generating plants up to 8 MVA in grids and up to 40 kV system
- Compliance with the IEC6400-21

Impact

- Validate simulation model against onsite test in R2 test
- Demonstrate fault ride through performance on site
- Support grid stability and improve security of supply
- Full-scale field testing with no adverse impact on the network

Successful outcomes

- Successfully commissioned 30 LVRT tests on 10 different wind turbines

Our partners

- Goldwind
- DNV GL

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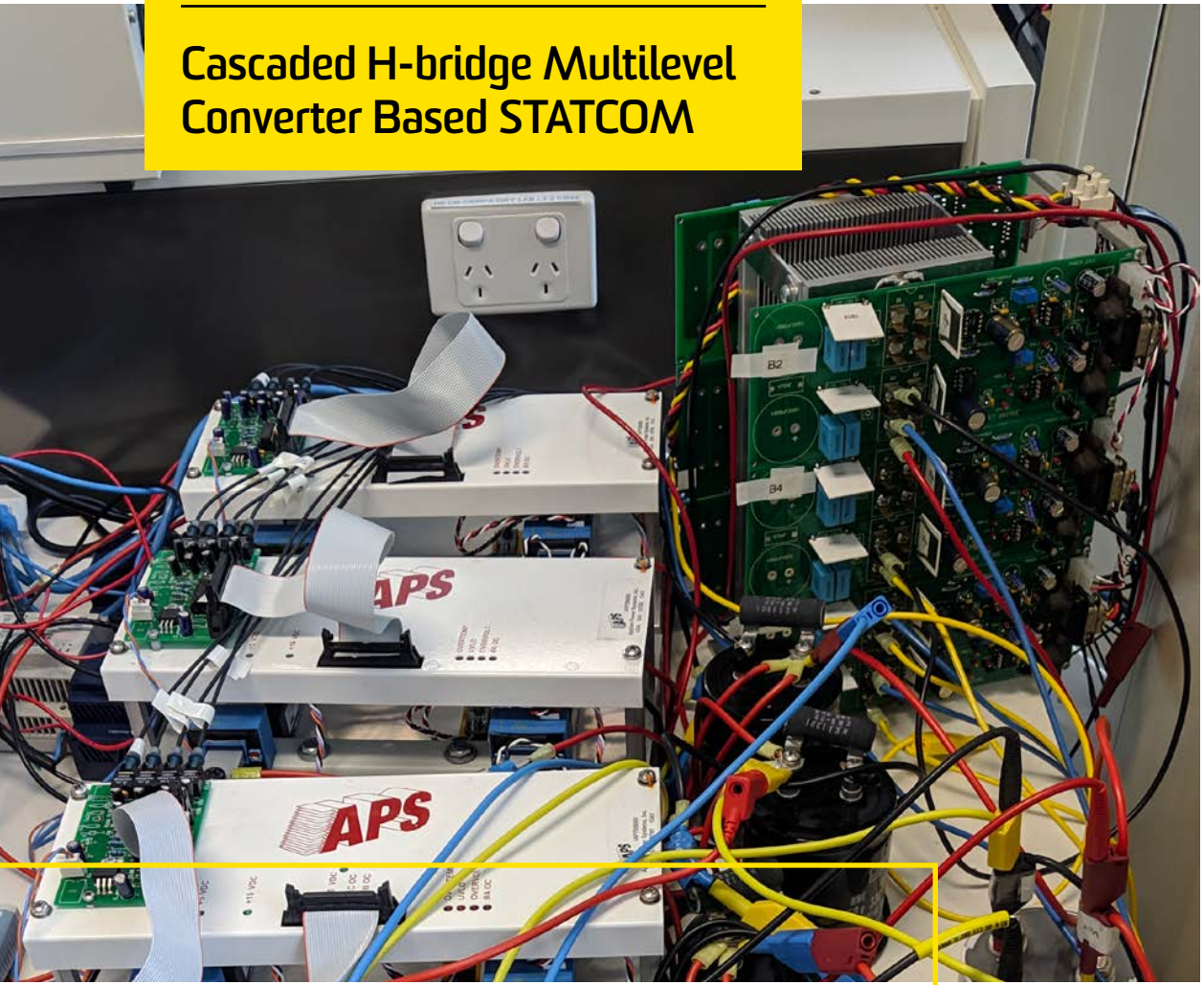
Cascaded H-bridge Multilevel Converter Based STATCOM



A cascaded H-bridge multilevel converter based low-capacitance STATCOM that is able to operate with extremely low DC capacitance values. It can achieve 80% reduction in the capacitor's size, improve current quality, and reduce the maximum voltage stress on the semiconductors compared to a conventional STATCOM.

Competitive advantage

- Significantly reduces the cost of large DC capacitors
- Avoids reliability issues related to electrolytic capacitor failure
- Reduces the cost of switching cell protection by reducing the DC-link fault level
- Reduces the weight and volume of the converter, which can makes it easier to containerise high power STATCOMs

Successful outcomes

- Experimental prototype of a single phase cascaded H-bridge multilevel converter based low-capacitance STATCOM

Capabilities and facilities

- Power electronics laboratory
- Hardware testing capability up to 50kVA, 1kV, 400A
- Arbin battery and supercapacitor tester with environmental chamber

More information

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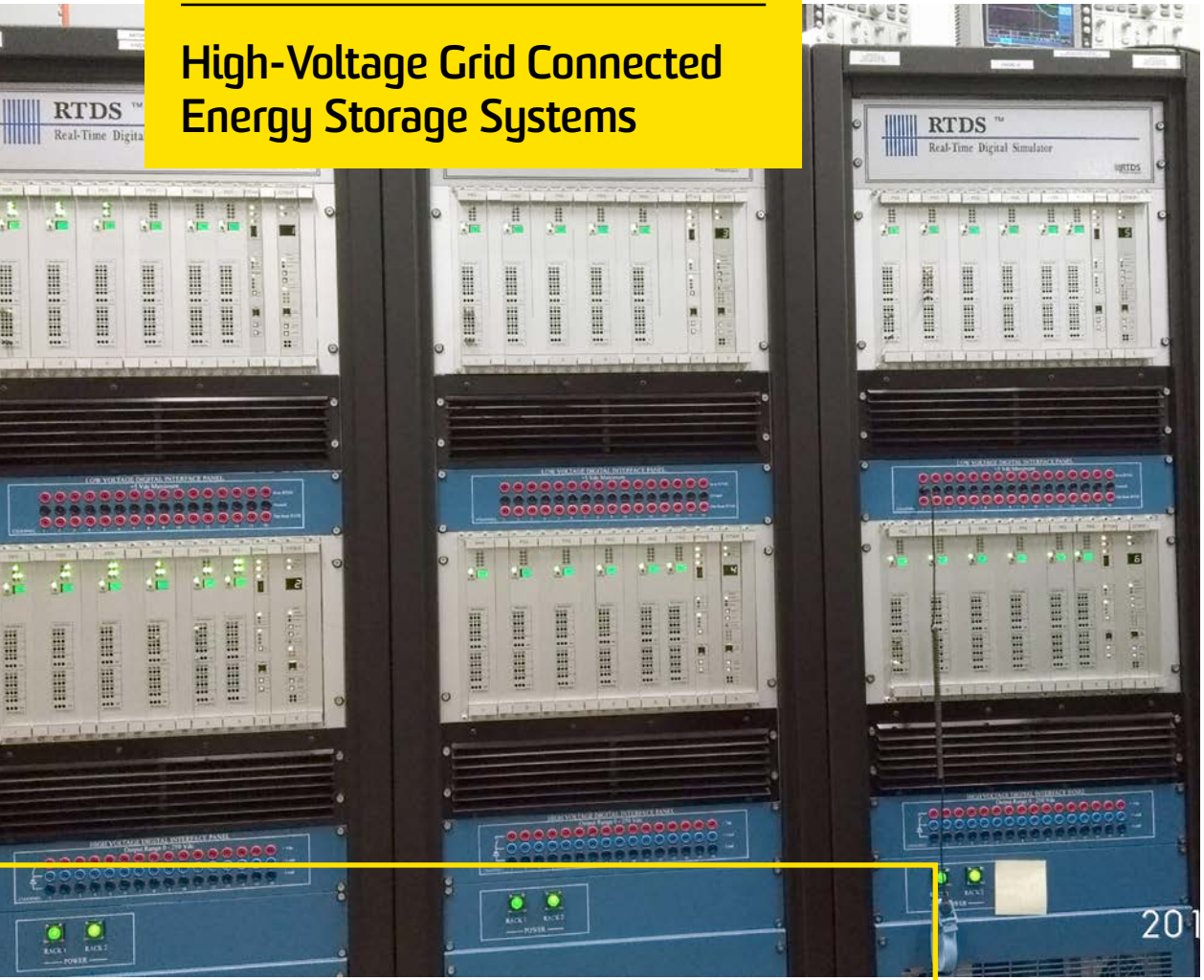
High-Voltage Grid Connected Energy Storage Systems



The development of novel converter topologies and controllers for Energy storage systems.

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, provide fast verification and quick adoption by industry for mass production
- World-class power hardware-in-the-loop capabilities to enable testing at full power

Impact

From small-scale to large-scale, power electronics is the enabling technology for integration of energy storage systems (ESS) to the grid.

Successful applications

- A cascaded boost inverter-based battery ESS with several advantages over a cascaded H-bridge ESS:
  - Lower number of series connected modules
  - Ability to reduce the second-order harmonic ripple component in the battery current without additional hardware components
  - No input voltage balancing is required
  - Generates a sinusoidal output voltage

Capabilities and facilities

- Hardware-in-the-loop simulation for rapid assessment of control techniques
- Hardware testing capability up to 50kVA, 1kV, 400A
- Arbin battery and supercapacitor tester with environmental chamber

More information

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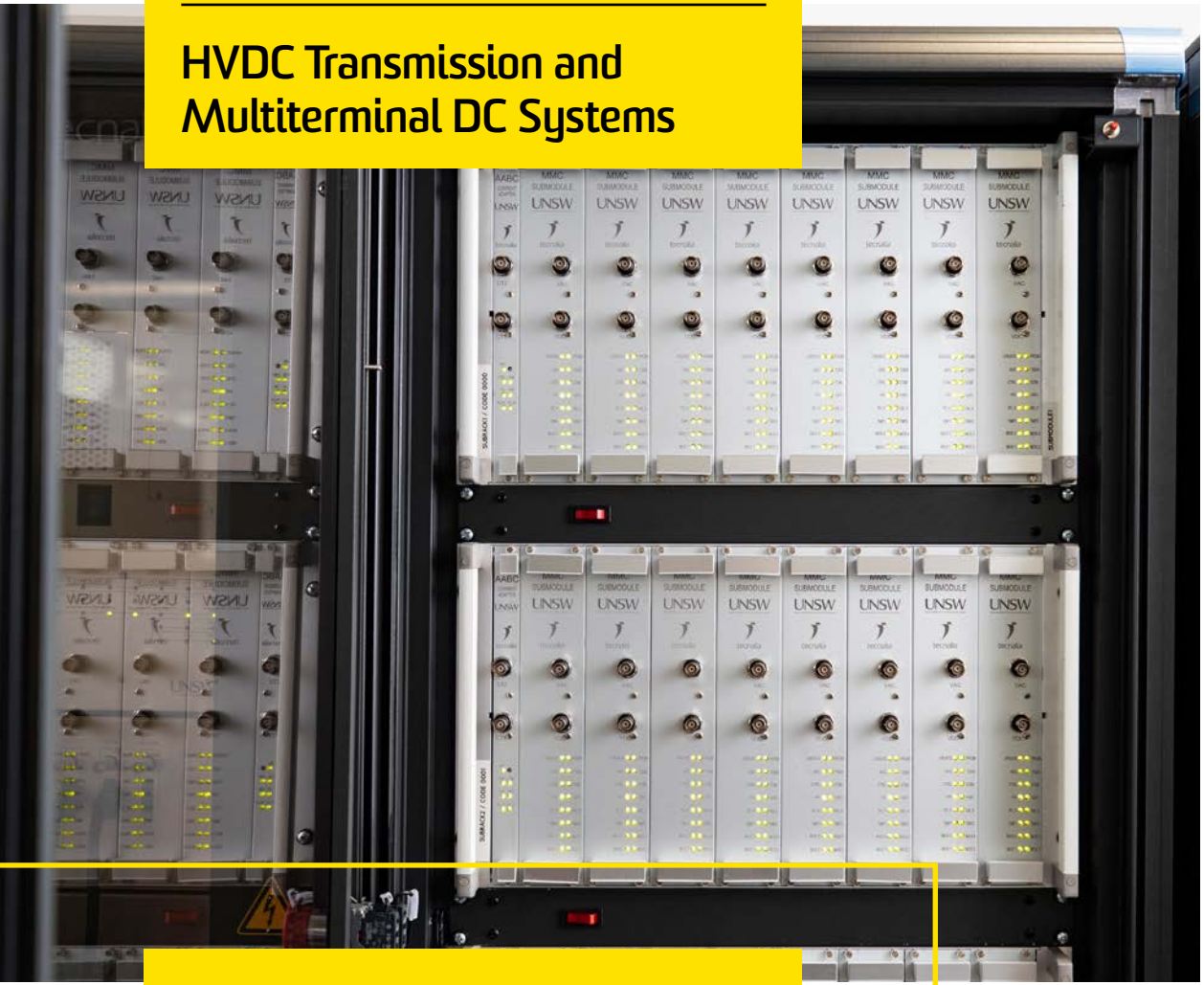
HVDC Transmission and Multiterminal DC Systems



Real-time simulation and hardware-in-the-loop testing expedites innovative solutions for interconnecting electricity grids over long distances, the integration of large-scale remote renewables, addressing intermittency and the formation of super grids.

Competitive advantage

- Expertise in:
  - Offline and real-time Phasor and EMT simulations
  - Power and control hardware-in-the-loop testing
- Wide range of experience in advanced HVDC converter models in multiple computational domains, ranging from fully average to component average, to detailed switching models
- State-of-the art and emerging converter technologies
- Extended simulation capability

Impact

- Contribution to AEMO's Integrated System Plan – 2018
- Submission to AEMC's Generation and Transmission Investment consultation – 2018

Capabilities and facilities

- The largest real-time digital simulator in Australia
- Fully configurable 4-terminal multiterminal HVDC hardware prototype
- Integration of simulators with laboratory hardware

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Real-Time Digital Power and Energy System Simulations

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.

Competitive advantage

- Having the largest real-time digital-simulation laboratory in Australia and one of the largest in academic and research institutions globally, offers unprecedented simulation capabilities
- Expertise in comprehensive modelling and the 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
- 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

- High-voltage DC grids for flexible and efficient electricity transmission
- ElectraNet Heywood Interconnector distance protection relay hardware-in-the-loop testing
- ElectraNet Heywood Interconnector series compensation protection testing
- Simplified 14-generator Australian network test system
- Battery energy-storage system models

Capabilities and facilities

- 18-rack, 180 CPUs for the RTDS real-time digital simulator
- 1 x OPAL-RT OP5607 real-time digital simulator
- 4 x OPAL-RT OP4500 real-time digital simulators
- 4 x Omicron CMS100 power amplifiers
- Interface with Regatron DC/AC supplies for power hardware-in-the-loop testing

Our partners

- AEMO
- AEMC

More information

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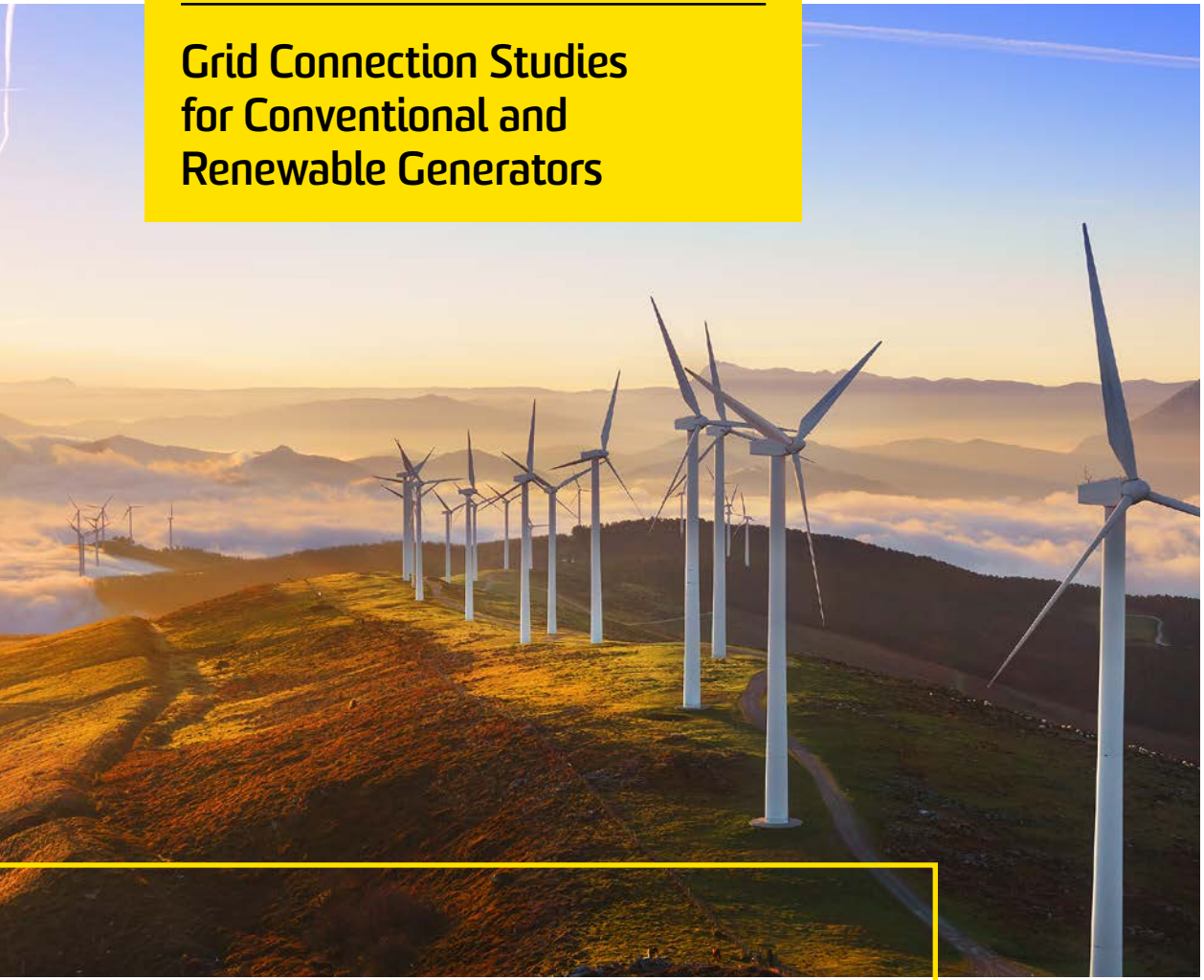
Grid Connection Studies for Conventional and Renewable Generators



Extensive expertise in both conventional and non-conventional power generation and provider of a wide range of power system engineering consultancy services to clients in generation, energy storage, transmission and distribution. These services include commercial and technical advice, assistance and strategic guidance for grid connection.

Competitive advantage

- Model structure review, generator performance standard study, dynamic model acceptance testing, and benchmark studies
- Synchronous generator modelling, parameter identification and control system design
- Automatic voltage regulator, speed governor and power system stabiliser tuning
- Power system simulation studies (RTDS, PSS/E, PowerFactory, PSCAD, Python)

Impact

- Better grid integration of conventional and renewable generators

Successful applications

- Strategies for grid connection and risk assessment on conventional generator connections and renewable farm grid connection studies
- Guidance on regulatory issues and system modelling with a number of wind farms

Capabilities and facilities

- Real-Time Digital Simulators (RTDS)
- Power System Simulator for Engineering (PSS/E)
- DIgSILENT Powerfactory
- PSCAD/EMTDC
- Matlab, Python, AMPL

Our partners

- GoldWind Wind Farm
- CSIRO
- Ausgrid
- Aurecon

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High Concentration Solar Furnaces

High concentration solar furnaces involve efficient interconversion of energy from sunlight to produce electricity, heat and fuel. Each form of energy has storage challenges; e.g. spectrum-splitting photovoltaics produce electrical power, hybrid PV–thermal systems produce electricity and heat, while ultra-high solar concentration furnaces can be used to manufacture solar fuels.

Competitive advantage

Development of novel optical systems applied to industrial-scale solar concentrators opens up new possibilities for high temperature solar furnaces. Integration of fluid lens optics and optic fibre provides a versatile platform for deployment of new high temperature reactors, as well as retro-fitting to existing systems.

Impact

- Enabling a range of high-temperature thermochemical cycles that may be used for the production of renewable solar fuels
- Extraction of metals from their ores using solar energy could position Australia as an exporter of clean and high value raw materials

Successful outcomes

- High efficiency photovoltaic devices
- High concentration solar cell architectures
- Development of new modelling tools for solar concentrators
- Design integration with concentrating solar power technology for deployment at scale

Capabilities and facilities

- 3D freeform optical surface growth for optimal non-symmetric optical concentrators
- Heliostat field integration and solar receiver optimisation
- Spectrum-splitting optics and high-efficiency photovoltaics
- Concentrating solar receiver design
- Thermodynamics of the interconversion of heat, electricity and light
- Characterisation of optical materials

Our partners

- Heliosystems Pty Limited
- Peritar Pty Limited
- Raygen Resources Pty Limited

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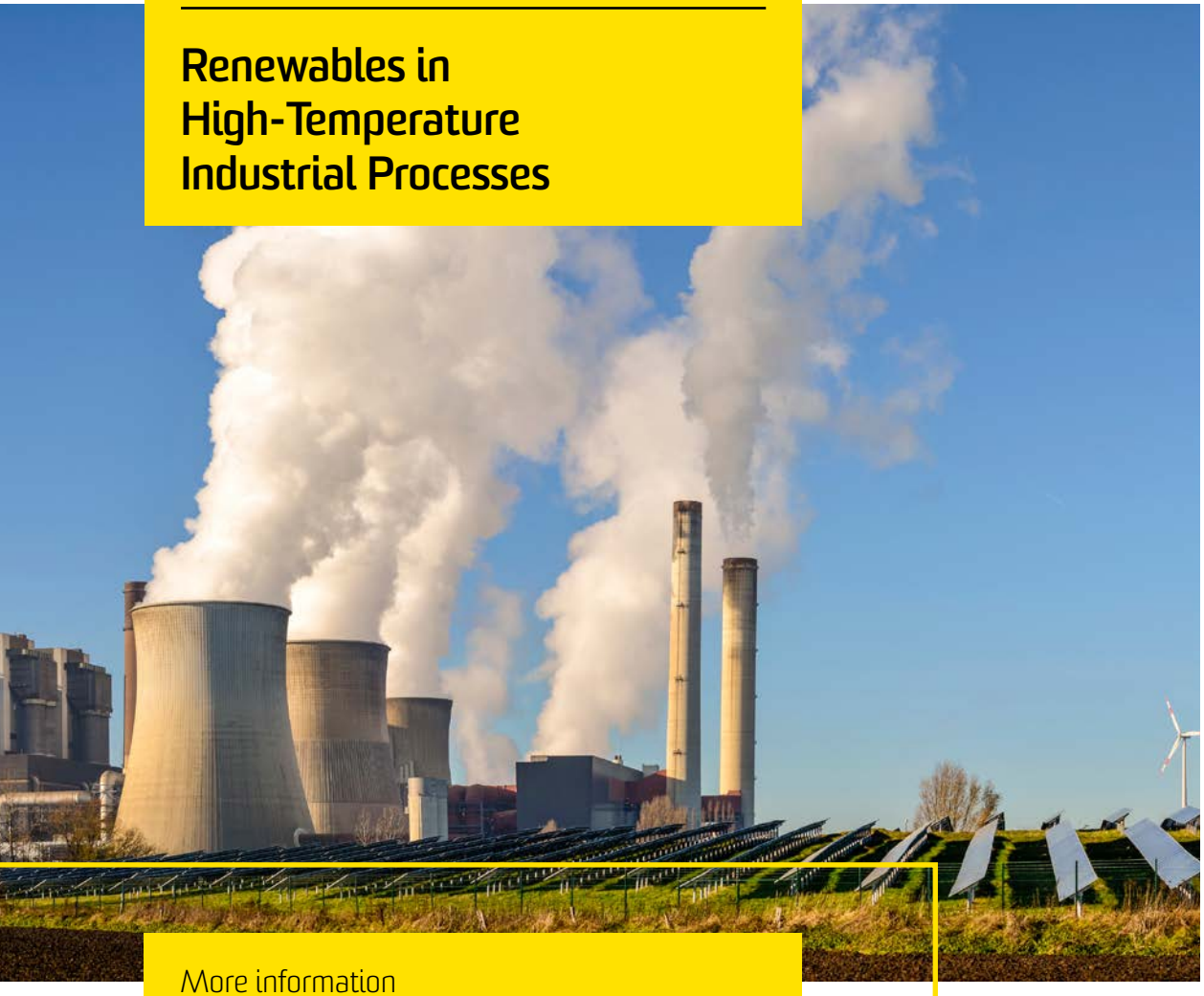
Renewables in High-Temperature Industrial Processes



Among the various energy applications, high-temperature industrial processes will be among the hardest to decarbonise. Renewable fuels and/or concentrated solar-thermal energy have the potential to address this, if existing processes can be adapted.

Competitive advantage

- Deep modelling and experimental capability in high-temperature, multi-phase, chemically reacting flows
- Expertise in technoeconomic modelling

Impact

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

Successful outcomes

- Work to integrate solar-thermal energy into the process for alumina production

Capabilities and facilities

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

Our partners

- Alcoa
- Australian Renewable Energy Agency

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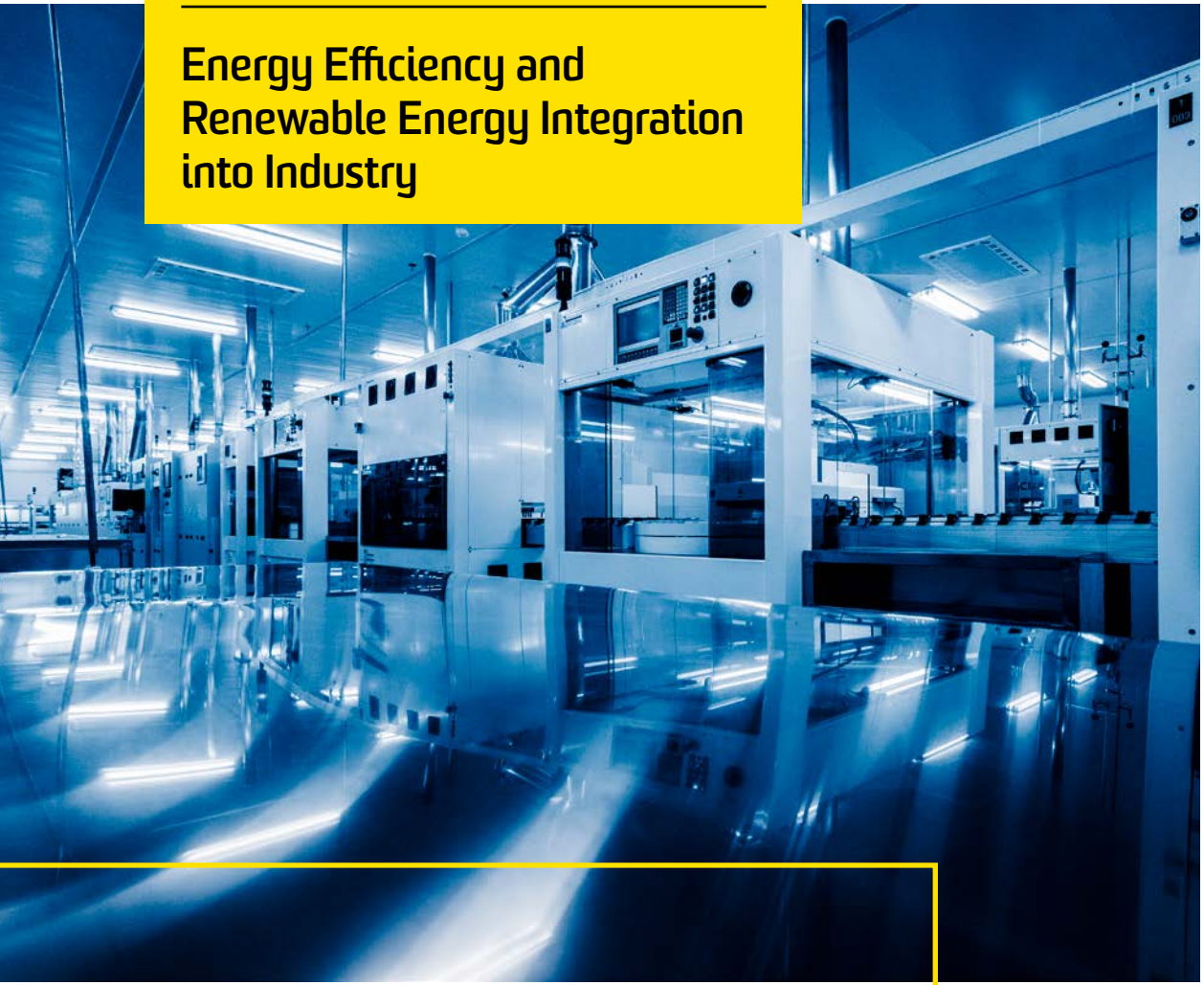
Energy Efficiency and Renewable Energy Integration into Industry



Using expertise in energy metering and monitoring to develop and implement energy efficiency solutions.

Competitive advantage

- The development and implementation of energy efficiency road maps
- 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 micro-grids
- Management of energy supply and demand in factories

Impact

Helping industry to save money and go 'greener' by increasing energy efficiency and integrating renewable energy into their operations.

Successful applications

- Significant reduction in energy cost and associated environmental footprint in the aluminium, pharmaceutical, metal fabrication, waste management and heavy engineering industries. In particular,
  - 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 on-site micro-grid in a pharmaceutical company which resulted in 85% on-site 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 partners

- ALCOA Australia
- Baxter Australia
- Preformed Line Products Australia
- FIP Breaks Pty Ltd
- Suez Australia
- IFU Hamburg, Germany

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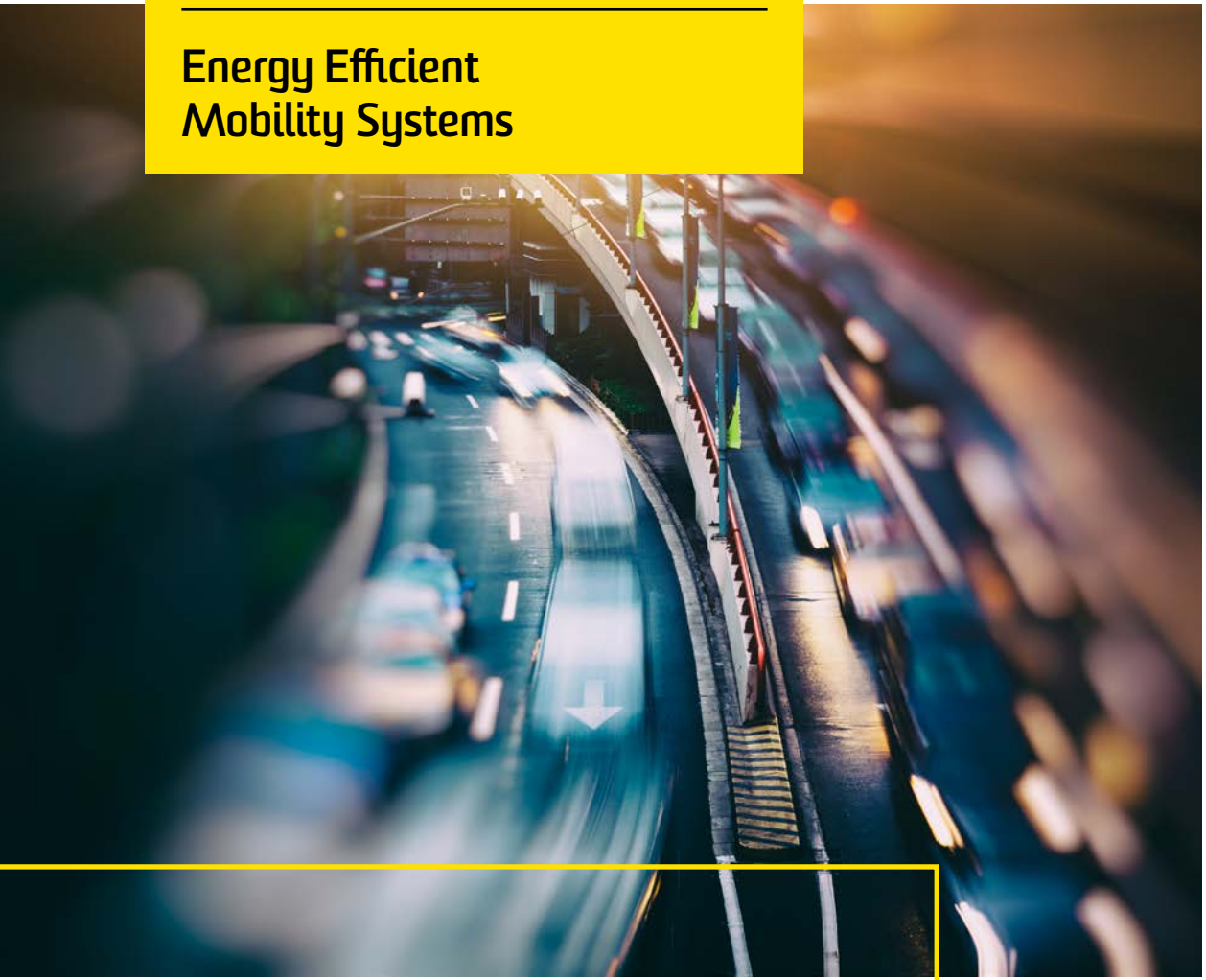
ELECTRIFICATION OF INDUSTRIES AND TRANSPORT

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

- Specialism in the areas of preference elicitation and discrete choice analysis
- Expertise at understanding how different agents will engage with new technologies and services
- Skilled at 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 – Low Carbon Living project with the New South Wales 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 partners

- Office of Environment and Heritage (through CRC-LCL)
- CSIRO
- US DOT
- Argonne National Laboratory

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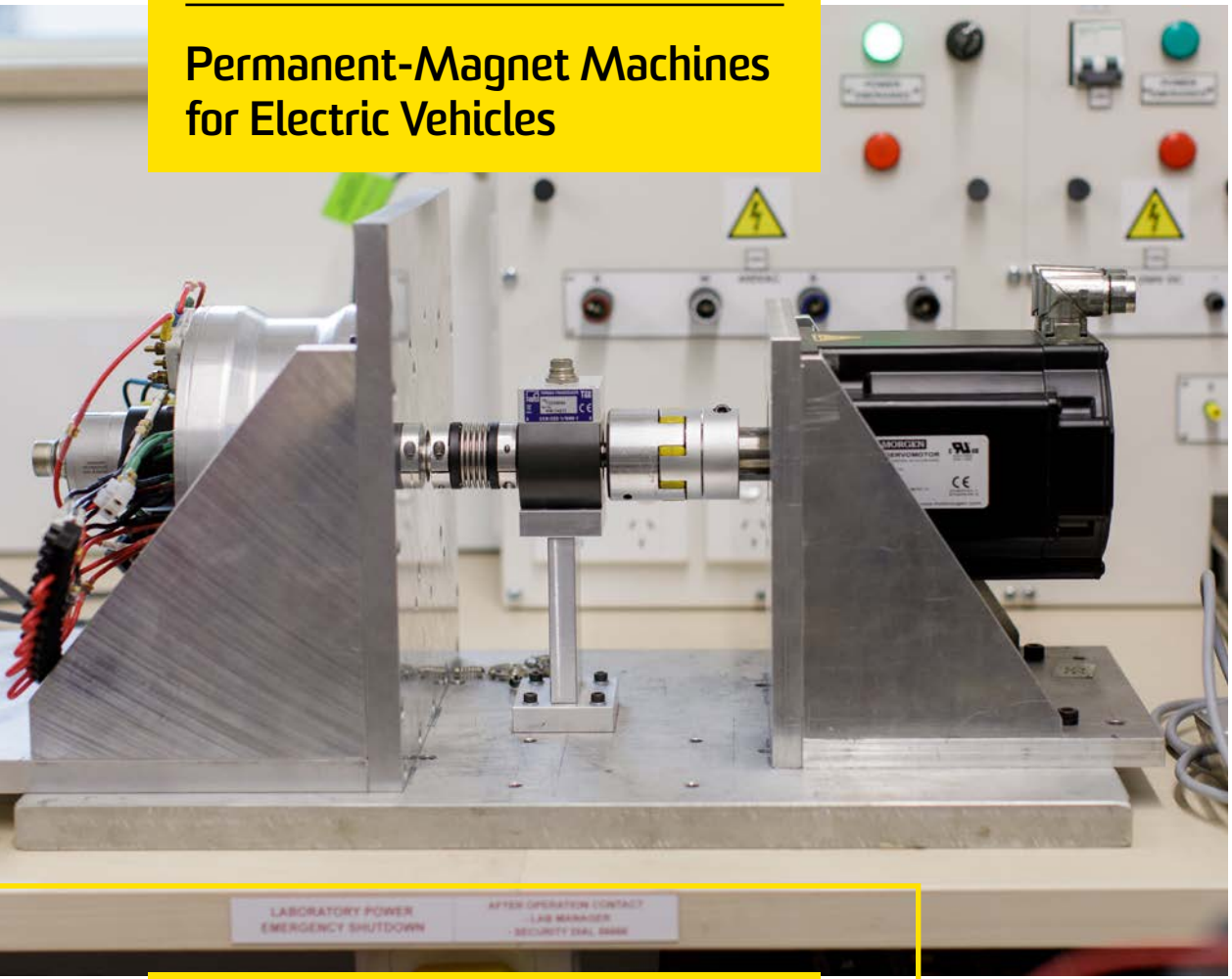
Permanent-Magnet Machines for Electric Vehicles



Expertise in designing and optimising various permanent-magnet (PM) machine geometries and electric drives, and in developing advanced control techniques to improve the performance of electric vehicles.

Competitive advantage

- World-class expertise in PM machine design and control, including wide-field weakening range
- One of the first in the world to develop mechanical sensorless control for an interior-type and a fractional-slot concentrated, wound interior PM machine
- Patented PM machine technologies with wide flux- weakening range and high-power density, and fractional-slot interior PM machines; patent application for novel multi-objective optimisation techniques for PM machines
- World's first experimental verification of fractional-slot concentrated wound stator with interior-type PM rotor

Impact

- Higher efficiency and better performance for EV-power trains
- Motors with wider constant power operation for traction applications

Successful applications

- Sensorless control techniques from zero to full speed for PM motor drives

Capabilities and facilities

- Finite-element packages, including Maxwell 2D/3D, Magsoft and ANSYS, with in-house optimization tools
- Simulation tools and platforms with Matlab–Simulink, and PSIM, FPGA and DSP systems with high-performance signal acquisition, estimation and switch gate-drive interfaces, to test and evaluate control techniques
- 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 krpm) PM machine test bed (work-in-progress)

Our partners

- CSIRO
- Wisconsin Electric Machines and Power Electronics
- Toshiba
- Regal Beloit

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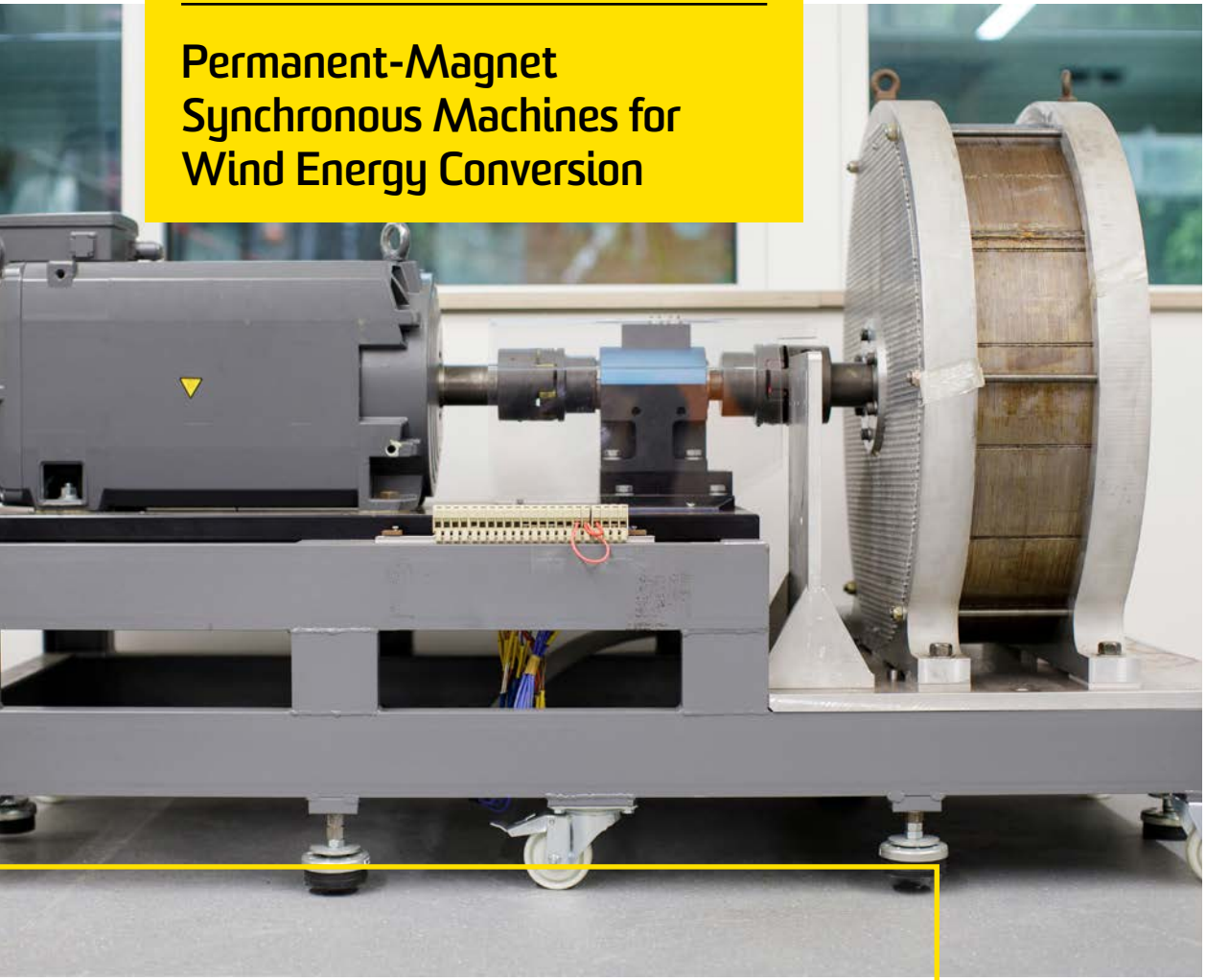
Permanent-Magnet Synchronous Machines for Wind Energy Conversion



Specialists in design and control of permanent magnet (PM) type electric machines. 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 on-line parameter identification with the possibility to use 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 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 optimization 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 partners

- CSIRO
- Wisconsin Electric Machines and Power Electronics
- Toshiba
- Regal Beloit

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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 state-of-the-art techniques that are leading contributors to the sensorless control of permanent-magnet synchronous motors (PMSM)
- Recent perfection of a new current derivative-based sensorless-control technique for the PMSM
- The first to develop a fast, online technique for estimating all electrical parameters of the PMSM, paving the way for monitoring the health of permanent magnets in the rotor of the machine, without requiring any sensors in the rotor

Impact

Many modern electric drives require sensorless drive capability in order to avoid using any sensor in the rotor and to improve the reliability of the drive. The estimation of the rotor position and speed without using shaft sensors saves cost 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 partners

- CSIRO
- Wisconsin Electric Machines and Power Electronics
- Toshiba
- Regal Beloit

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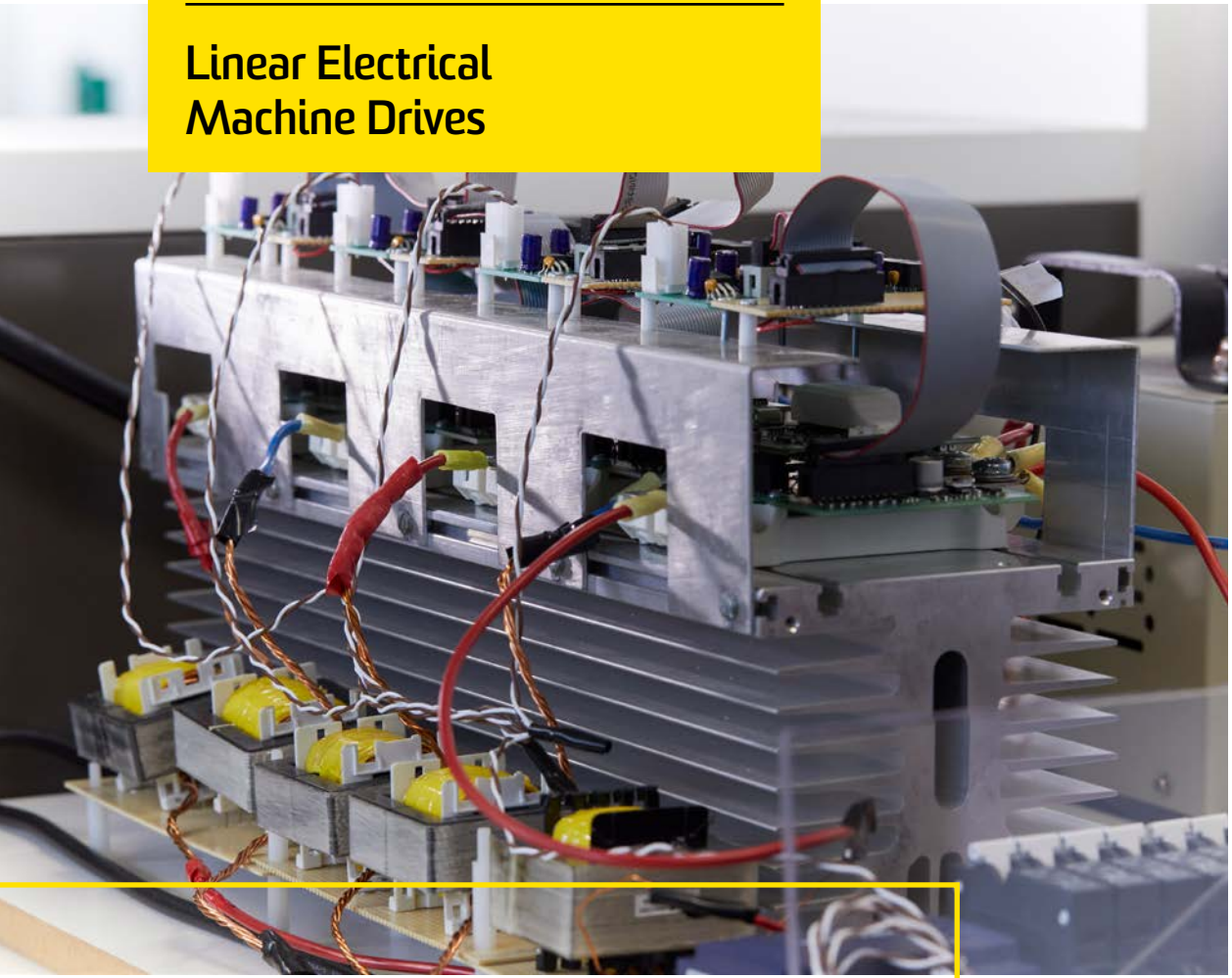
Linear Electrical Machine Drives



Linear electrical machines are used in an ever-increasing number of applications. Recent areas that we have developed linear machine solutions for include down-hole pump applications and electrical launch systems. UNSW has also recently developed a new type of permanent magnet rotor that has its starting performance improved by including 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. Development of linear machine solutions to support what is a rapidly growing market.

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 controllers, sliding-mode control, model-predictive control)
- Ability to rapidly develop and prototype controllers
- Custom linear machine design and prototyping

Impact

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 partners

- Motorica

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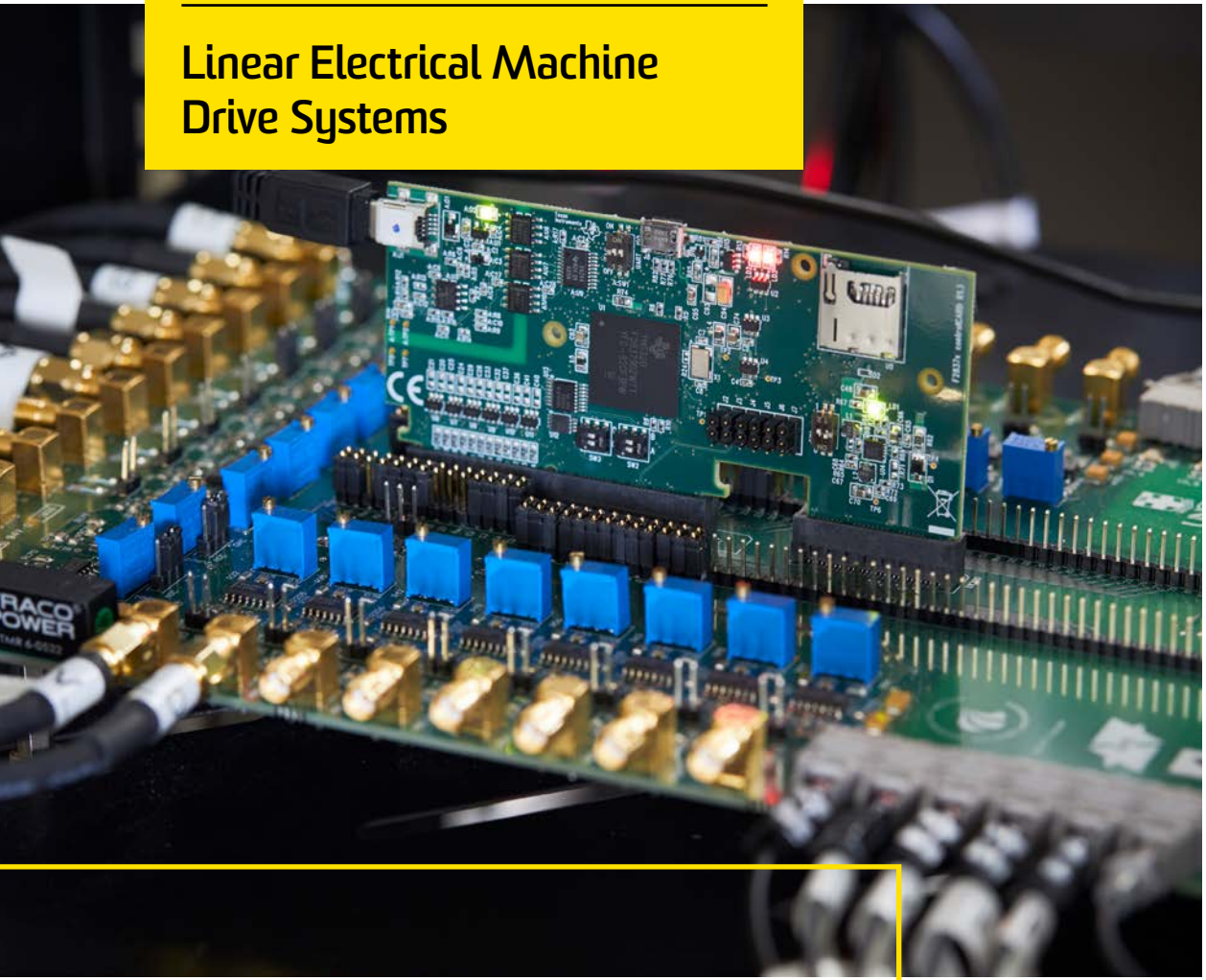
Linear Electrical Machine Drive Systems



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 also enhance the line-start capability of the permanent-magnet linear synchronous machine.

Competitive advantage

- Expertise at using damping windings for modelling and drive strategy
- Ability to deliver higher tolerance in the estimated position

Impact

- Line start within all ranges of initial mover position
- Rapid acceleration to synchronous speeds without the need for accurate position sensor

Successful applications

- Up to 6 per cent reduction in overshoot of the periodic motion
- Prototype electromagnetic launch system
- General linear machine drive systems

Capabilities and facilities

- Hardware setup for testing linear machines, with two types of mover
- dSPACE 1104 real-time experimental platform
- Complete motion control system

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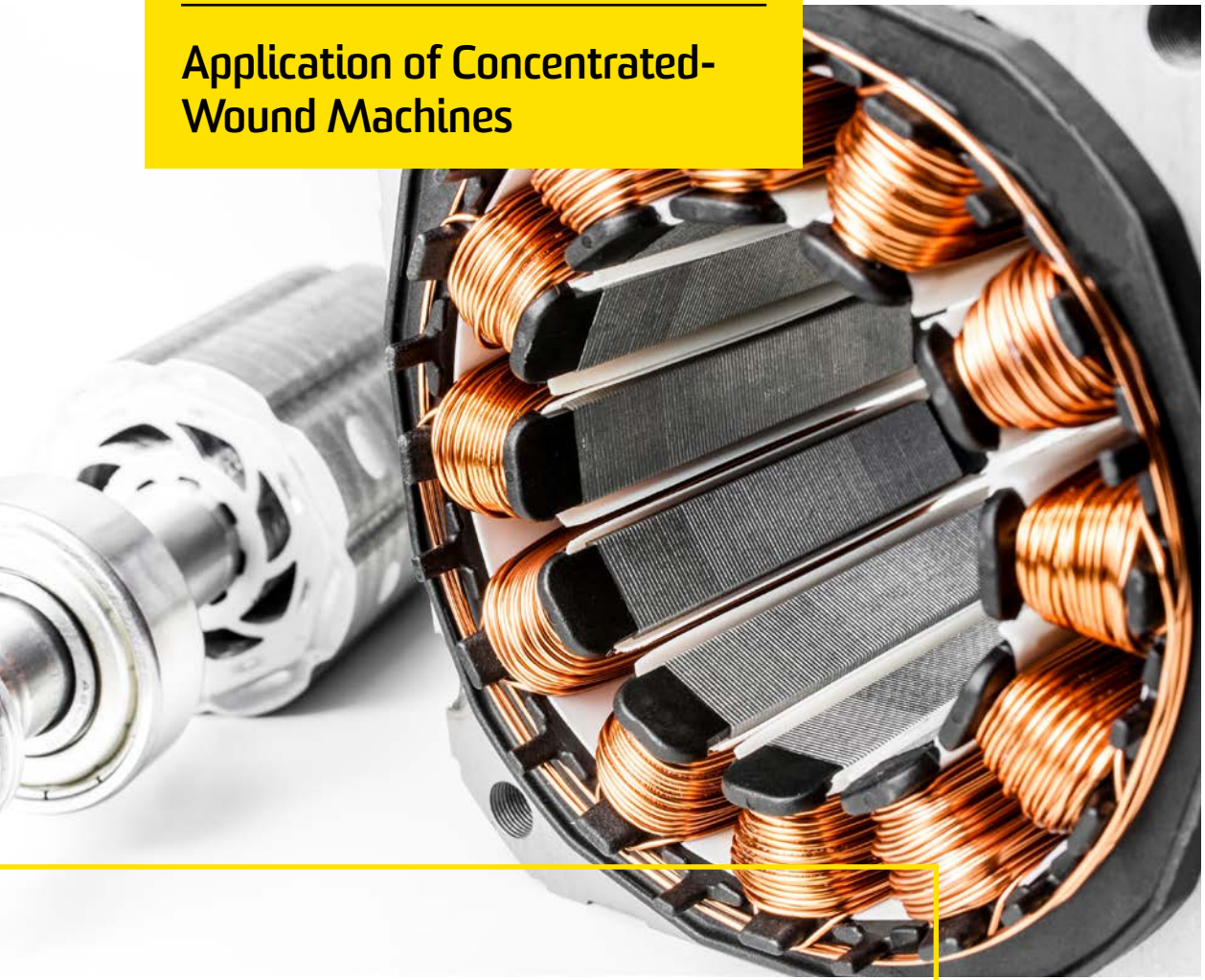
Application of Concentrated-Wound Machines



As the world endeavours 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 faults propagating through the machine.

Competitive advantage

- Many years' 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
- Improves the performance of electric vehicles and other powertrains
- Improved operation under machine faults

Successful applications

Applications in powertrains, electric vehicles and aerospace

Capabilities and facilities

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

Our partners

- Motorica

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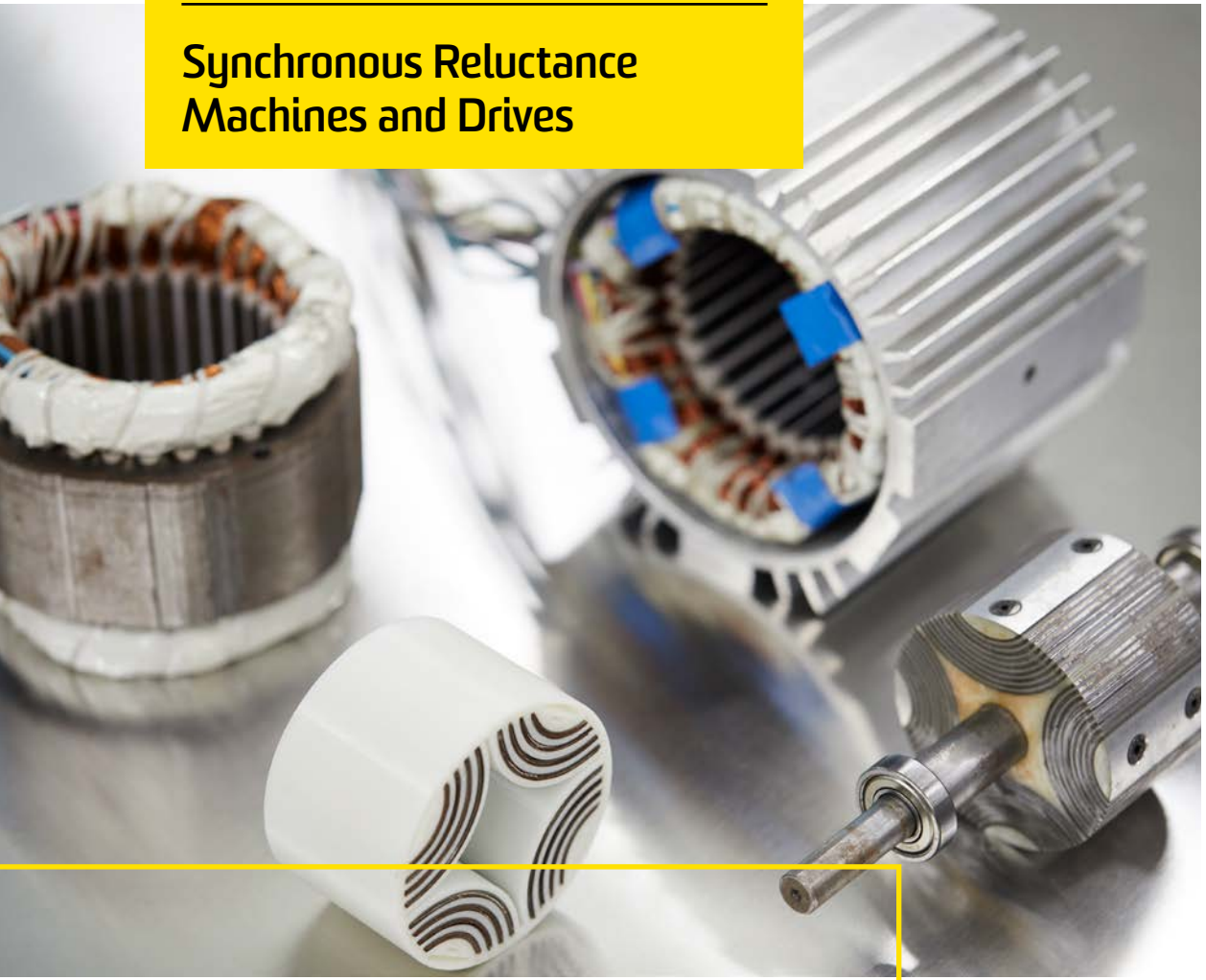
Synchronous Reluctance Machines and Drives



Development of a new type of synchronous reluctance machine that has a skewed, axially-laminated rotor, which solves the problem of torque ripple normally associated with traditional rotors.

Competitive advantage

- An innovative axially-laminated rotor that is skewed, which improves machine performance and creates near-zero torque ripple
- Novel multi-phase winding techniques improve output torque
- 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, which makes 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 do not require permanent-magnets and do not 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 load machines and high-speed load machines

Our partners

- Shandong BOFA Power Machinery
- Motorica

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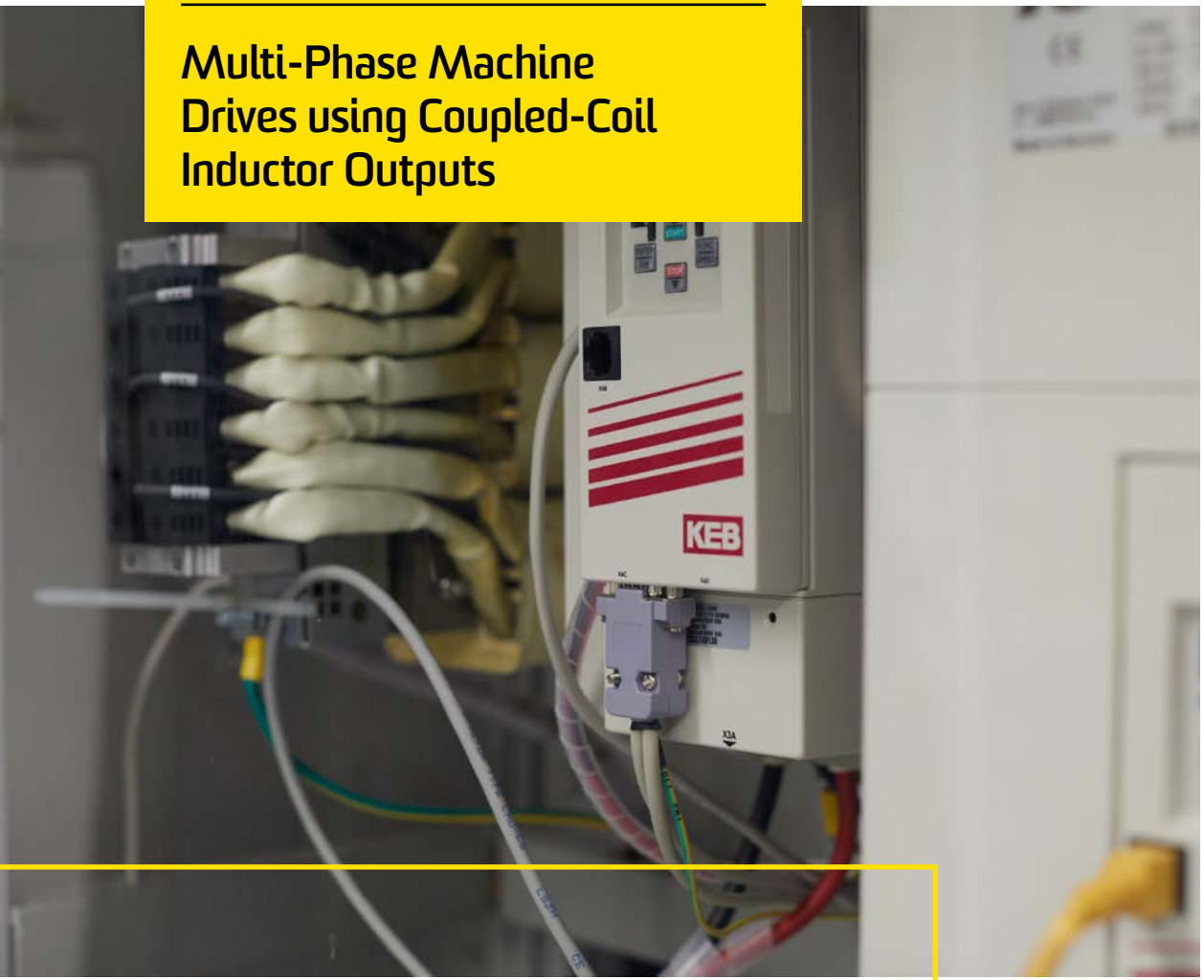
Multi-Phase Machine Drives using Coupled-Coil Inductor Outputs



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 but only uses 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 voltage on the DC-link capacitor does not need to be balanced
- Vast experience at 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 multiphase inverters

Impact

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

Capabilities and facilities

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

Our partners

- Shandong BOFA Power Machinery
- Motorica

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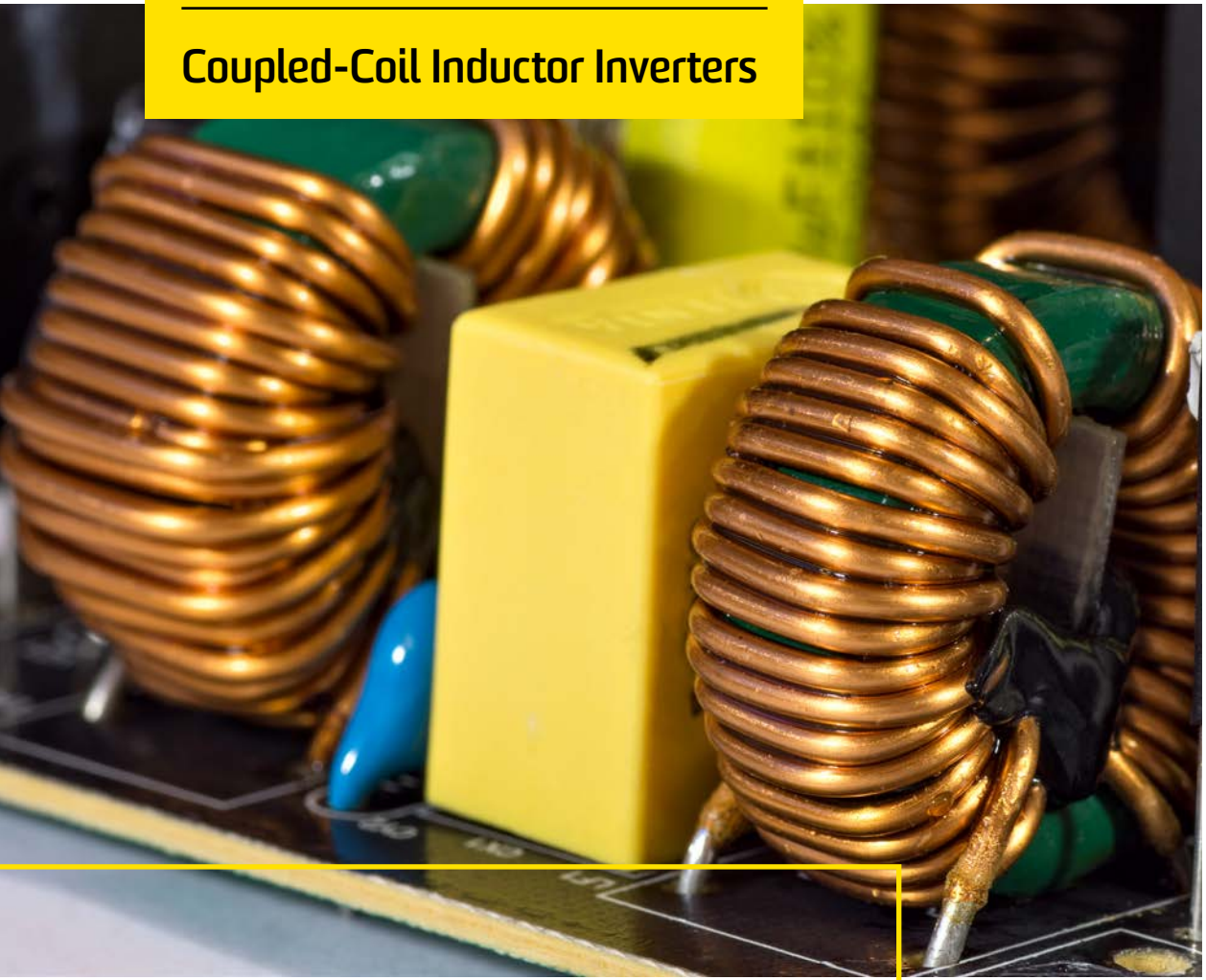
Coupled-Coil Inductor Inverters



Producing multi-level 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 capacitors 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
- Multifunction test rig
- Four-quadrant 20 kW programmable power supply

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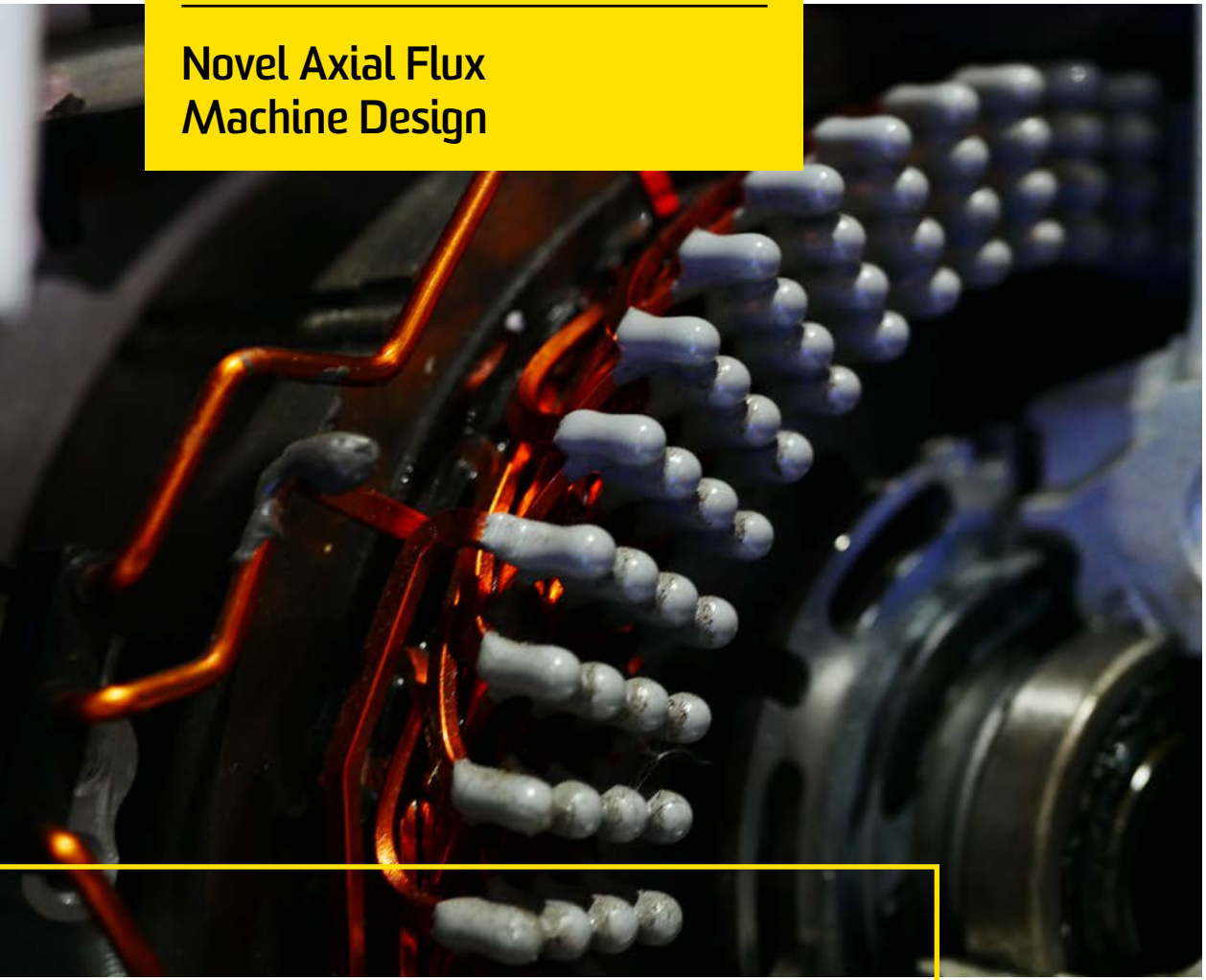
Novel Axial Flux Machine Design



The development and assessment of ground-breaking and innovative axial machines. Axial flux machines have a form factor that suits in-hub motors for electric vehicles. They have been used for many years as the motor of choice for the world record-breaking Sunswift team, and are a popular choice of electrical generators for small- and large-scale wind turbines.

Competitive advantage

- Innovations that include 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 use in axial flux machine design
- Academic team that has 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 application

Capabilities and facilities

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

Our partners

- Hummingbird Electronics

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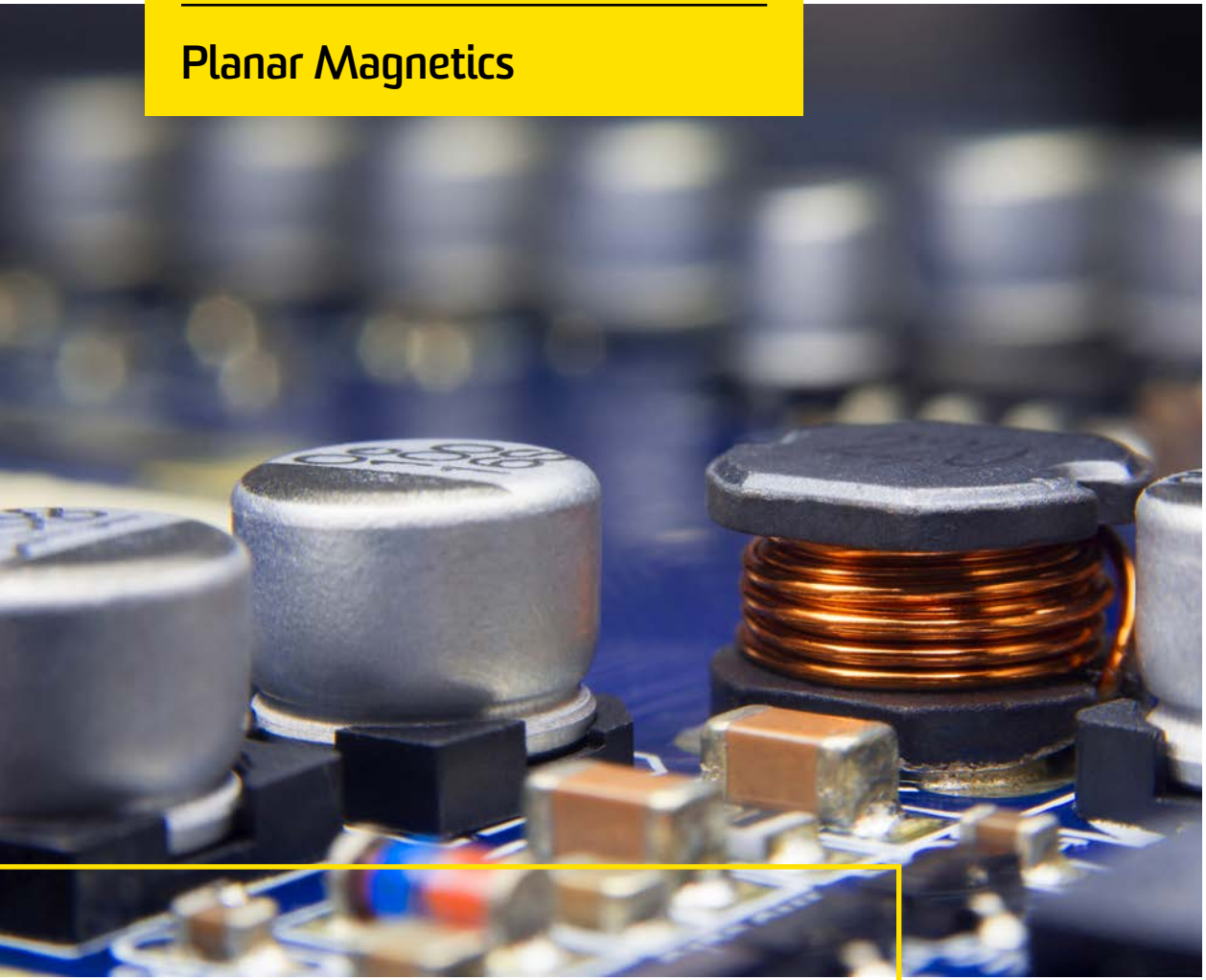
Planar Magnetics



Developing new planar structures and verifying simplified models for both high- and low-power applications, and exploring new, flexible matrices of magnetic components that can be reconfigured online. As the power electronics industry continues to grow and develop ever-smaller power supplies across a range of scales, from consumer electronics through 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, brings 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 partners

- Shandong BOFA Power Machinery
- Motorica

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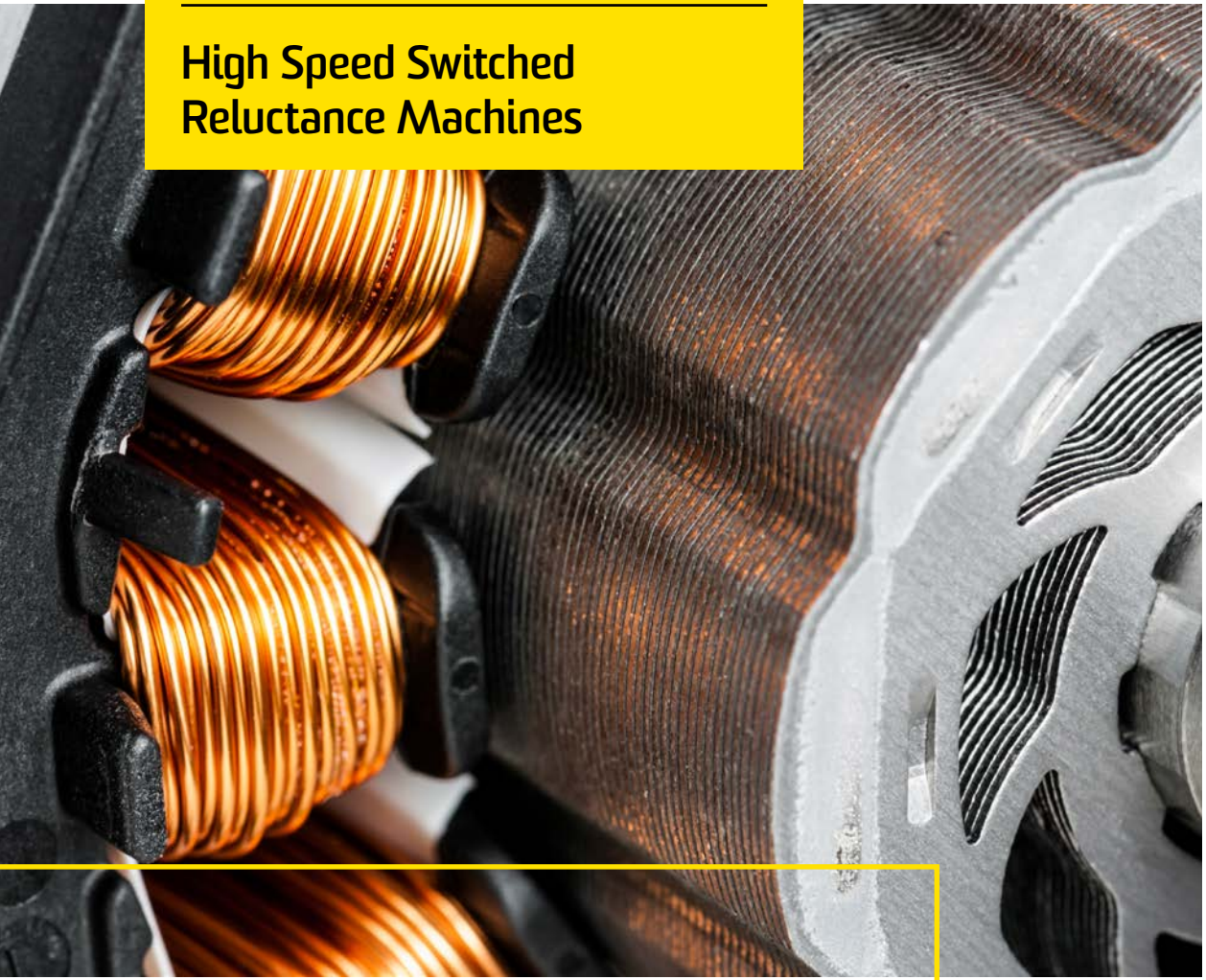
High Speed Switched Reluctance Machines



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

Competitive advantage

- Experts in high speed, fault tolerant, technology
- Knowledge of a wide range of prototyping capability 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 requiring no windings or permanent magnets. This allows the rotor to spin at high speeds. The windings can be manufactured separately then mounted in 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

- Switched reluctance electrical machine design experience
- Fault-tolerant machine design techniques
- Low-phase number drives and controls

Our partners

- Bao Feng Industries

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Advanced Condition-Monitoring for Optimised Maintenance of Critical Equipment

Maintenance is the major operational cost for renewable energy plant. Condition monitoring provides major economic benefits in terms of plant availability, maintenance optimisation and safety.

Competitive advantage

- Extensive experience in condition-monitoring and condition-based maintenance for critical equipment in wind, solar-thermal, hydroelectric and fossil-fuel plants
- Able 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

- Targeted maintenance creates massive cost savings, increases asset availability, and enhances personnel safety with early detection and prediction of failures in rotating machine systems

Successful applications

- Hydraulic instability detection for hydro-turbines
- Detection and prediction of gear faults for wind turbine planetary and spur gears, helicopter gearboxes, and planetary gears and bearings; aero-engine bearing diagnostics
- Maintenance optimisation for concentrated solar power plants
- Monitoring of pump wear

Capabilities and facilities

Capabilities in terms of fault detection, diagnostics and prognostics are supported by:

- Test rigs with diagnostic and prognostic capabilities
  - Spur and planetary gearbox test-rigs
  - Rolling element bearing test-rig
- Large range of vibration and acoustic emission instrumentation
- Portable acquisition systems for on-site measurements
- Oil and wear debris analysers

More information

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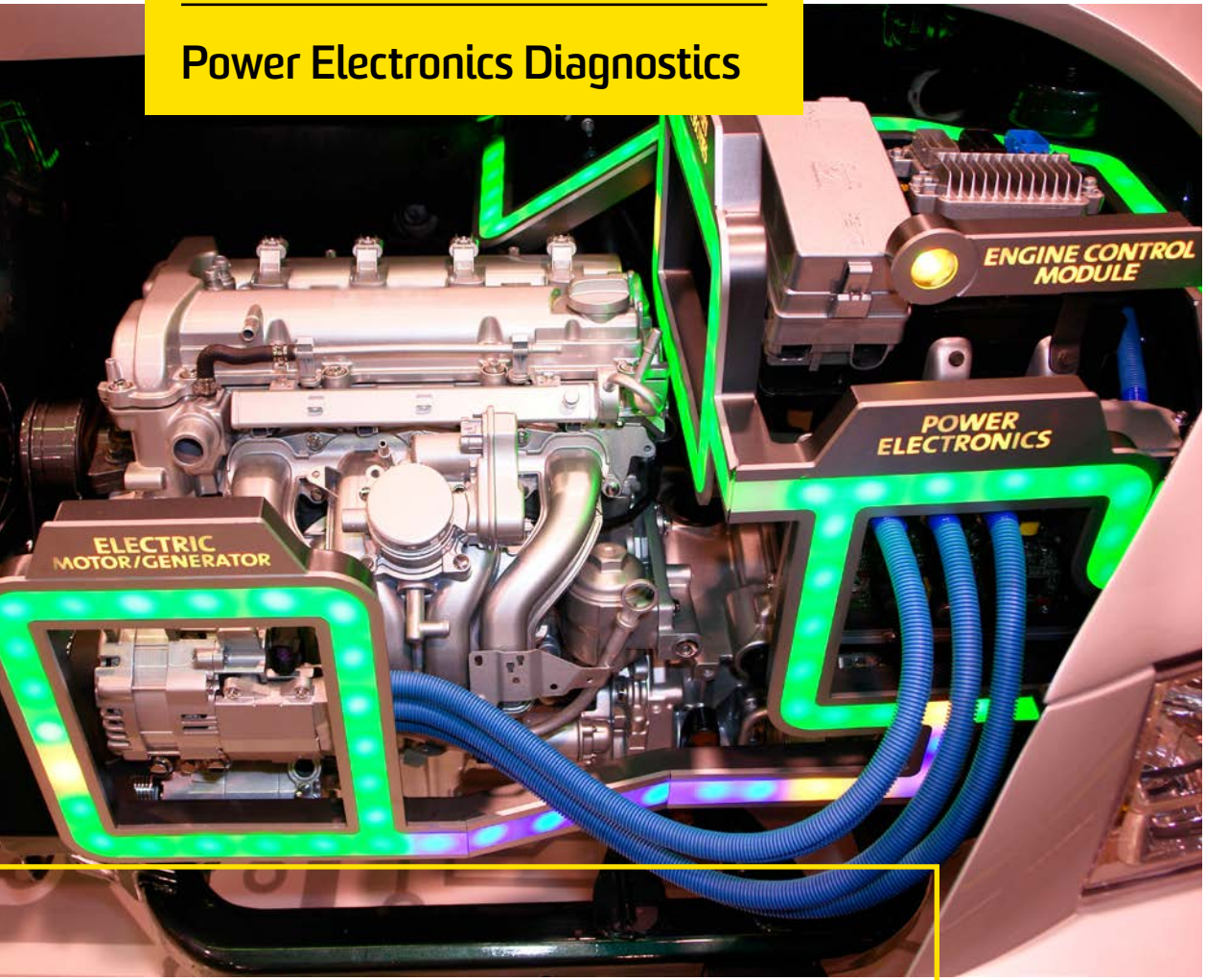
Power Electronics Diagnostics



More than two decades of expertise in the research and development of inverter and associated power semiconductors. Able to model both healthy and faulted conditions, to enable the development of proper control strategies that maintain the operation of electric machines when faults occur.

Competitive advantage

Substantial expertise in:

- Analysis of the failure mechanism in inverters for three- and multi-phase machines
- Optimisation of inverter design to minimise the potential for failure
- Developing control strategies for high-reliability inverter-driven machines and enabling them to operate 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 Micro LabBox

Our partners

- Motorica
- Hummingbird Electronics

More information

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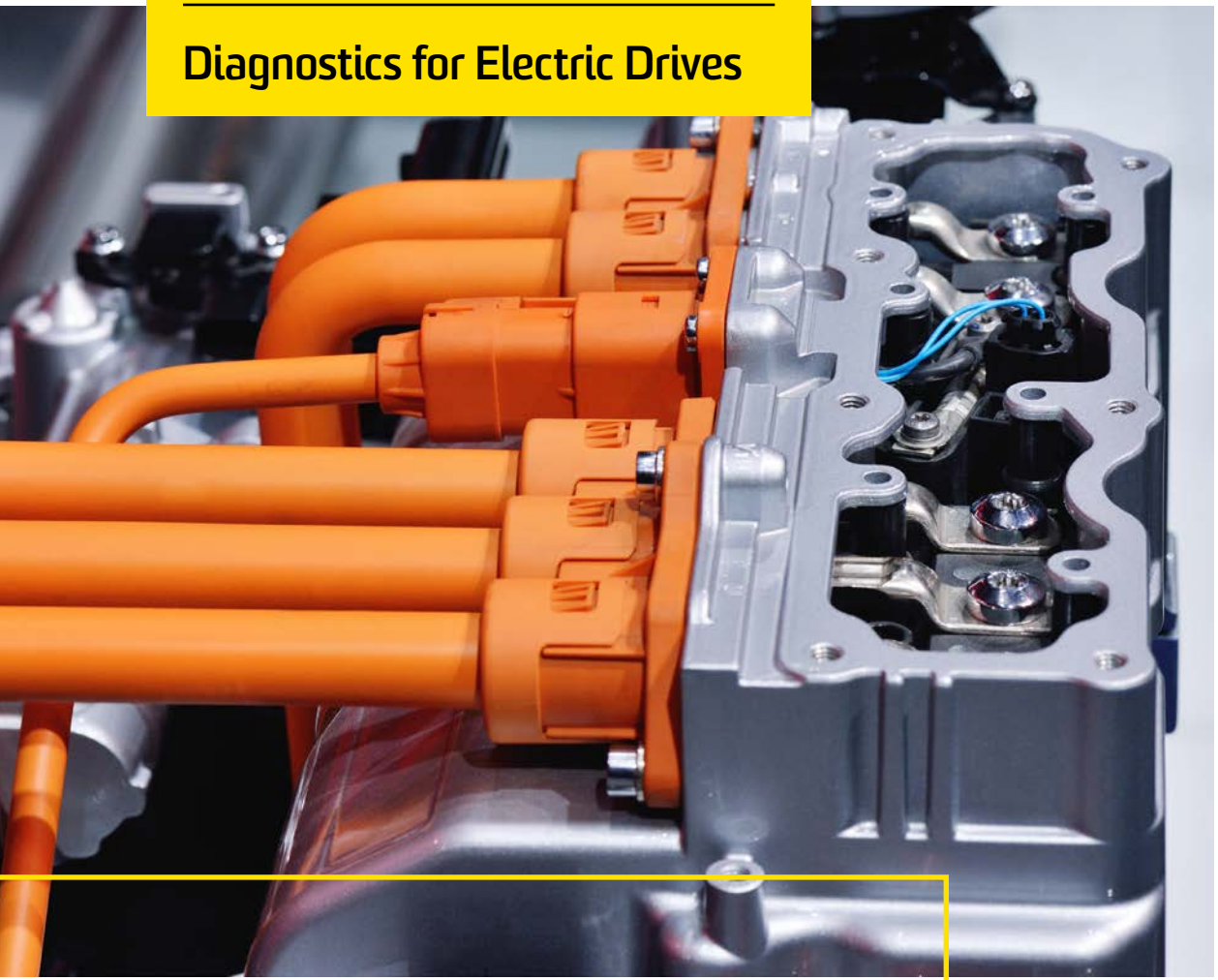
Diagnostics for Electric Drives



Developing techniques to diagnose failures in electric drives and conducting research to prognose faults.

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, especially 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

- Self-healing techniques have been demonstrated for electrical drives

Capabilities and facilities

- Electrical machine design for performance improvements under faulted operation

Our partners

- Motorica

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Safety-Critical Electric Drives

Expertise in 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 also incorporate novel multi-phase designs that enhance torque production, smooth ripple-free torque, and provide tolerance to faults

Impact

- More efficient, safer transport solutions

Successful applications

- Open winding multi-phase drive system for fault tolerance

Capabilities and facilities

- Four-quadrant dynamometer
- Bidirectional grid simulators
- High-speed load machines
- Medium-voltage testing

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Safety Critical Electric Drives for High-Value Industries

The research and development of a range of fault-tolerant electrical drives for use in applications that require 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 that enhance torque production, smooth ripple-free torque, and provide tolerance to faults

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 load machines and high-speed load machines

Our partners

- Motorica

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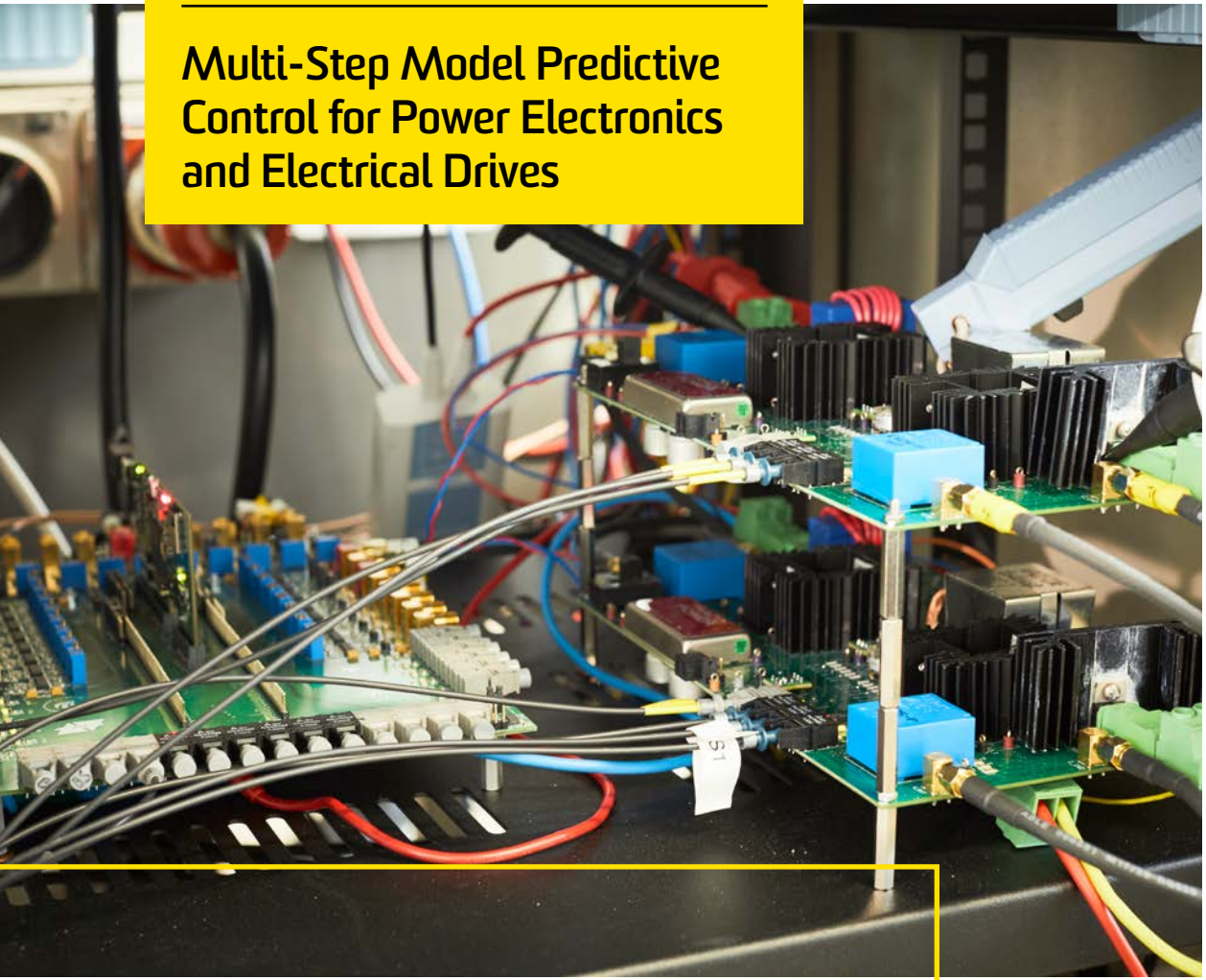
Multi-Step Model Predictive Control for Power Electronics and Electrical Drives



Model predictive control has emerged as a promising alternative control technique for power electronic applications which provides rapid dynamics and responses to demand changes. It can handle multiple variables and system constraints and achieve a fast, dynamic response.

Competitive advantage

- The use of a computationally efficient optimizer, namely sphere decoding algorithm (SDA)
- Experience in the practical application of n-multistep MPC using the 'Sphere Decoding Algorithm' 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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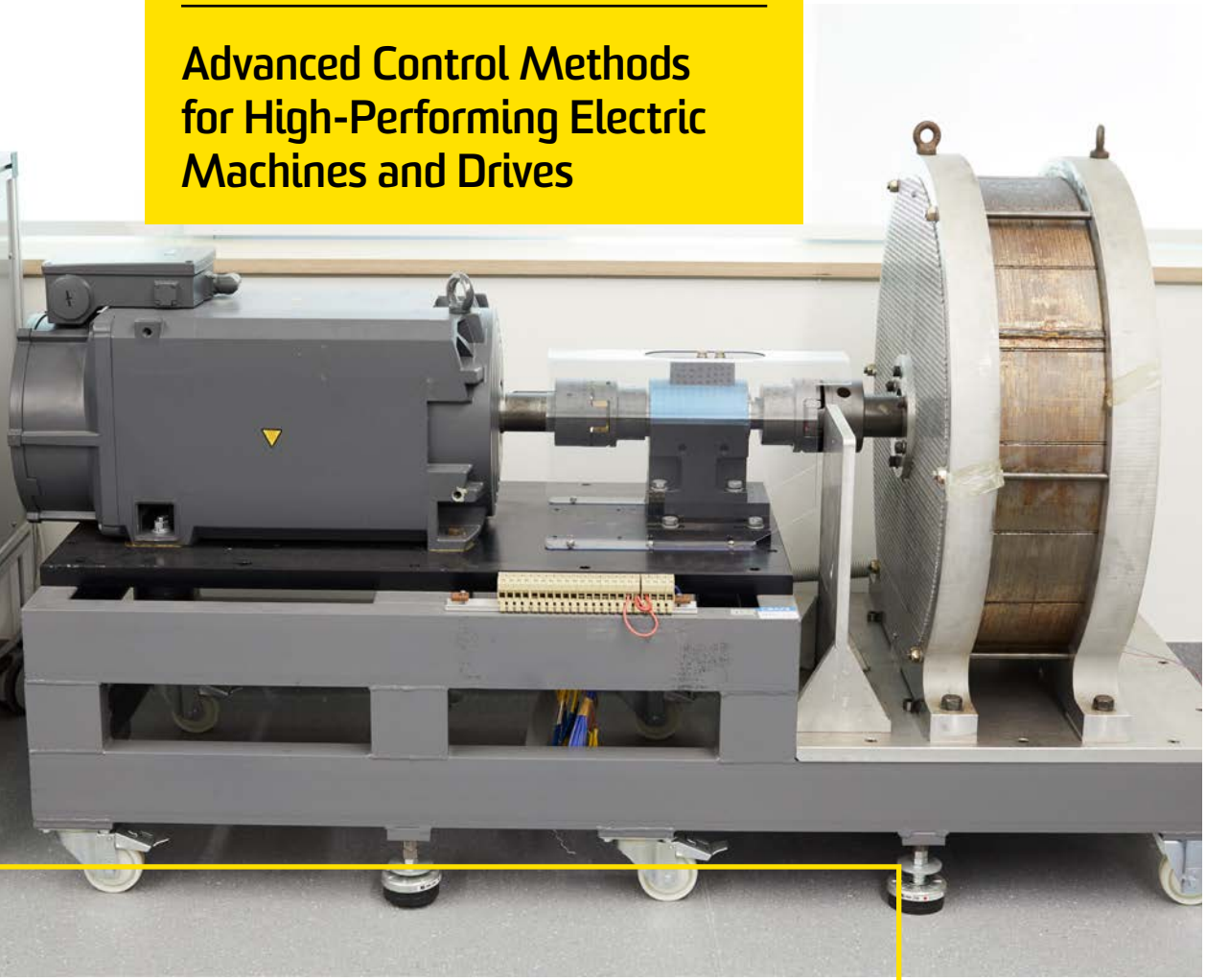
Advanced Control Methods for High-Performing Electric Machines and Drives



The push towards the widespread adoption of electric vehicles has spurred rapid new technological advances in electric machines, sensors, electric drives, and batteries. These new technologies have prompted the need for advanced 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, and optimal control theory, for the design and analysis of advanced control systems
- Expertise in modelling of power electronics and electrical machines
- An experienced interdisciplinary research team with a significant collaborative 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

- State-of-the-art laboratories for electrical machine testing and characterisation, power electronics and electrical drives
- State-of-the-art real-time digital simulation facilities for hardware-in-the-loop testing

Our partners

- Motorica

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Methodologies for Fault Diagnosis in Power Electronic Systems Operating in Harsh Environments

Power electronic systems operating in harsh environments, such as mines, are exposed to extreme temperatures, dust, moisture, hazardous environments, 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

Improving the reliability of equipment that operates in hazardous environments

Successful applications

- Fault diagnosis methods for power electronic systems used 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 partners

- Austindo

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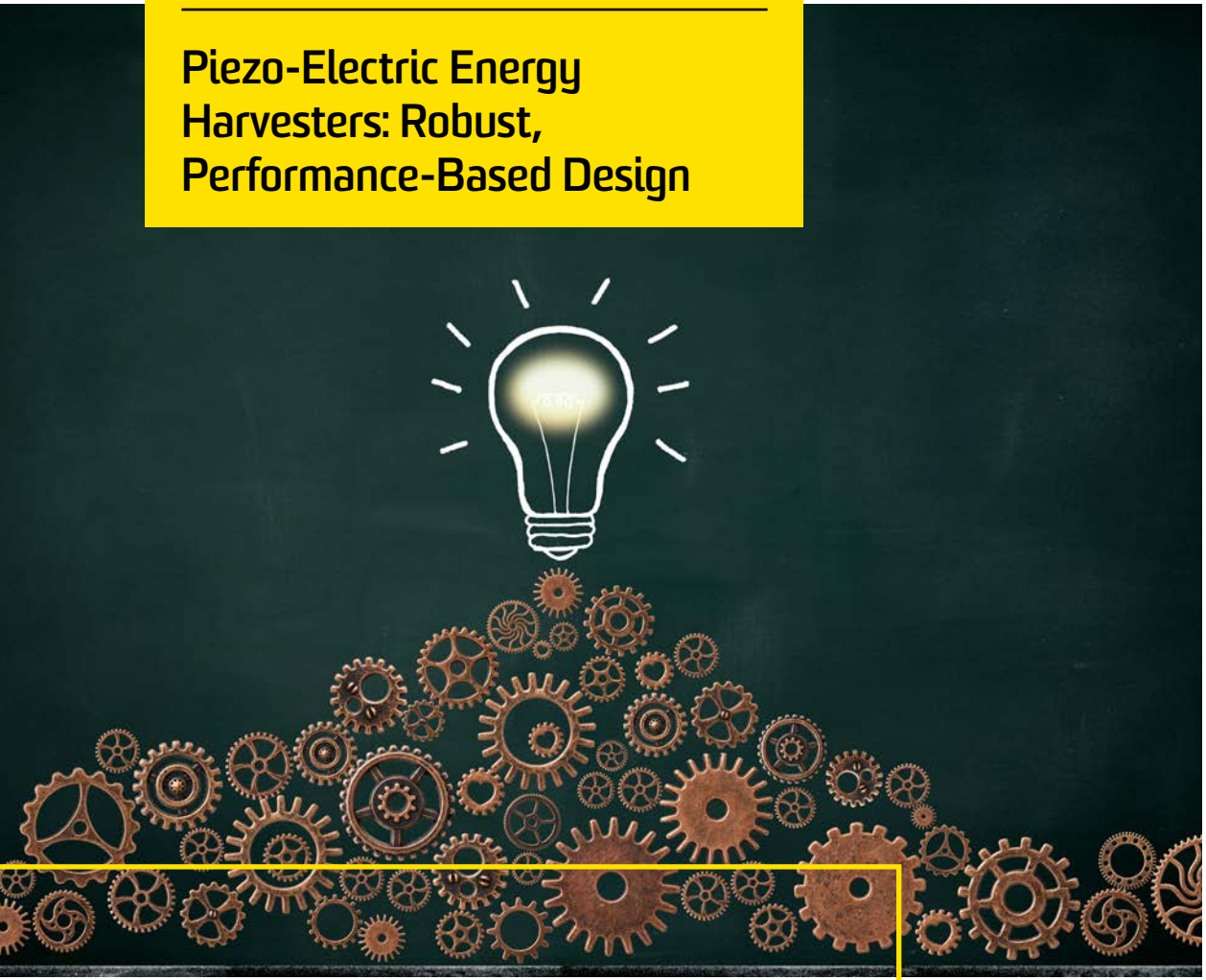
Piezo-Electric Energy Harvesters: Robust, Performance-Based Design



Developing software for accurate and efficient numerical simulations of piezo-electric energy harvesters (PEHs), with an aim to obtain non-conventional designs for optimal and reliable performance. Piezo-electric energy harvesters (PEHs) are used to convert mechanical vibrations into electric power, enabling generation of energy from the environment to power small electronic devices.

Competitive advantage

- Leading-edge methods of computational mechanics and algorithms for shape and topology optimisation aiming to maximise the performance of piezo-electric energy harvesters
- Expertise with simulations based on the mathematical model of thin piezo-electric cantilever plates
- Able to incorporate uncertainties in the 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 parameters. The design can be used for manufacturing high-performing devices.

Successful applications

- Design of devices of non-conventional shapes for maximum frequency and/or energy/area ratio

Capabilities and facilities

- Extensive expertise for modelling of CAD coupled with in-house bespoke software development

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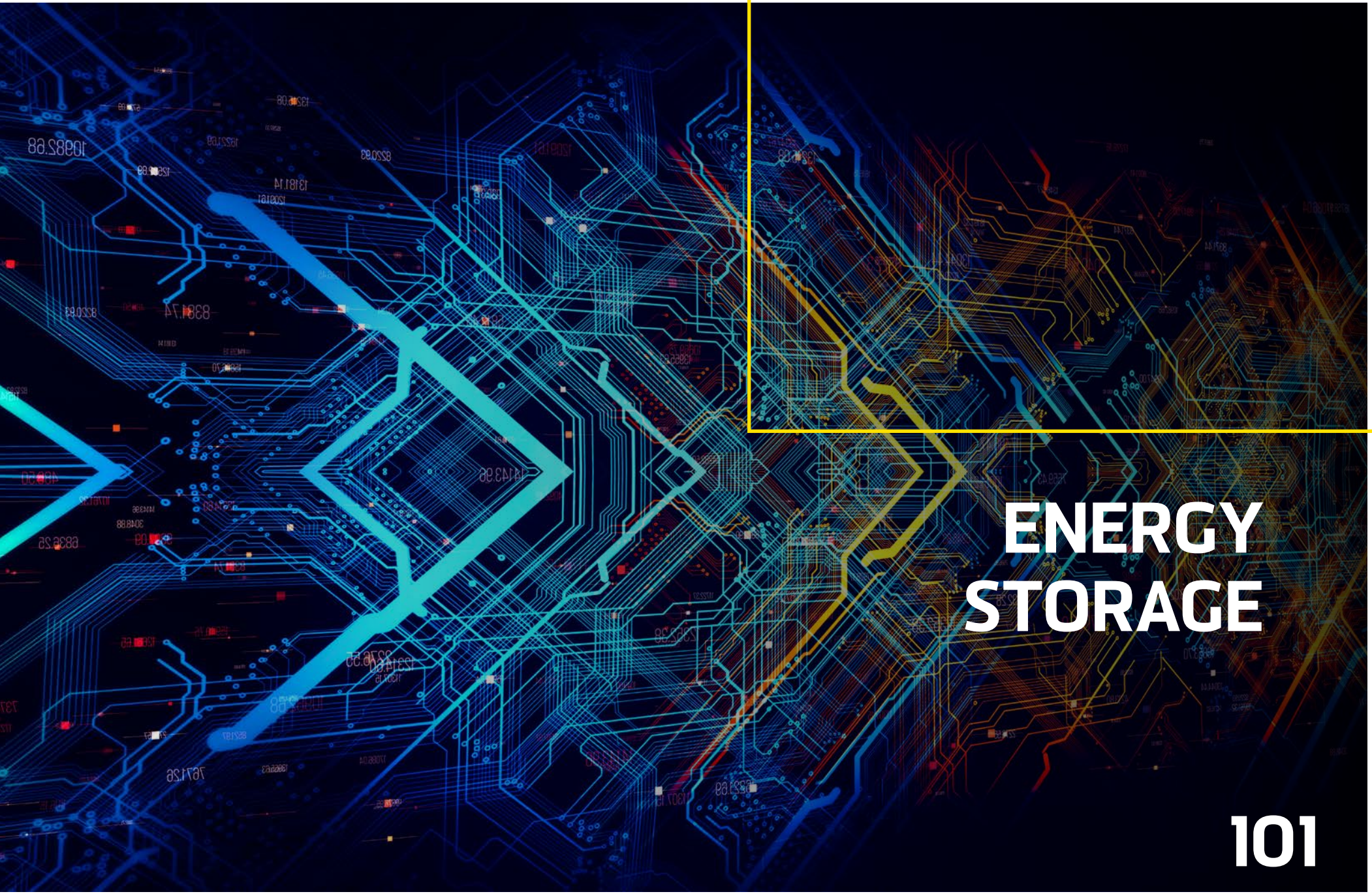
ENERGY
STORAGE
101

Compressed Air Energy Storage Systems

Small-scale energy storage plays a critical role in managing mismatch between loads and renewable energy supply. In recent years, micro compressed air energy storage (CAES) systems have gained significant attention, as they can potentially overcome these issues and provide hybrid electric-thermal storage for buildings and plants that require significant amounts of heating and cooling in addition to electricity.

Competitive advantage

CAES systems are a scalable technology that use mechanical compressors to convert electricity into potential energy stored as pressurised air, with the pressurised air expanding to generate power when needed. Unlike electrochemical batteries, this technology does not rely on toxic, resource-limited or degradable materials. Conventional CAES systems generate a large amount of heating and cooling energy, which is wasted during compression and expansion, resulting in a low round-trip storage efficiency.

Impact

- Better small-scale integration of intermittent renewable energy sources into commercial and residential buildings

Successful applications

Ongoing prototype development of a new type of compressor for use in a CAES system for residential or small-scale applications, Cyclonas Pty Limited.

Capabilities and facilities

- Two LDA systems (including a Dantec 3D LDA/PDA system)
- Five PIV systems (including tomographic capability)
- Flow visualisation lasers
- Computational facilities, including in-house clusters and access to NCI shared clusters
- Software, including unlimited site license for ANSYS products and open-source codes such as OpenFOAM
- In-house developed code

Our partners

- Cyclonas Pty Limited

More information

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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

Impact

- Permanent magnet motor-generators of rated speed in excess of 50 krpm
- 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

Capabilities and facilities

- Finite-element packages, including Magsoft and ANSYS, with optimization 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 krpm) PM machine test bed

Our partners

- CSIRO
- Wisconsin Electric Machines and Power Electronics
- Toshiba
- Regal Beloit

More information

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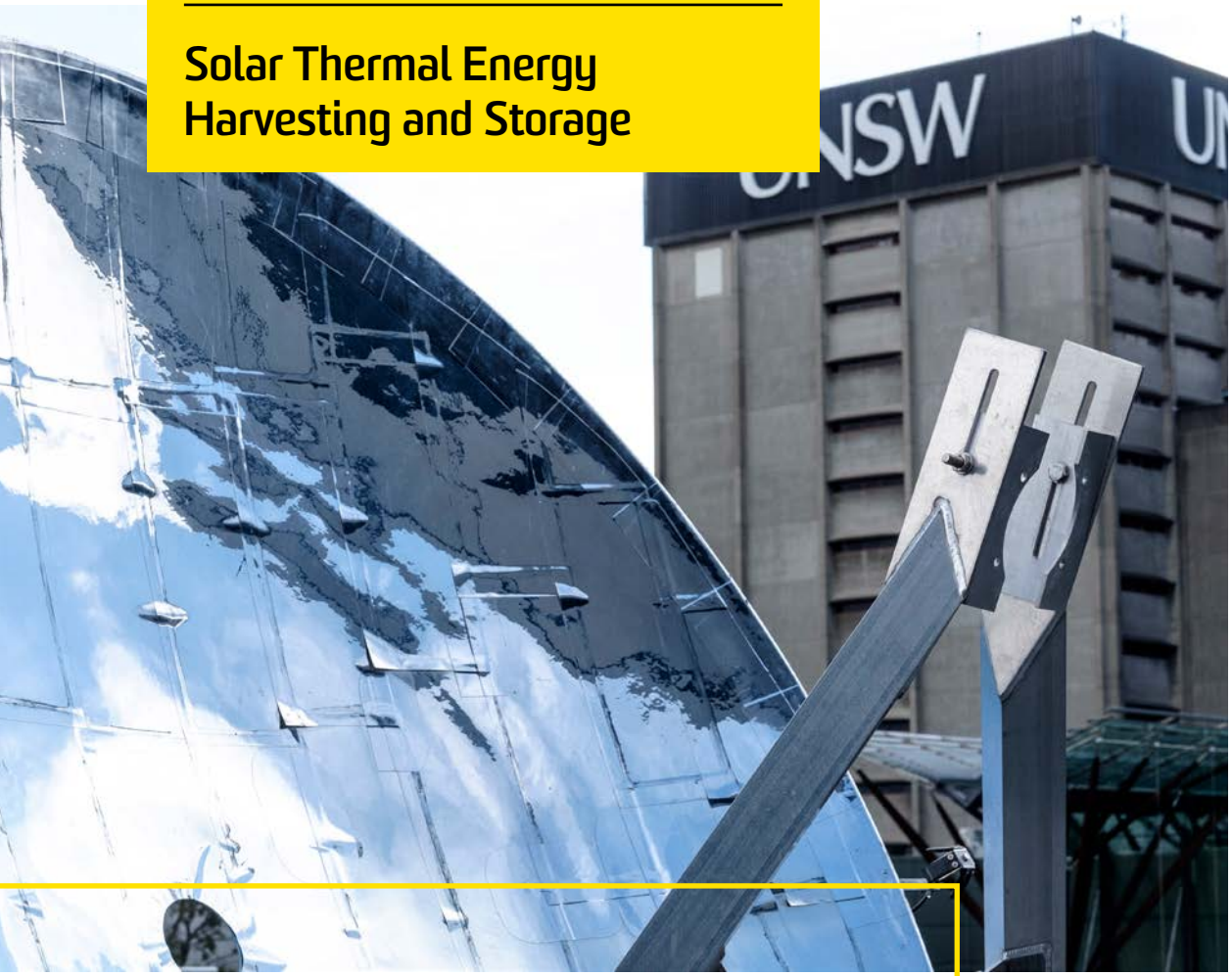
Solar Thermal Energy Harvesting and Storage



Extensive expertise in development of new solar thermal and thermal energy storage technologies with testing capabilities to understand the performance of existing technologies, with an emphasis on real-world experimentation 'on-sun', where appropriate.

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.

Impact

Improve technologies for solar thermal and thermal energy storage.

Successful applications

- Lead investigator on two ARC projects:
  - Superhydrophobic/nanotechnology, micro solar collectors
  - Waste heat recycling for desal in solar thermal power plants
- Chief Investigator on four ARENA funded projects in solar thermal areas:
  - Aluminium processing with solar energy (current project)
  - Hydrogen production via solar thermal/pv system (in collaboration with Chemical Engineering)

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 partners

- Vast Solar (CSP Engineering)
- Apricus (Solar Hot Water)
- GREE (HVAC manufacturer)
- Solar and Thermal Energy Solutions (Consulting)

More information

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Materials for Hydrogen Generation Using Solar Energy

Design and development of novel semiconducting materials systems for efficient, direct conversion of solar energy to hydrogen allows solar energy to be stored and transported in the form of a chemical fuel, so that it can be used on-demand.

Competitive advantage

Integrating expertise across computational materials design, a range of materials fabrication techniques, advanced characterisation and device testing. This allows a holistic approach covering all stages from design to testing, thus accelerating materials development.

Impact

- New materials that can absorb energy from sunlight and convert it to hydrogen
- 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.

Capabilities and facilities

- High-performance computing capabilities
- Expertise in applying computational materials science to designing new materials and understanding materials performance across a range of applications, including photocatalysis, photovoltaics, battery materials and catalysis

More information

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Hydrogen Production from Water Electrolysis

Hydrogen is regarded as the fuel of the future because 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 H_2.

Competitive advantage

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

Impact

- High profile research and development that has received extensive attention in the international community
- The new generation electrodes greatly reduce water electrolysis energy consumption
- Accelerated commercialisation of hydrogen technologies

Successful applications

- Industrial application of electrodes for highly-efficient, large-scale hydrogen production
- Advanced flow water electrolyser cell, for the production of 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 mechanism understanding
- State-of-the-art laboratory and industrial facilities for electrode fabrication, characterisation and real-time durability testing in harsh conditions

Our partners

- Kohodo Hydrogen Energy Co. Ltd
- RayGen Resources Pty Ltd

More information

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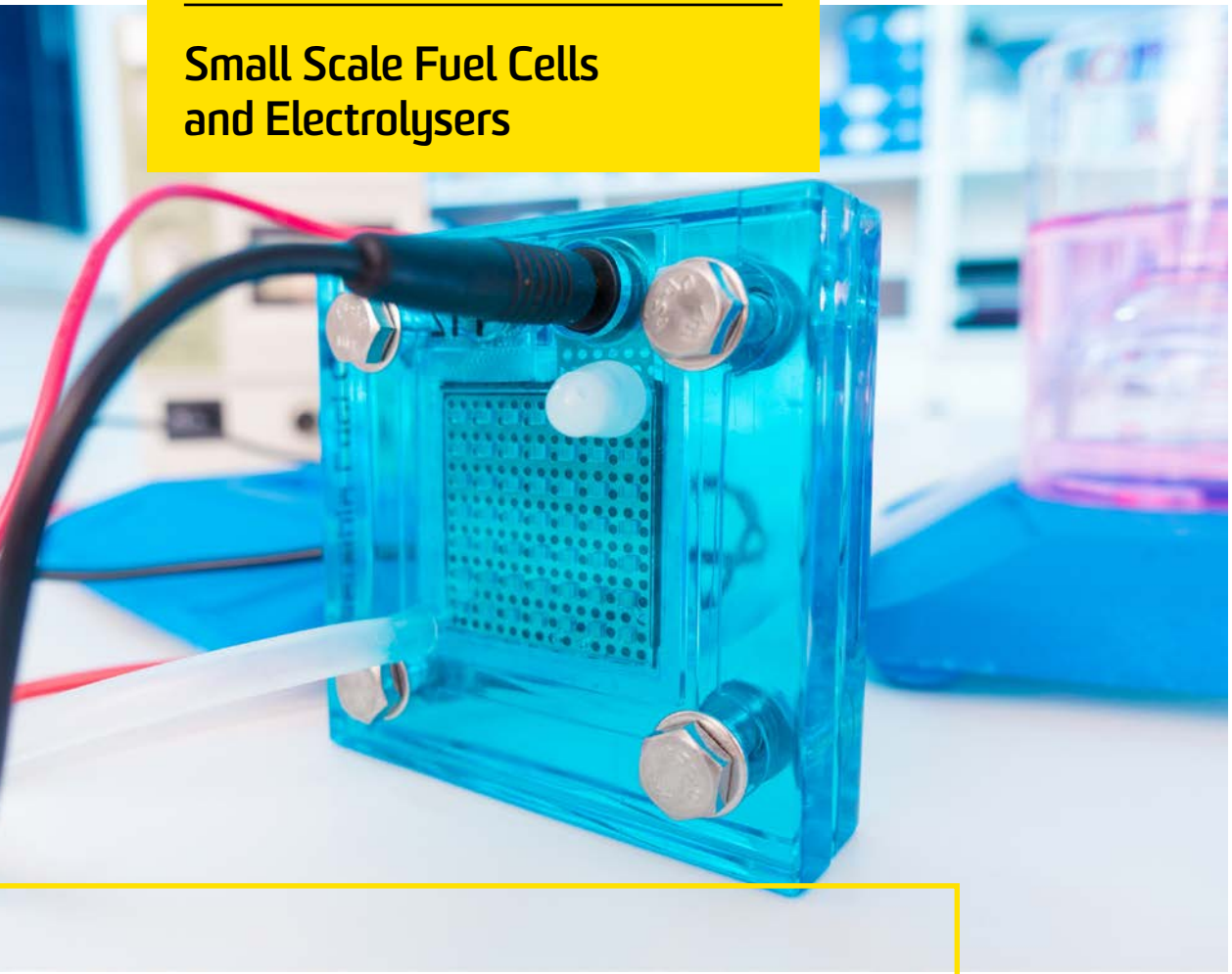
Small Scale Fuel Cells and Electrolysers



Hydrogen is a clean energy vector that can enable zero emission and a decarbonised economy. Development of suitable technology to enable the general public to produce and utilise hydrogen safely has the potential to revolutionise the way energy is generated and used.

Competitive advantage

- Unique world class expertise in the design of planar fuel cells and electrolysers for small scale applications
- Small scale fuel cells (< 300 W) with a planar design (light and thin) to enable application in a range of portable and mobile electronic appliances and devices
- Small scale plug and play electrolysers to enable on-site generation of hydrogen to power small devices or recharge small hydrogen canisters.
- Robust and simple technology

Impact

Potential to revolutionise the way hydrogen can be produced and used in everyday life. By enabling the utilisation of hydrogen across the entire energy sector, the general public can become prosumers, generate and use their own hydrogen.

Successful applications

- Planar fuel cell to increase the efficiency of electrical bicycles
- Plug and play electrolysers to self-recharge hydrogen canisters

Capabilities and facilities

- State-of-the-art research facility for designing and testing of small scale fuel cells and electrolysers
- Prototyping and optimisation capability

More information

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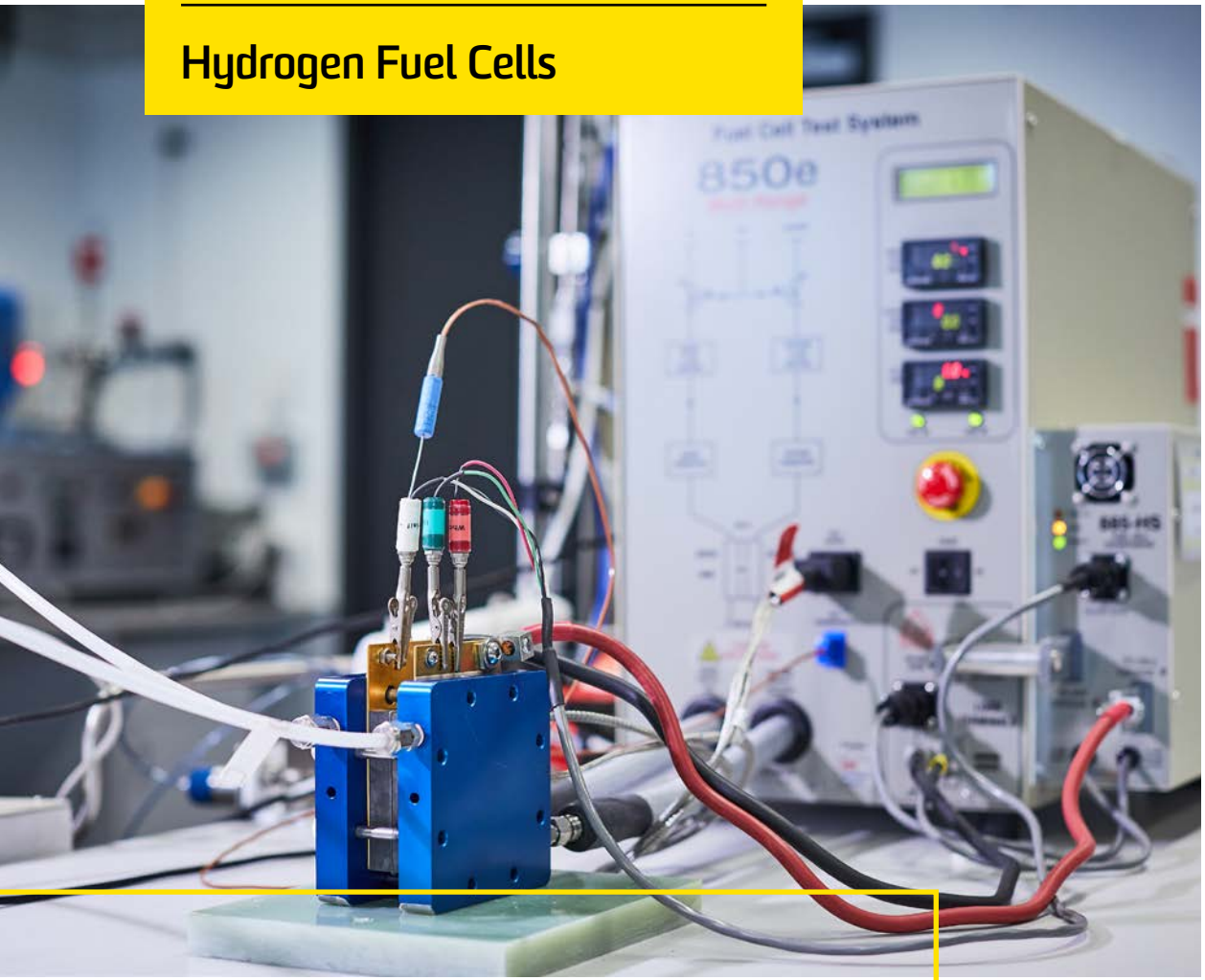
Hydrogen Fuel Cells



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

Competitive advantage

- Zero-CO_2 emission technology
- In-house expertise exists 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 membrane in hydrogen fuel cells
- Assessing the electrochemical performances of novel catalysts in electrochemical devices

Capabilities and facilities

- Expertise in fuel cell catalysts development and diagnostic techniques
- State-of-the-art 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

Our partner

- Kohodo Hydrogen Energy Co. Ltd

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Waste Biomass to Renewable Hydrogen

The production of renewable hydrogen from preconditioned biomass is an important source of energy and a key component of Australia's future energy offerings for the generation and exporting of hydrogen. It is economically viable and environmentally friendly, with zero carbon dioxide emissions.

Competitive advantage

- Preconditioned biomass (from raw biomass stream) can be obtained at very low cost
- Electrocatalytic hydrogen extraction from pre-conditioned biomass is generally easier than water electrolysis
- It is selective, delivers zero carbon dioxide emissions and can produce value-added organic products with potential to be used as precursors for plastic fabrication

Impact

- Competitive energy production by utilising waste to produce renewable hydrogen
- Alleviate global warming by reducing the carbon footprint
- Resource recovery and new materials

Successful applications

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

Capabilities and facilities

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

Our partners

- Origin Water International Pty Ltd
- Apricus Energy Pty Ltd

More information

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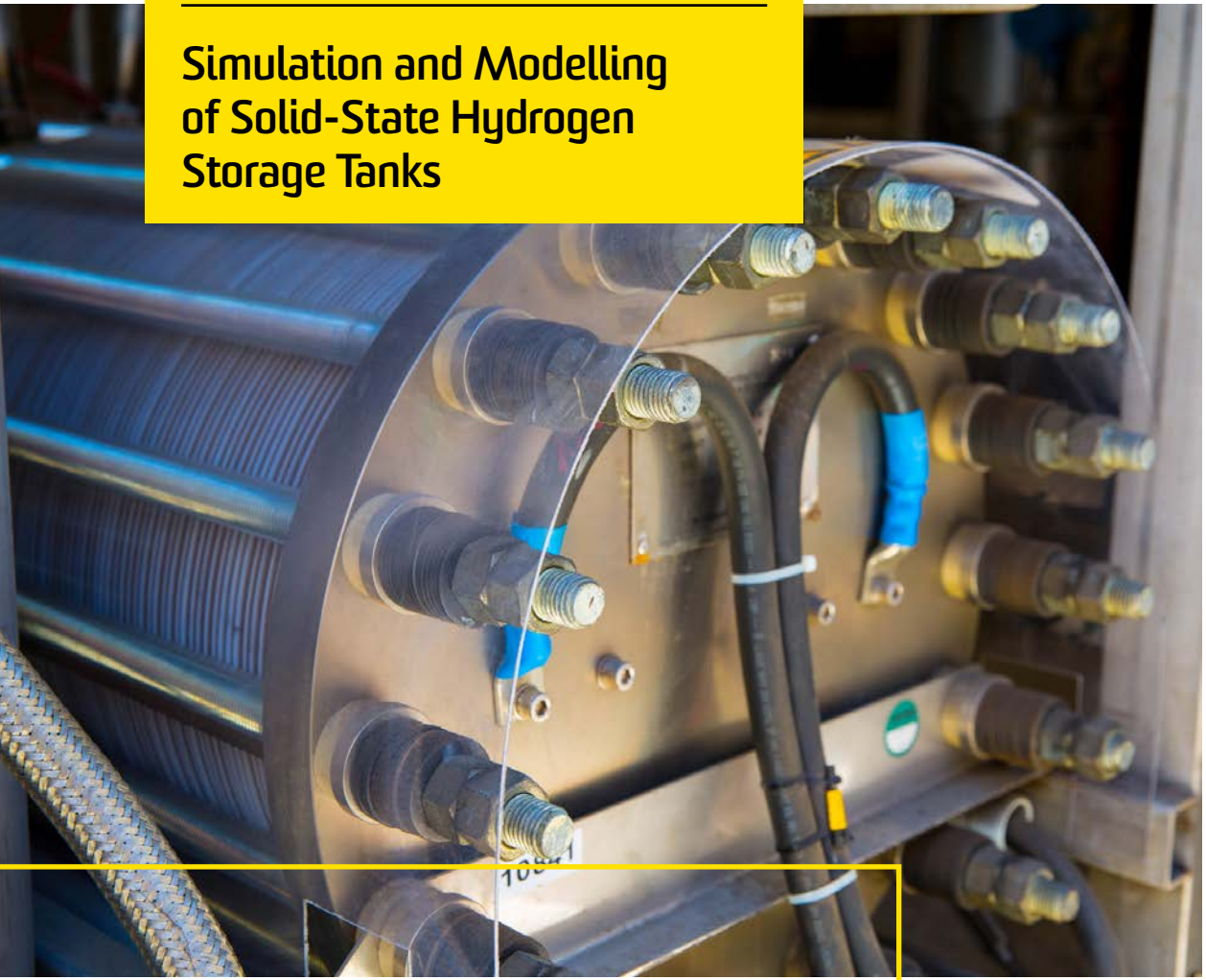
Simulation and Modelling of Solid-State Hydrogen Storage Tanks



Hydrogen is a clean energy vector that can enable storage of any form of energy including renewable with high density. Development of suitable models to enable the design of effective solid-state hydrogen storage tanks will enable the transition to a new economy based on the use of hydrogen.

Competitive advantage

- Unique world class expertise in the modelling of solid-state hydrogen storage tanks for the effective recovery of the hydrogen storage and the associated heat and hydrogen flow management.
- Optimisation of hydrogen storage solution for high energy efficiency
- Most advanced simulation packages for the design and optimisation of hydrogen storage tanks and their integration into existing infrastructures

Impact

Potential to revolutionise the way energy is generated, distributed and used at small, intermediate and large scales.

Successful applications

Design of solid-state hydrogen storage tanks integrated to electrolysers and fuel cells.

Capabilities and facilities

- State-of-the-art research facility for designing and testing solid state hydrogen tanks and verification of simulation models
- Prototyping and optimisation capability

More information

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Solid-State Hydrogen Technology for Advanced Energy Storage

Hydrogen is a clean energy vector that can enable storage of any form of energy including renewable with high density. Development of suitable technology to store hydrogen safely and with high efficiency will enable the transition to a new economy based on the use of hydrogen.

Competitive advantage

Unique world class expertise in solid-state hydrogen storage from fundamental material design to implementation in the field. Hydrogen is a versatile energy carrier that can provide both heat and electricity.

Commercialisation of solid-state hydrogen solutions:

- The most effective energy storage solution enabling both high volumetric and gravimetric energy density (6 times that of Li-ion batteries)
- Long cycle life (> 30,000 cycles of hydrogen uptake and release)
- No memory effect and recoverable stored hydrogen > 90%
- Simple and robust technology enabling increased safety in the use of hydrogen
- Pre-commercialisation cost comparable to existing technologies such as batteries
- Solid-state materials heat and cool upon hydrogen uptake and release. This provides additional energy in the form of heating/cooling owing the unique properties of solid state hydrogen storage materials

Impact

Potential to revolutionise the way energy is generated, distributed and used at a small, intermediate and large scale.

Successful applications

- Storage and transport of renewable energy
- Integration to the grid for load levelling or long term electricity storage
- Heat and/or cooling for applications that require both energy storage and heat recovery

Capabilities and facilities

- State of the art research facility for designing and testing solid state hydrogen materials
- Prototype solid-state hydrogen tanks design and optimisation capability
- Integration of solid-state solutions in existing infrastructures

More information

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Cryogenic Testing of Advanced Fibre Composite

Lightweight storage vessels are important for the transportation and storage of hydrogen in vehicles such as spacecraft, satellites, cars and marine ships. Existing carbon-fibre reinforced composites suffer matrix cracking that leads to leakage and lower strength. Techniques to eliminate matrix cracking by nano-scale engineering of polymer matrixes are being developed.

Competitive advantage

Lightweight and strong fibre composites that can safely operate at cryogenic temperatures without microcracking are urgently needed 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 improving 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 partners

- Lockheed Martin

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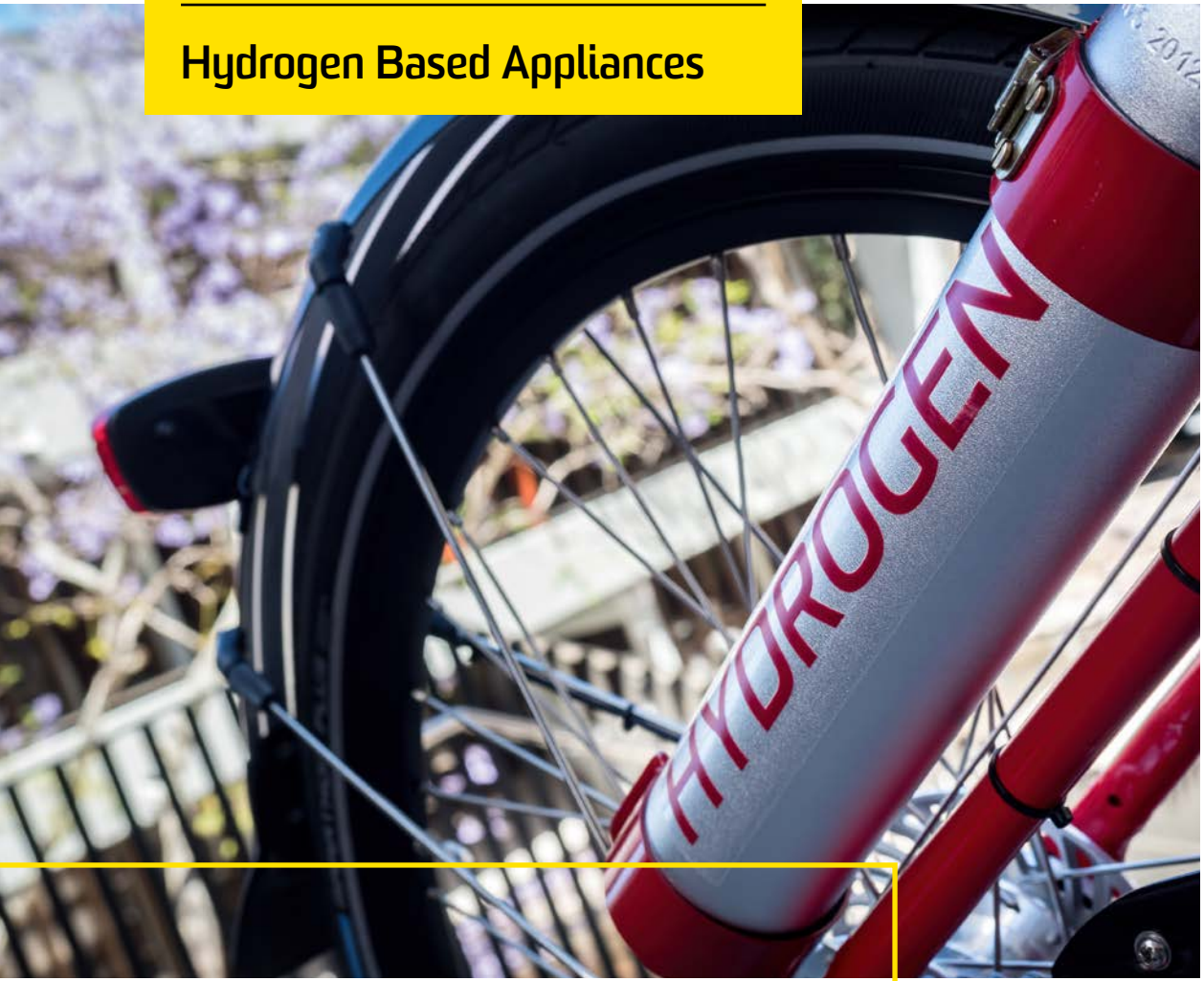
Hydrogen Based Appliances



Hydrogen is a clean energy vector that can enable zero emission and a decarbonised economy. Development of suitable technology to utilise hydrogen safely and with high efficiency will enable the transition this a new economy based on the use of hydrogen.

Competitive advantage

- Unique world class expertise in the design/conversion of common appliances effectively using hydrogen as a fuel to generate electricity or heat. Expertise for the integration into existing infrastructures
- Hydrogen can be used with a fuel cell to generate electricity with high efficiency and water a sole emission
- Hydrogen can be catalytically burnt to generate heat to do work
- Robust and simple technology based on the most advanced innovative solutions developed at UNSW

Impact

Potential to revolutionise the way hydrogen can be used in everyday life and facilitate the transition to a hydrogen based economy.

Successful applications

- Hy-cycle, hydrogen powered bicycle demonstrating the effective use of hydrogen with a fuel cell to generate electricity on-board a bicycle
- H2Q, a hydrogen powered BBQ, catalytically burning hydrogen without any flame

Capabilities and facilities

- State of the art research facility for designing and testing appliances/devices effectively using hydrogen
- Prototyping and optimisation capability

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Advanced Energy Materials

Recent advances in lithium-ion battery technology have seen them used in applications ranging from portable electronic devices to electric vehicles. In the future, developing energy storage applications for renewable resources will become increasingly important.

Competitive advantage

- Unique interdisciplinary research experience in battery engineering
- Expertise in synthetic organic chemistry, for developing next-generation energy storage systems
- Extensive research experience in design and fabrication of organic-based rechargeable batteries

Impact

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

Successful applications

- 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
- Battery analysis equipment

More information

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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 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

Our partners

- Planet Innovation Ltd
- Atmo Biosciences Ltd
- Department of Agriculture, Australia
- Department of Industry, Innovation and Science, Australia

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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 carbonnitrides. They are emerging materials for electrochemical storage and possible use in lithium-ion batteries for applications such as cell phones and electric vehicles. However, their practical applications are currently limited by challenges with manufacturing, and fire and explosion safety.

Competitive advantage

MXene is an emerging material with outstanding electronic properties and large surface areas ensure the inherent advantages as the electrode for electrochemical energy storage.

Impact

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

Successful applications

- Development of a highly thermally-insulated three-dimensional architectured composite structure comprising epoxy, graphene and hydroxylated boron nitrides nanosheets
- Reinforcing the fire resistance 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 of ANSTO to study molecular morphological structure of MXenes
- Application of novel computation codes to predict the structural, mechanical, electrical, magnetic and thermoelectric properties of MXenes

More information

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Materials Development for Next Generation Batteries

Batteries of the future will need to supply more energy. To make this happen, new materials and new concepts are required for alternative battery chemistries, such as lithium-sulfur and potassium-ion.

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 batteries and potassium-ion batteries.

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

More information

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Lithium-Ion Batteries; Atomic Scale Know-How to Develop New Components and Understand Degradation

Lithium-ion batteries are currently used extensively across a range of applications. Their increasing uptake in larger-scale applications requires an understanding of degradation mechanisms at the atomic scale and developing new materials or concepts for these batteries.

Competitive advantage

- 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, and solid-state NMR
- Knowhow for analysing data from a range of analytical techniques to build a picture of degradation
- Directed materials design for optimised performance
- Ability to develop materials, characterise, examine electrochemical performance and understand the chemical reasons behind performance

Impact

- Development of the next generation of materials for higher performing or specialised lithium-ion batteries
- Ability to non-destructively assess battery degradation
- Understanding failure and degradation modes to help design next generation batteries

Successful applications

- Non-destructively examined the state-of-health of batteries used in testing by Volvo
- Non-destructively examined the role chemical composition of the cathode plays on 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
- Investigated new cathodes, anodes and electrolytes

Capabilities and facilities

- 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
- Battery materials development to research-scale cell development

Our partners

- Volvo
- Valence Technologies

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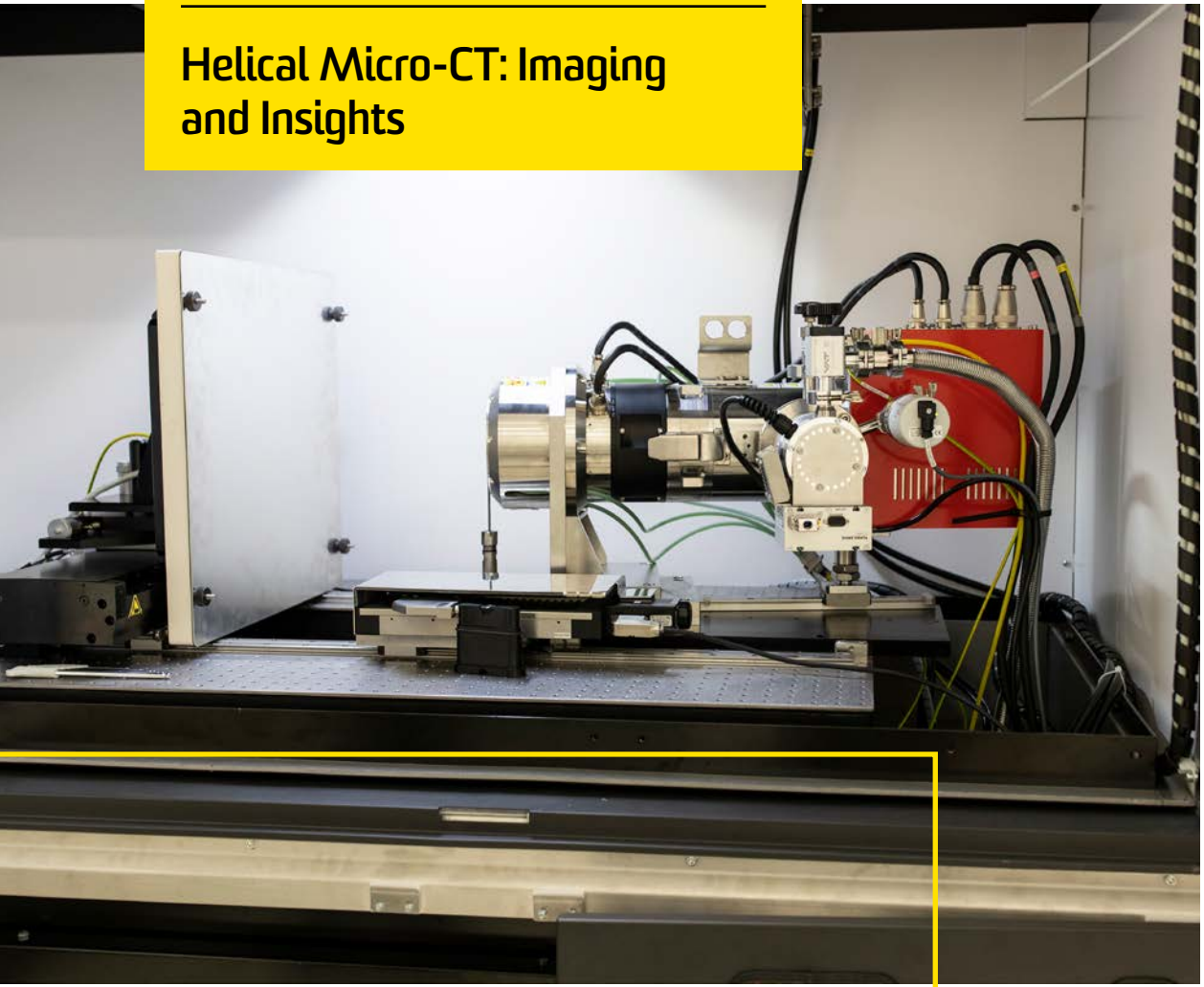
Helical Micro-CT: Imaging and Insights



High-resolution imaging combined with image analysis, physical property calculations and measurements. 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 3-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

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 present a solution to these challenges, 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 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.

Capabilities and facilities

- Materials synthesis
- Pulse laser deposition growth of certain electrodes
- Access to key analytical techniques such as solid-state NMR, surface analysis and electron microscopy
- Use of unconventional techniques such as quasi-elastic and inelastic neutron scattering

Our partners

- CEA

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Sodium-Ion Batteries 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. Making sodium-ion batteries commercially viable requires developing components for these batteries and understanding their structure-property relationships.

Competitive advantage

- Development of environmentally friendly cheap electrode materials
- Use of a range of analytical techniques, particularly operando synchrotron X-ray diffraction, to elucidate structure-property relationships
- Using waste as a source for electrodes for sodium-ion batteries, 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 materials properties in devices

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

Our partners

- CIC Energigune

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Graphene-Based Materials for Energy Storage and Conversion

Revolutionising the synthesis of graphene-based materials for use in a wide range of applications, including energy storage and conversion.

Competitive advantage

- A unique plasma-assisted method for the synthesis and functionalisation of vertical graphene
- Fabrication of various graphene-based hybrid structures
- Design, integration and evaluation of graphene-based energy storage devices
- Optimisation of graphene-based electrodes for catalysis and hydrogen generation

Impact

- Transforming the manufacturing sector through advanced and innovative materials technology
- Promoting renewable energy utilisation by developing efficient and high-performance energy devices

Capabilities and facilities

Facilities include:

- State-of-the-art materials synthesis equipment (e.g. PECVD), characterisations (SEM, TEM, Raman), and measurements (potentiostat, battery analyser, electrolyser)

Capabilities include:

- The controlled synthesis and functionalisation of vertical graphene
- Device fabrication
- Materials characterisation
- Electrochemical energy storage devices, such as batteries and supercapacitors
- Catalysis and hydrogen generation

Our partners

Partnerships with a range of organisations from local SMEs to multinational companies.

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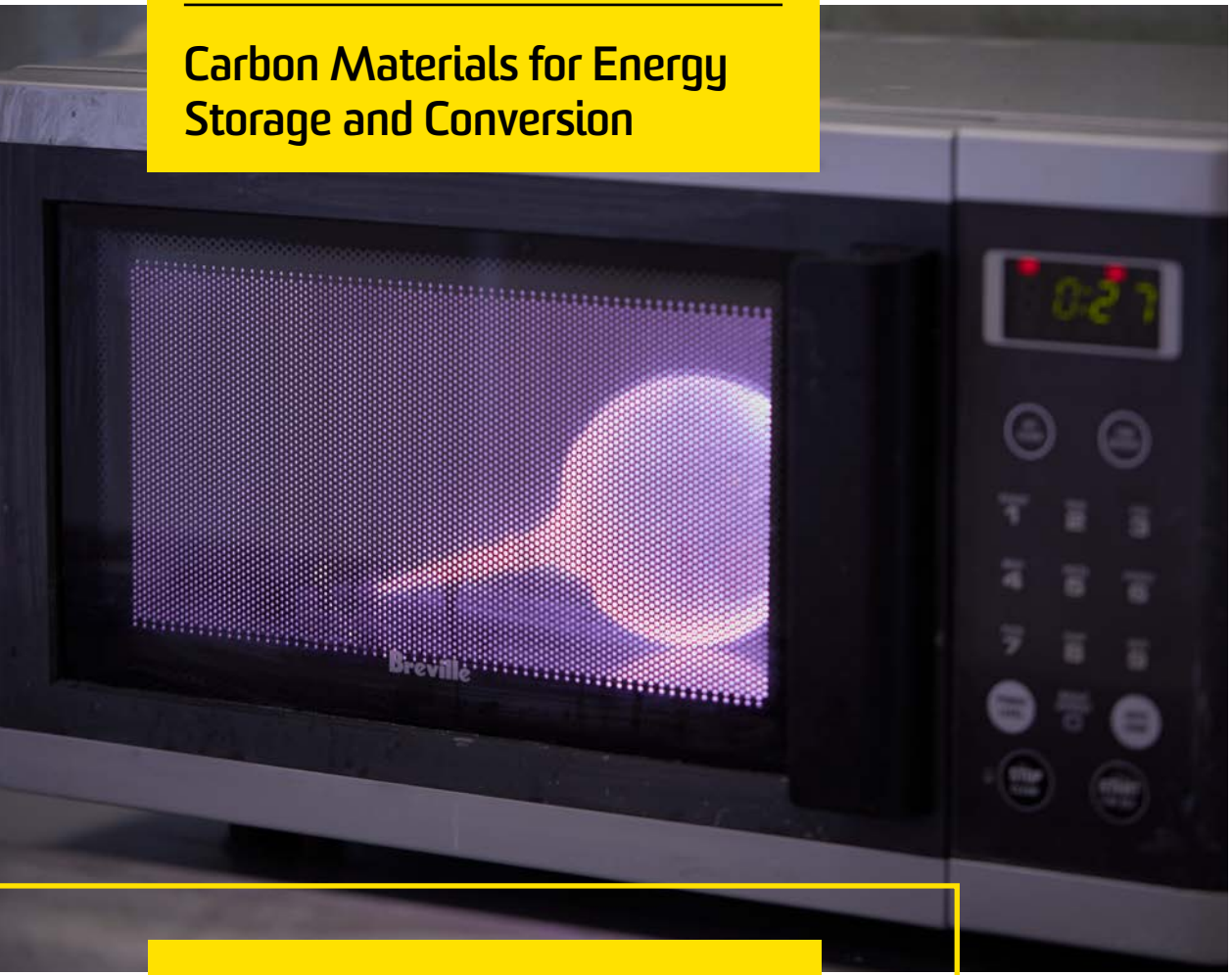
Carbon Materials for Energy Storage and Conversion



Carbon materials are excellent candidates for energy-related applications, from batteries and supercapacitors to fuel cells and electrocatalysis. A series of carbon nanostructures, such as graphene platelets and films, can be provided, along with innovative, scalable synthesis strategies, to enable the uptake of these materials in applications.

Competitive advantage

- Experience in producing state-of-the-art carbon nanostructures with tuneable properties
- Expertise in innovative strategies for carbon material synthesis and functionalisation
- Diverse platforms for integrating carbon materials into energy storage/conversion systems

Impact

Novel carbon materials are key to high-performance energy storage and conversion.

Successful applications

- Rapid synthesis of a variety of graphene-based materials using microwave technology
- Growth of large-area, monolayer graphene using chemical vapour deposition strategy
- Highly conductive carbon foils made of stacked/overlapped graphene platelets
- Highly efficient carbon nanostructured electrocatalysts for water splitting
- High-performance carbon-based electrode materials for potassium ion batteries

Capabilities and facilities

- Chemical vapour deposition system for graphene growth
- Chemical laboratory equipment
- Electrochemical testing platform and battery analysis setup
- Access to advanced chemical and physical analytical techniques

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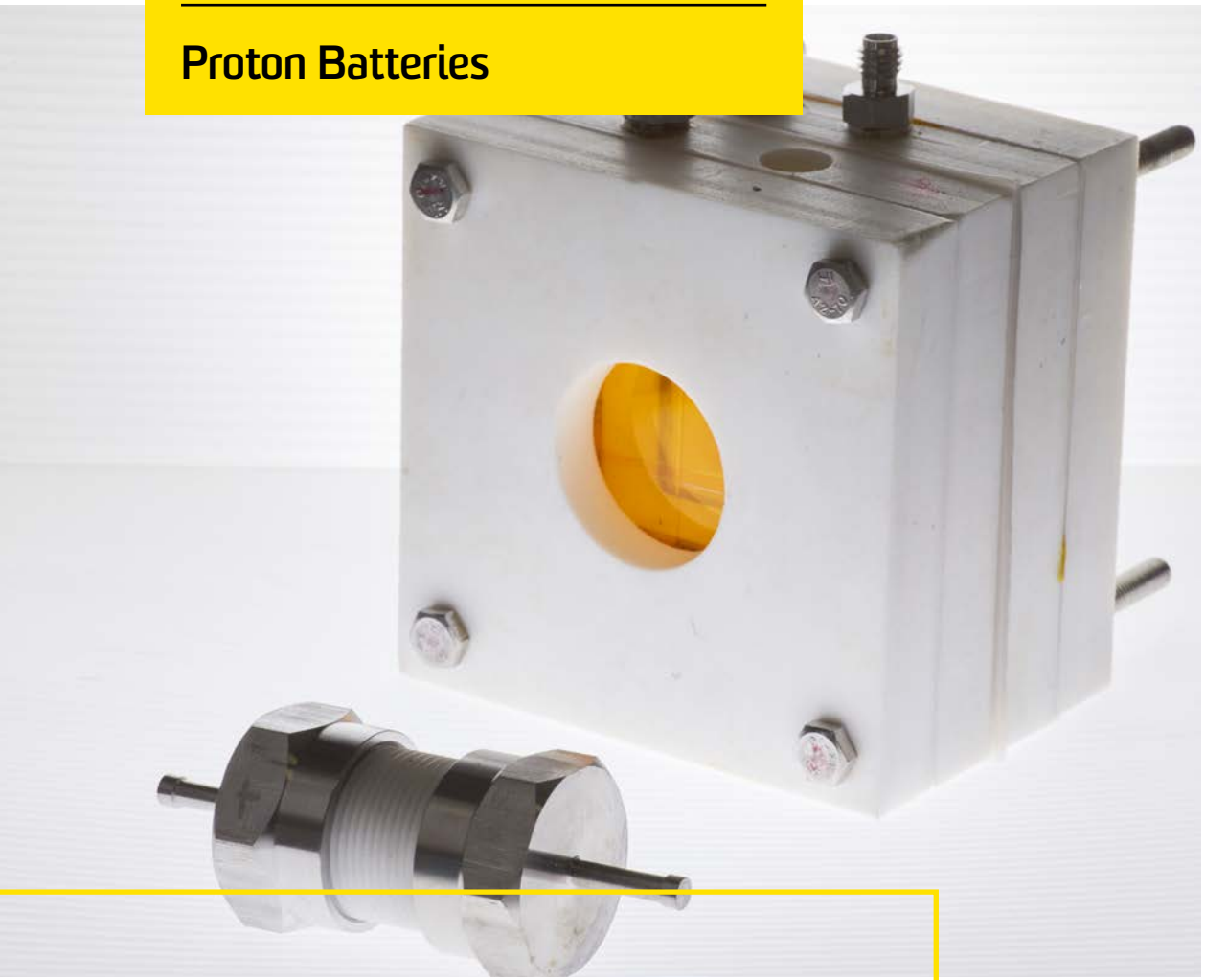
Proton Batteries



Developing materials with the energy density of batteries and the power density of supercapacitors is an exciting target for energy storage. New-concept proton batteries, which use the fastest-transferred hydrogen ion as carriers, can potentially 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 storage of protons

Impact

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

Successful applications

Development of a prototype proton full battery, reaching 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 and 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

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Battery Precursor Materials from Industrial and Mining Waste Streams

Industrial and mining wastes are literally 'treasure troves' of valuable elements like cobalt, nickel, vanadium, lithium and zinc, which are critical for next generation, high-efficiency batteries and energy storage systems.

Competitive advantage

- Critical elements can be selectively extracted via world-class leaching and complexation techniques
- Expertise in the synthesis of magnetic electrochemically reactive 'carrier' materials for selective and easy recovery of extracted critical elements
- Ability to regenerate 'carrier' materials to create an environmentally friendly and sustainable process

Impact

- Adding value to waste streams through the recovery of critical elements is good for the economy, society and environment
- More economical and sustainable management of industrial and mining waste streams

Successful applications

Recovery of gold, copper, lead and zinc from electronic wastes and mine-impacted soils via galvanic interactions.

Capabilities and facilities

- Extensive laboratory facilities for extraction, recovery and electrochemical-based studies
- Expertise and analysis facilities for studying surface deposition mechanisms, complexation and redox reactions and solid-liquid interfacial interactions

More information

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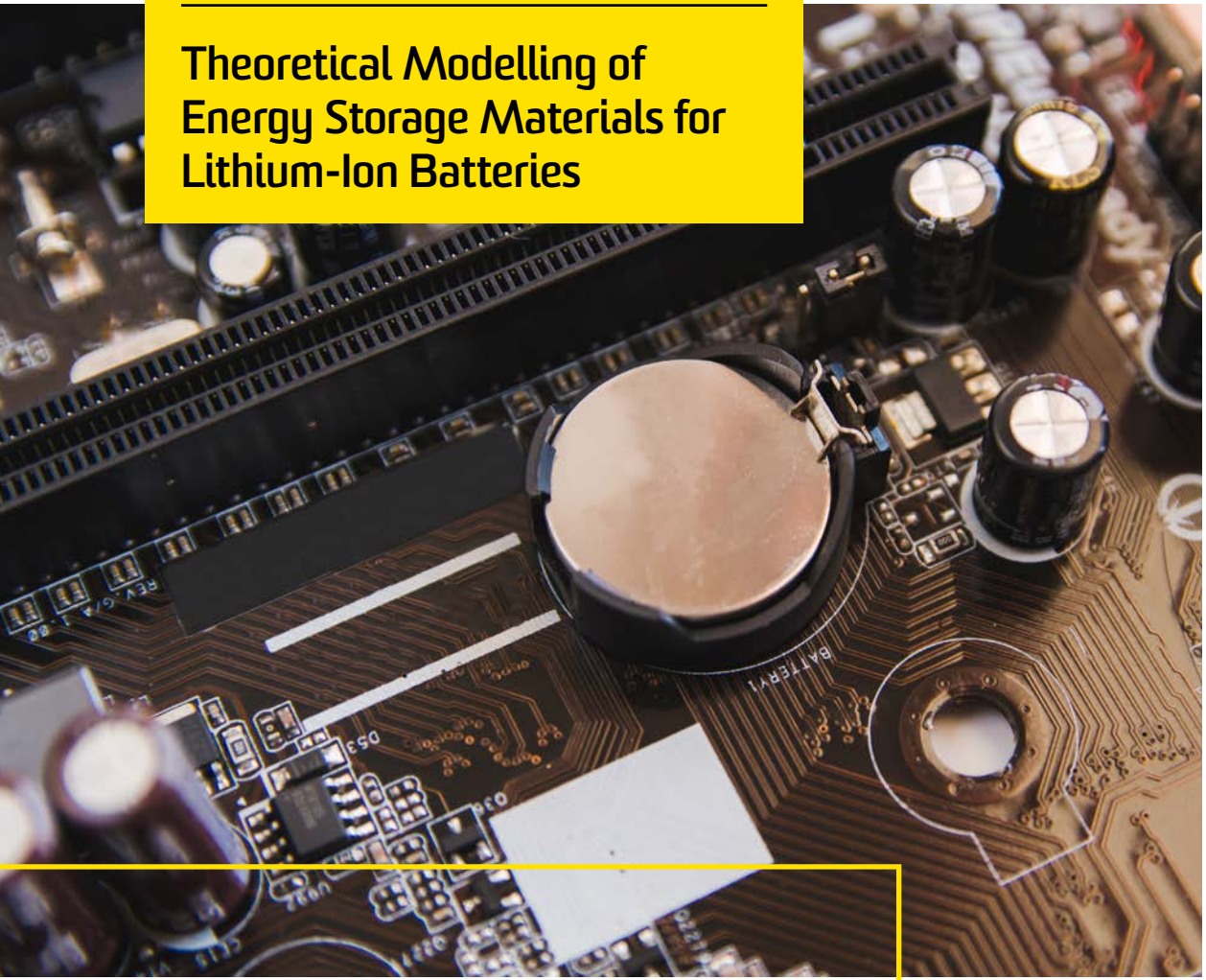
Theoretical Modelling of Energy Storage Materials for Lithium-Ion Batteries



Understanding how lithium-ion migrates during the electrode charge/discharge is important for improving the performance of lithium-ion batteries (LIB). Atomic simulation of the lithiation process provides the capability to recognise the mechanisms and key parameters, and use them to aid the design and manufacturing of LIB electrodes.

Competitive advantage

- Knowledge in atomic simulation using density functional theory (DFT) and molecular dynamics (MD)
- Expertise in modelling the electrochemical interfaces
- Experience in modelling the defects in materials

Impact

- Demonstrated the electronic and ionic transports at the electrode/electrolyte interfaces
- Potential to develop a novel manufacturing (bottom-up) approach based on theoretical findings

Successful applications

- Identified lithiation mechanisms on a titanium dioxide electrode
- Identified important factors during lithiation process on a titanium dioxide electrode

Capabilities and facilities

- Quantum mechanics calculation such as VASP, CP2K and Gaussian
- Molecular mechanics calculation such as LAMMPS
- Computational electrochemistry and materials
- High performance computing cluster

Our partners

- Raijin National Computing Infrastructure
- Pawsey Supercomputing Centre

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High Rate Lithium Ion Energy Storage

Lithium ion batteries that can be charged and discharged at high rates can play a critical role in stabilising electricity grids with a high proportion of renewable energy generators. These devices blur the distinction between supercapacitors and batteries, and may also find applications in electrical power buffering for mass transport systems.

Competitive advantage

- Expertise in fabrication of binder-free 3D electrodes for high rate electrodes and amorphous metal oxide electroactive materials
- New electrochemical modelling methods that can be used to distinguish between double layer storage and Faradaic charge storage
- Integrated experimental-modelling approach

Impact

- High rate electrochemical storage will be critical for electrical grid stabilisation
- Potentially lower cost alternative to electrochemical capacitors in mass transport applications

Successful applications

- 3D porous electrodes using metal foams and 3D printed current collectors
- Anodic titanium oxides binder-free electrodes for high-rate anodes

Capabilities and facilities

- State-of-the-art electrochemical fabrication and characterisation facilities
- Expertise and access to PFG NMR and solid state NMR facilities
- Expertise in atomic scale modelling of electrode materials and electrochemical processes

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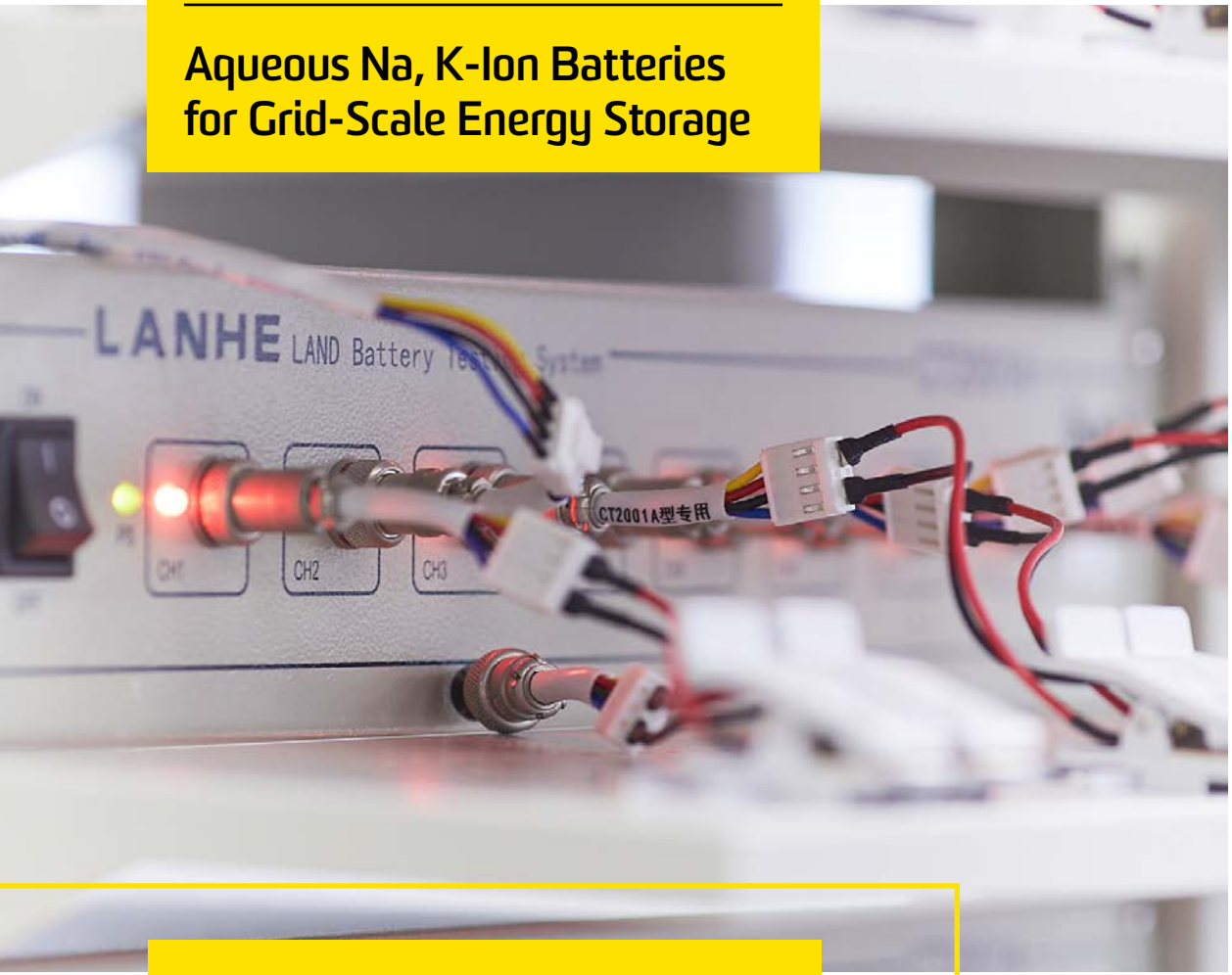
Aqueous Na, K-Ion Batteries for Grid-Scale Energy Storage



Sodium- and potassium-ion batteries are promising candidates for next-generation grid-scale energy storage, due to the elements' abundance and their encouraging battery performance. Their commercialisation requires the development of new electrode materials and a fundamental understanding of their structure-performance relationships.

Competitive advantage

- Development of low-cost, scalable electrode materials with high power density and prolonged cycle life
- Utilisation of a range of in situ and ex situ techniques, such as synchrotron X-ray diffraction, to uncover the structure-performance relationship
- Development of prototype full cells to demonstrate the capability for commercial application
- Expertise in device scale modeling of electrodes

Impact

The development of sodium- and potassium-ion full cells could lead to low-cost and sustainable solutions for intermittent grid-scale energy storage.

Successful applications

- Mesoporous Prussian blue and its analogue's cathode with unprecedented cycle life
- An ultrafast aqueous potassium-ion battery with a charge or discharge time of less than 5 seconds
- A K+/Na+ hybrid aqueous full cell with high-rate capability

Capabilities and facilities

- Materials and electrochemical processes
- Extensive state-of-the-art electrochemical laboratories
- Access to comprehensive analytical techniques such as diffractions, surface analysis, and electron microscopy

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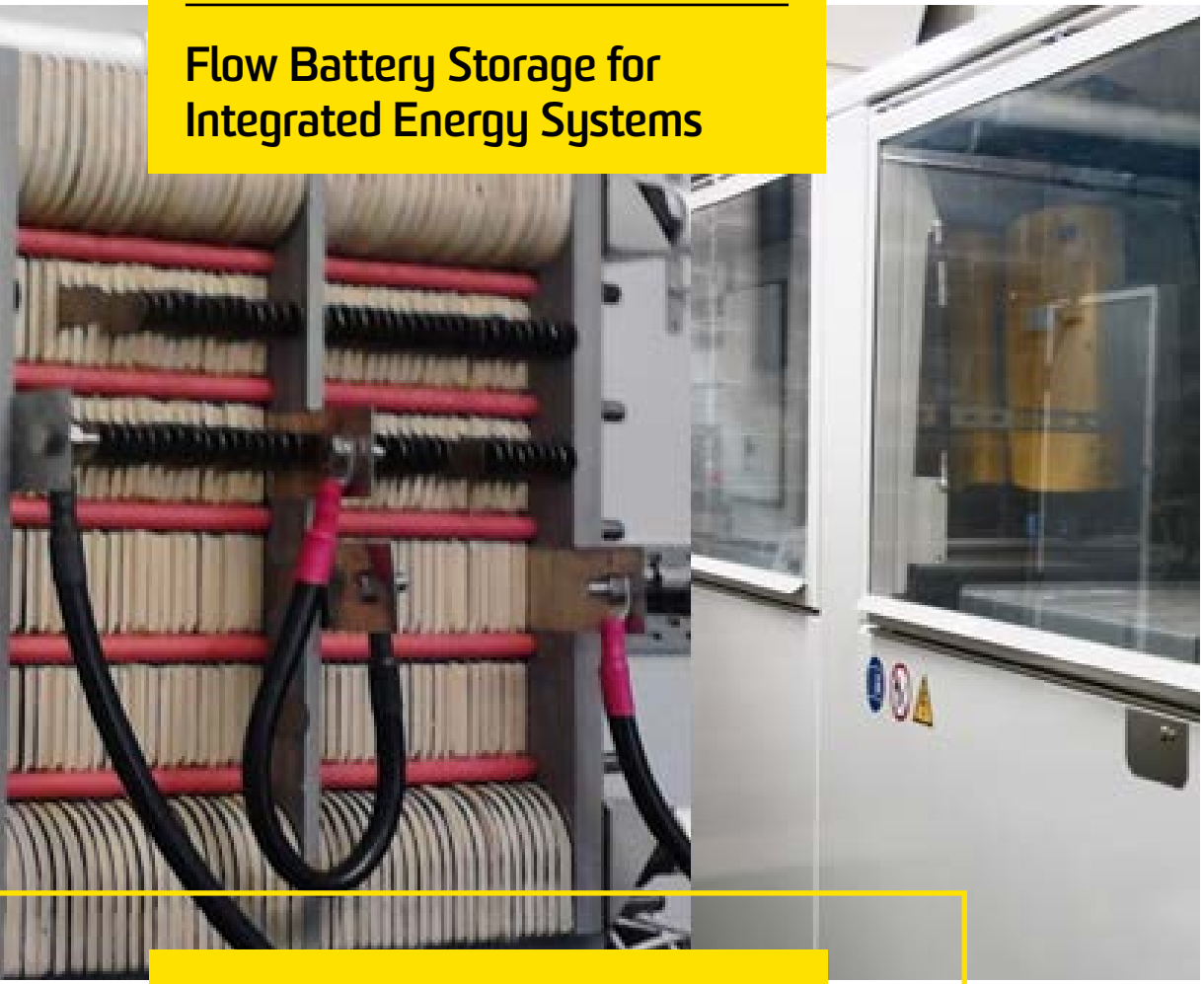
Flow Battery Storage for Integrated Energy Systems



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 with no 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
- 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

Impact

The vanadium flow battery developed at UNSW is currently manufactured commercially by companies in Japan, China, USA, UK and Germany. A 200 MW/800 MWh VRB is currently being installed in Dalian, China.

Successful applications

- Vanadium flow battery developed at UNSW now manufactured commercially
- 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 partners

- Fraunhofer ICT
- Fusion Power Systems

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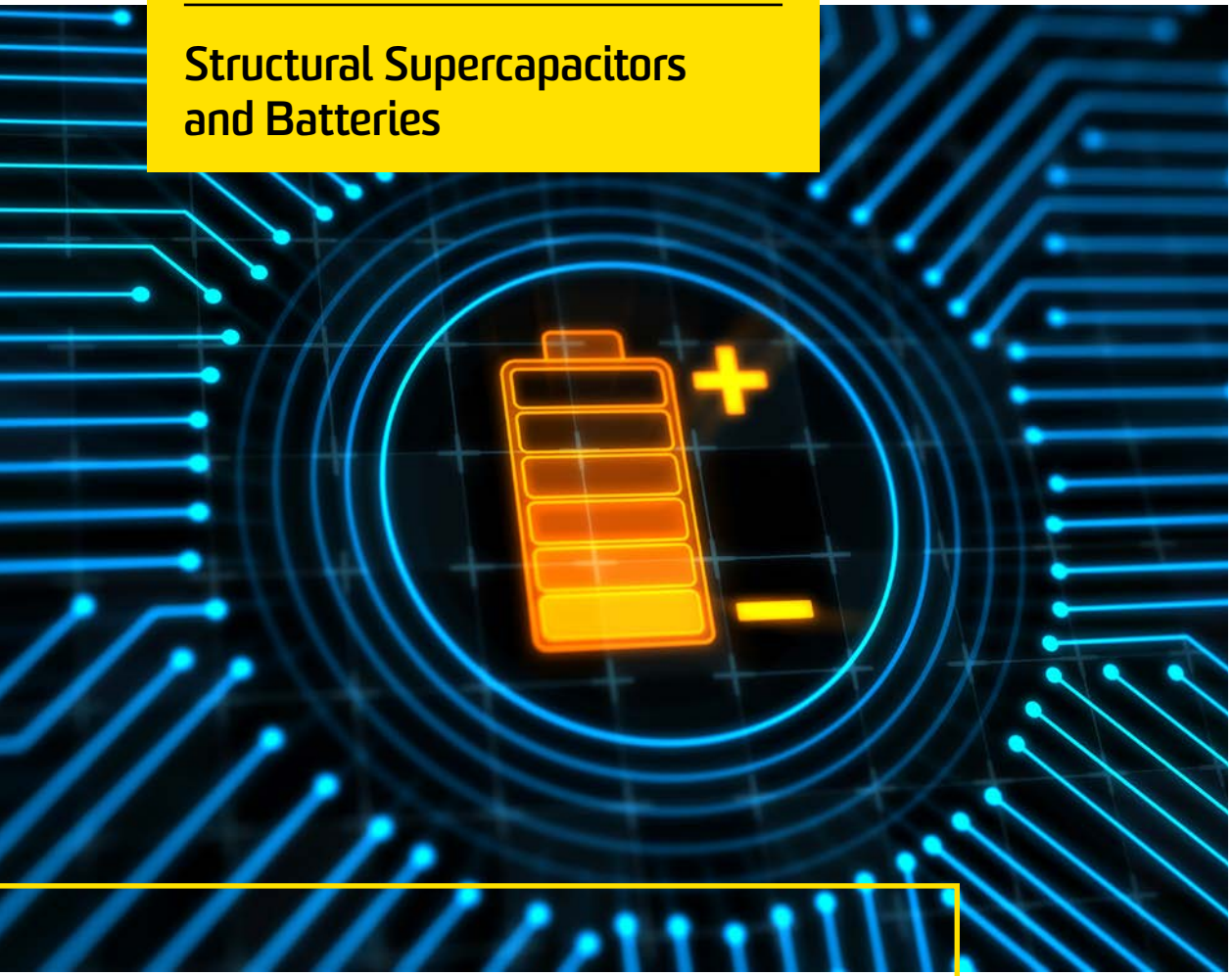
Structural Supercapacitors and Batteries



Lightweight energy storage is vital to environmentally friendly transport, including electrical vehicles, electrical 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 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 which also exhibits the high ionic conductivity needed 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 the need for a traditional energy storage device and its weight from the platform
- Significant weight savings in autonomous vehicles leading to improved energy efficiency for direct energy requirements, and embedded communications and sensing technologies enabling energy to serve other capabilities leading to greater capabilities

Impact

Light weight energy storage devices for Defence applications where high energy storage density is required.

Successful applications

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

Our partners

- Defence Science and Technology (DST)

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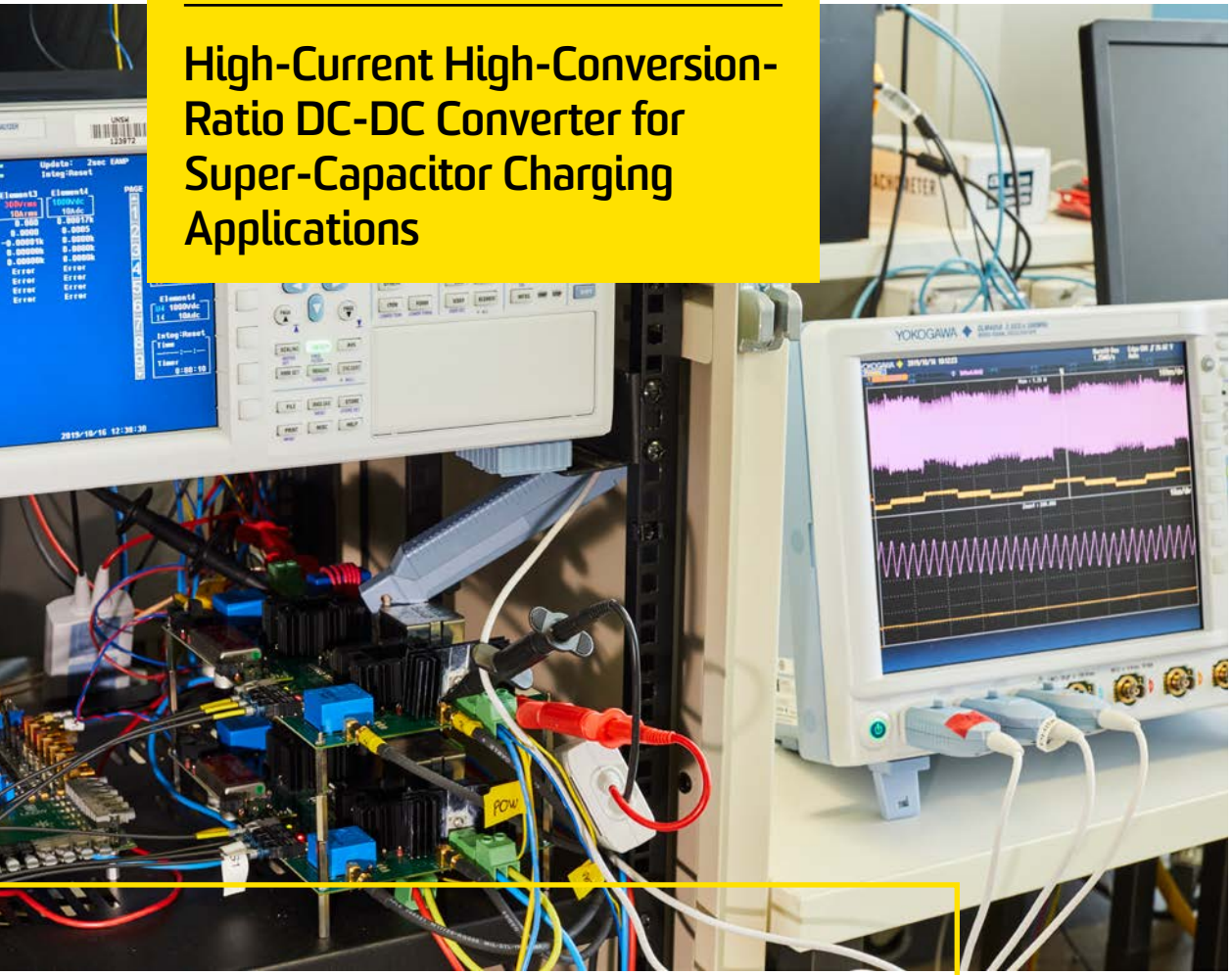
High-Current High-Conversion-Ratio DC-DC Converter for Super-Capacitor Charging Applications



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

Competitive advantage

Class-leading and unique, with:

- Both digital and analogue control
- High-efficiency and high-reliability
- Cost-effective design

Impact

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

Successful applications

Customized high-current DC-DC converter for capacitive de-ionisation 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 partners

- Instrument Works
- Goldwind Environmental

More information

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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 3 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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Reconfigurable Energy Storage Systems

Reconfigurable Energy Storage (ES) systems incorporate a module switching circuit which allows the topology of the ES modules connected to the output converter to be controlled. The voltage and current capacity of the reconfigurable ES system can be adjusted, which increases flexibility and operating range.

Competitive advantage

Innovative reconfigurable energy storage systems have been developed that can:

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

Impact

- Unlike conventional systems, the ES shares components among the different operating modes, which makes it more compact
- Existing redundant modes increase reliability

Successful applications

DC linked battery and battery/ultracapacitor reconfigurable energy system prototype.

Capabilities and facilities

- Energy storage system prototypes
- Hardware-in-loop simulation for rapid assessment of control techniques
- Hardware testing capability up to 50kVA, 1kV, 400A
- Arbin battery and supercapacitor tester with environmental chamber

More information

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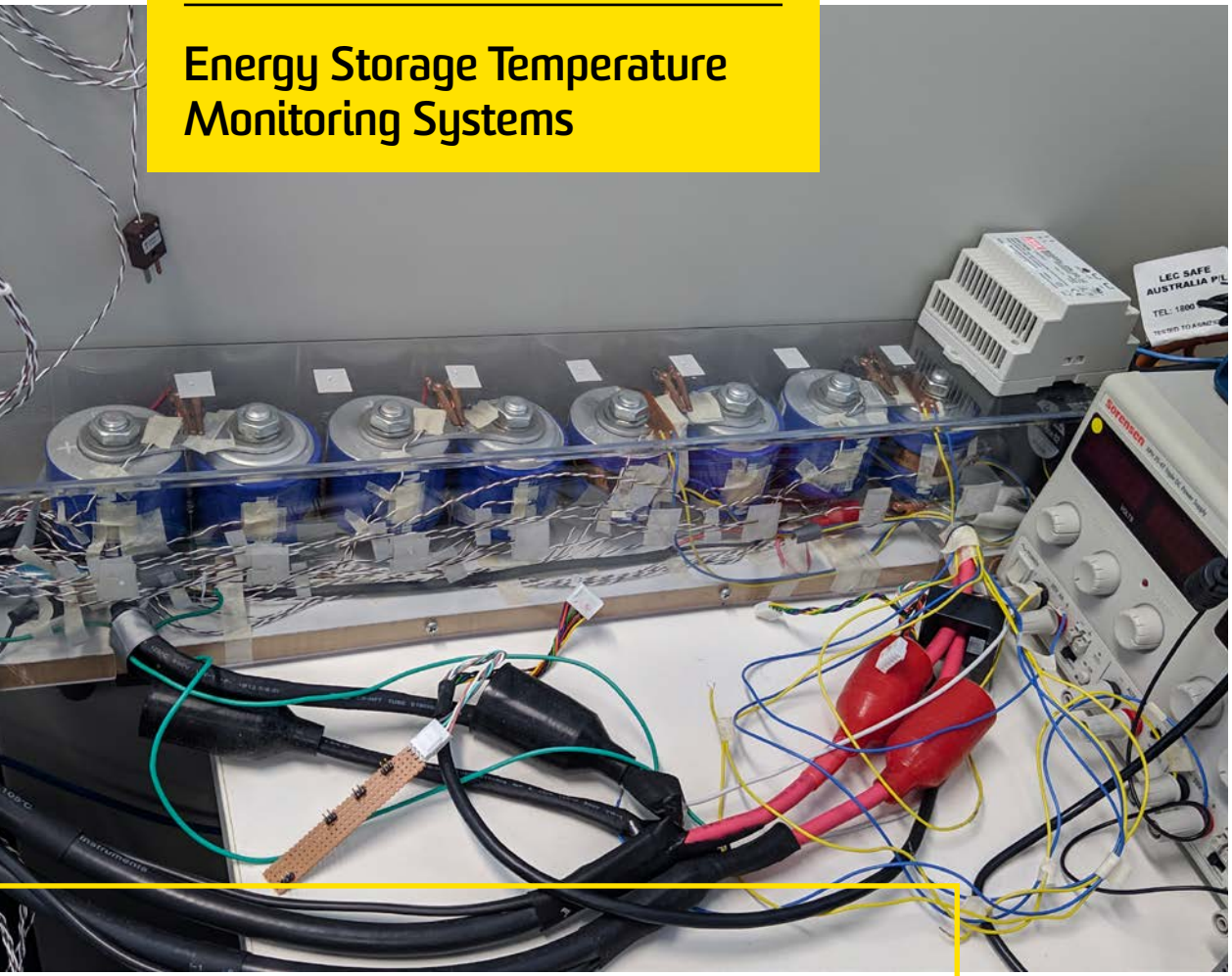
Energy Storage Temperature Monitoring Systems



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 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 temperature of all cells as well as to detect and localise an abnormally overheating cell, with the limited number of temperature sensors. The optimal location of the temperature sensors is determined by analysis of the observability Gramian

Impact

- Reduced cost due to reduced number of temperature sensors
- Increased safety as abnormal overheating of cell within a string can be detected

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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Battery Management Systems

Expertise in battery management systems including the ability to monitor temperature, state-of-charge, and maintain the system within safe operating limits to improve battery life.

Competitive advantage

- Cooperative state of charge balancing
- Advanced state-of-charge, state-of-health estimation algorithms
- Monotonic charging/discharging of battery packs
- Temperature monitoring using limited number of temperature sensors
- Reduction of battery current variation

Impact

- Extended lifetime of batteries
- More efficient and reliable battery products

Successful applications

- Direct AC linked hybrid (battery/ultracapacitor) energy storage system with second order harmonic current reduction
- Distributed cooperative balancing system for reconfigurable battery systems
- Modular multilevel battery storage system with second order harmonic current reduction
- Temperature monitoring system for ultracapacitor strings using limited number of temperature sensors

Capabilities and facilities

- Power Electronics Laboratory
- Arbin Instruments battery tester
- Prototypes of hybrid (battery/ultracapacitor) energy storage system, reconfigurable (hybrid) energy storage system and temperature monitoring system for supercapacitors strings

Our partners

- ABB

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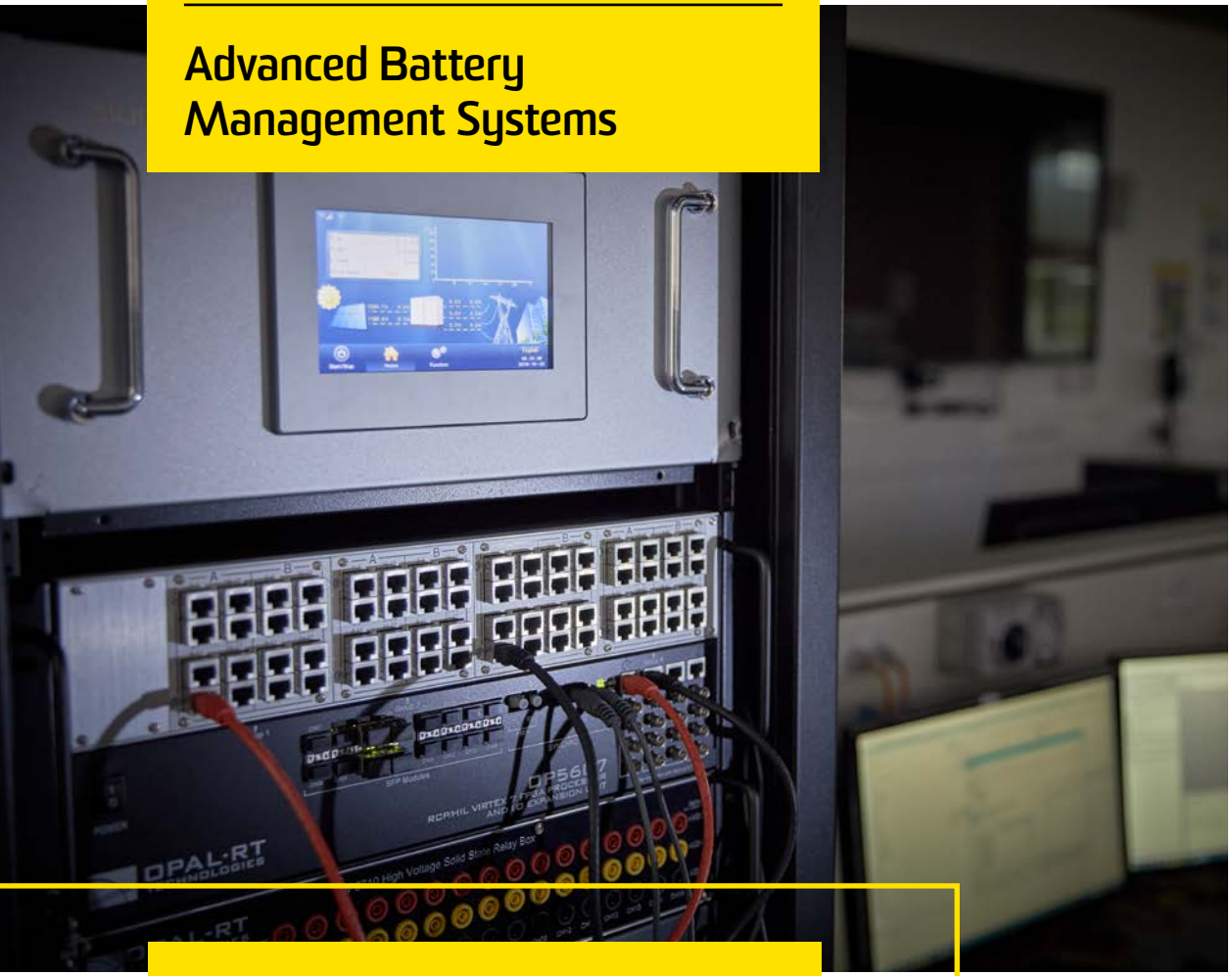
Advanced Battery Management Systems



Battery management systems (BMS) for managing both charge and discharge of individual or groups of cells is essential for safety and increasing performance of the system. Balancing can be a simple passive circuit that normalises voltages in the steady-state or highly complex, using networks of active converter circuits that provide balancing function in both transient and steady-state.

Competitive advantage

- A range of technologies from low-cost cell balancing technologies to complex management systems that utilise ultra-low power IOT/wireless technologies to simplify the gathering of cell parameters and control the cell charge 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 interfacing that decreases the complexity of the system, improving reliability and security
- Ability to provide lab-scale development with interface capability up to 50kVA

Impact

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

Successful applications

- Solar car battery management systems
- Pipeline 'pig' applications
- BMS systems for traction drives

Capabilities and facilities

- Hardware-in-loop simulation for rapid assessment of control techniques
- Hardware testing capability up to 50kVA, 1kV, 400A
- Arbin battery and supercapacitor tester with environmental chamber

Our partners

- RST Projects
- Taipei Locomotives

More information

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$LiFePO_4$ battery management system

A wireless battery management system for $LiFePO_4$ batteries that can survive cold-soaking at -80°C and has been proven 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; the firmware is programmable using infrared
- 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 4100m altitude in Antarctica under -80°C 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

- -80°C fridge for environmental testing
- Fault-tolerant software using low-power AVR microcontrollers

Our partners

- Polar Research Institute of China
- Purple Mountain Observatory, China

More information

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Cooperative Balancing of Distributed Energy Storage Systems

Massive penetration of energy storage systems presents new opportunities for power network operators and individual customers. Innovative cooperation of distributed energy storage systems can improve power quality while bringing additional capacity, flexibility and redundancy into power networks.

Competitive advantage

Expertise in developing centralized and distributed multi-agent control strategies for energy storage systems. This provides:

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

Impact

Cooperative balancing can lead to the avoidance of 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
- Have plug-and-play capability

Capabilities and facilities

One of the largest Real Time Digital Simulators (RTDS) in academic and research institutions globally. It allows:

- Real-time verification of algorithms and simulation of power networks together 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 the 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

Our partners

- ABB Corporate Research, Sweden

More information

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Advanced Monitoring and Control for Energy Storage Systems

World-leading development of advanced control systems and maximising performance of energy storage system technologies including the vanadium redox flow (VRB) battery. 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
- Use of flow batteries as a multi-functional energy storage system for voltage stability and power quality improvement without complementary energy stoage devices to reduce system costs and improve reliability

Impact

- Significant improvement of flow battery systems
- Greater flexibility in battery operation to allow optimal 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, Dalian, China

Capabilities and facilities

- 30 kW/130 kWh commercial VRB system
- Extensive state-of-the-art electrochemical and mechanical laboratories.
- Climate controlled chambers for evaluating effects of environmental parameters on energy storage system performance

Our partners

- Fraunhofer ICT

More information

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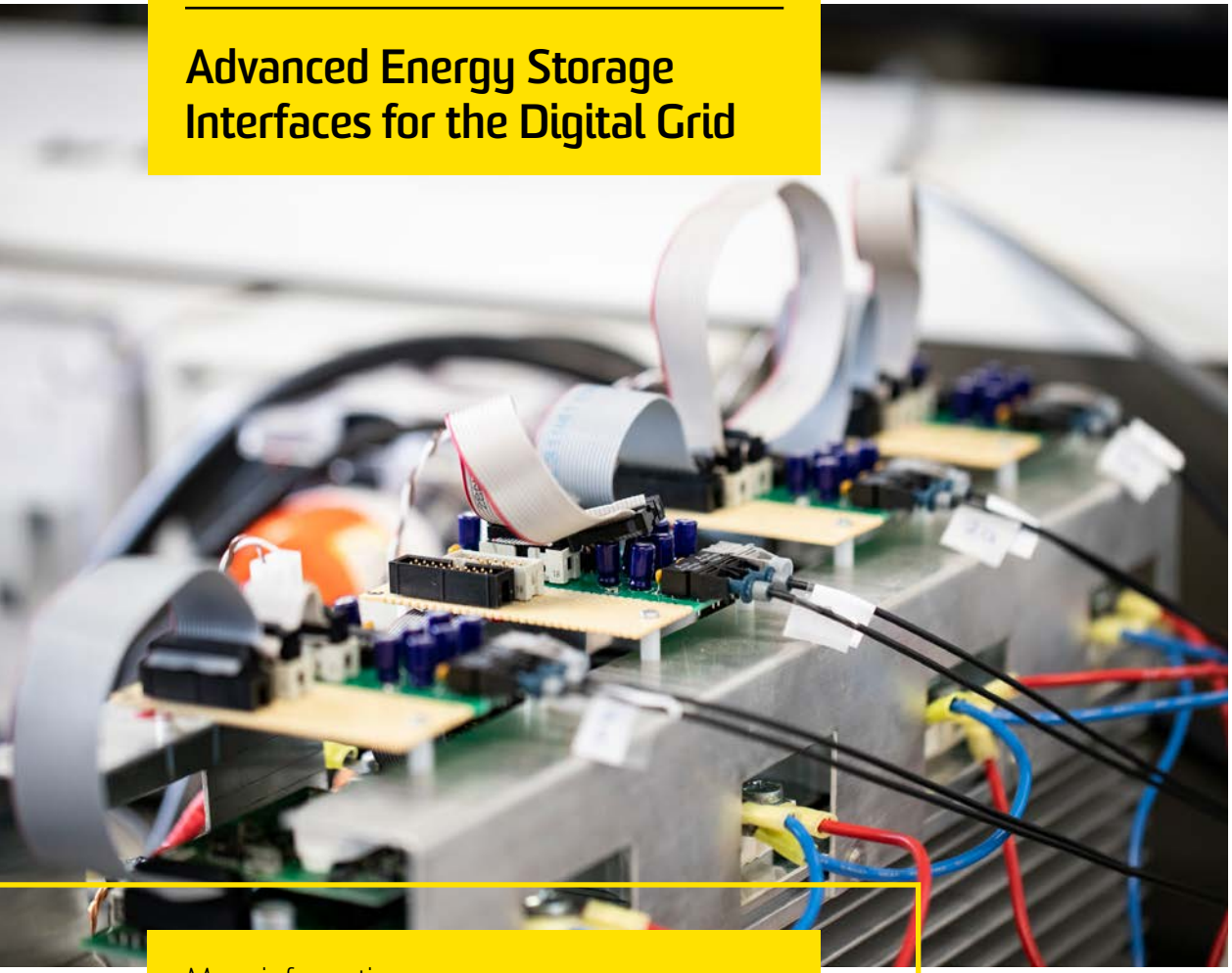
Advanced Energy Storage Interfaces for the Digital Grid



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 areas related to energy storage
- Novel interfaces for single- and three-phase AC systems reduce costs and improve storage utilisation
- Unique research and demonstration of hybrid energy storage systems 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

- Realtime 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 partners

- ARUP
- RES
- Transport for NSW
- AEMO
- TransGrid
- Ausgrid

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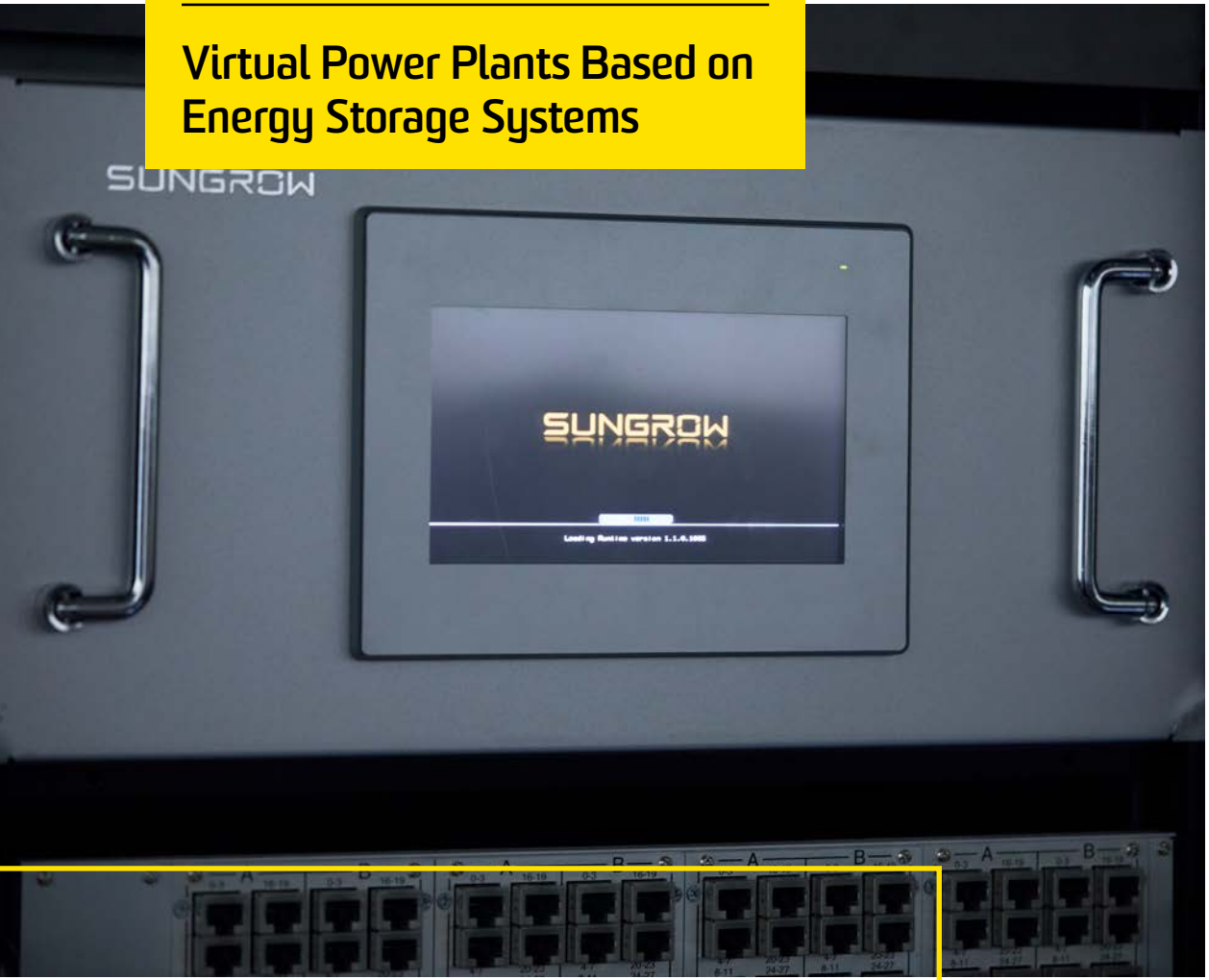
Virtual Power Plants Based on Energy Storage Systems



Simplifying the coordination of vast numbers of Energy Storage (ES) Systems by clustering them dynamically into Virtual Power Plants (VPPs). The main technical challenge caused by massive penetration of different types of ES is the coordination of vast numbers of ES systems, bringing together various types and capacities of ES systems, individual customer behaviour, connections and disconnections of ES systems and potential power network changes.

Competitive advantage

Expertise in developing distributed multi-agent control strategies for ES systems and their aggregation into virtual power plants based on operating requirements and ES system 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 a roadblock associated with limited hosting capacities on feeders

Successful applications

Development of algorithms for on-line peer-to-peer based distributed aggregation of ES systems into virtual power plants.

Capabilities and facilities

One of the largest Real Time Digital Simulators (RTDS) in academic and research institutions globally. The RTDS allows:

- Real-time verification of algorithms and simulation of power networks together 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 the opportunity for rapid research, development and verification necessary for translating theoretical advances in multi-agent cooperative control and aggregation algorithms into new strategies suitable for deployment in power system networks

Our partners

- ABB Corporate Research, Sweden
- ARUP

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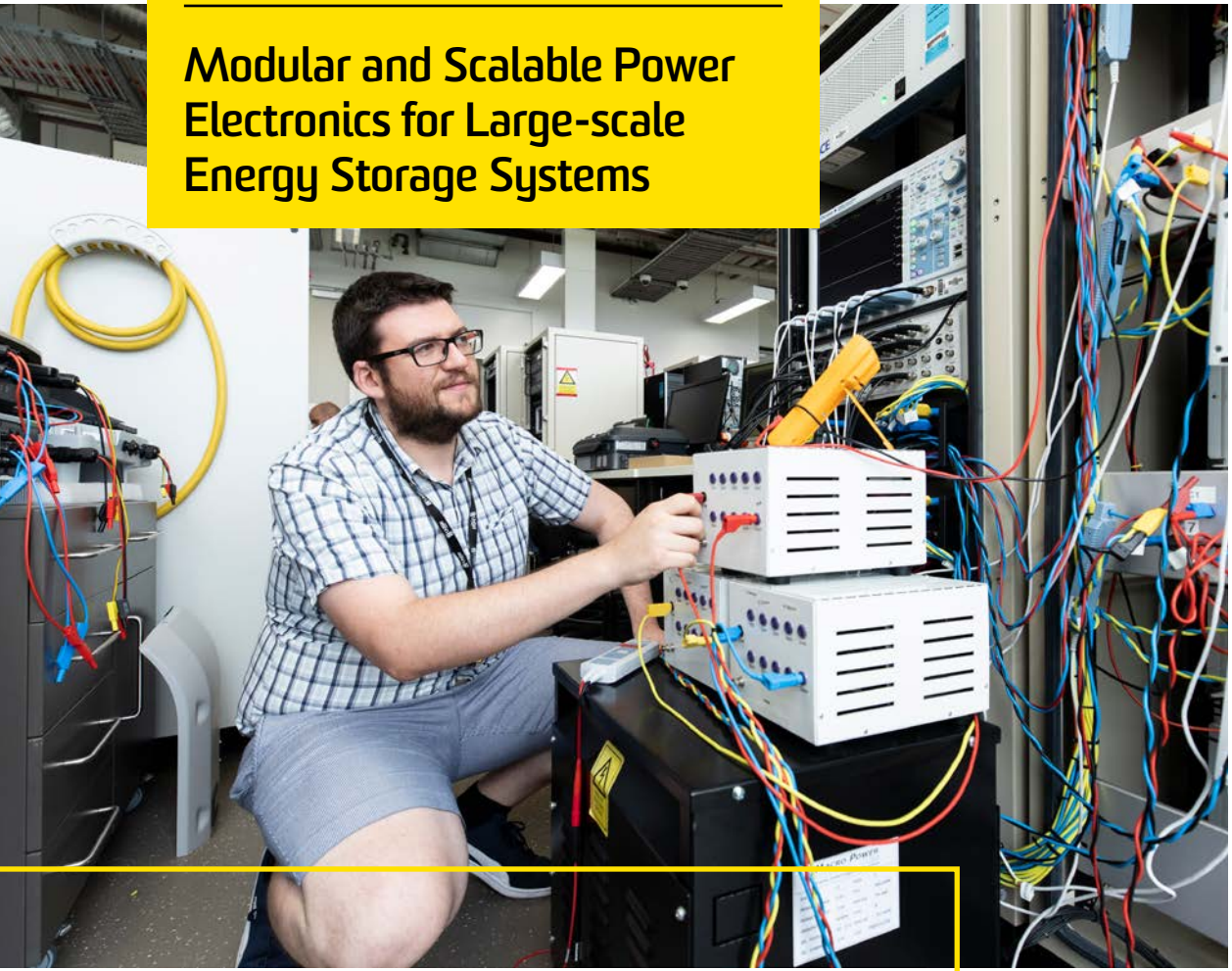
Modular and Scalable Power Electronics for Large-scale Energy Storage Systems



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

More information

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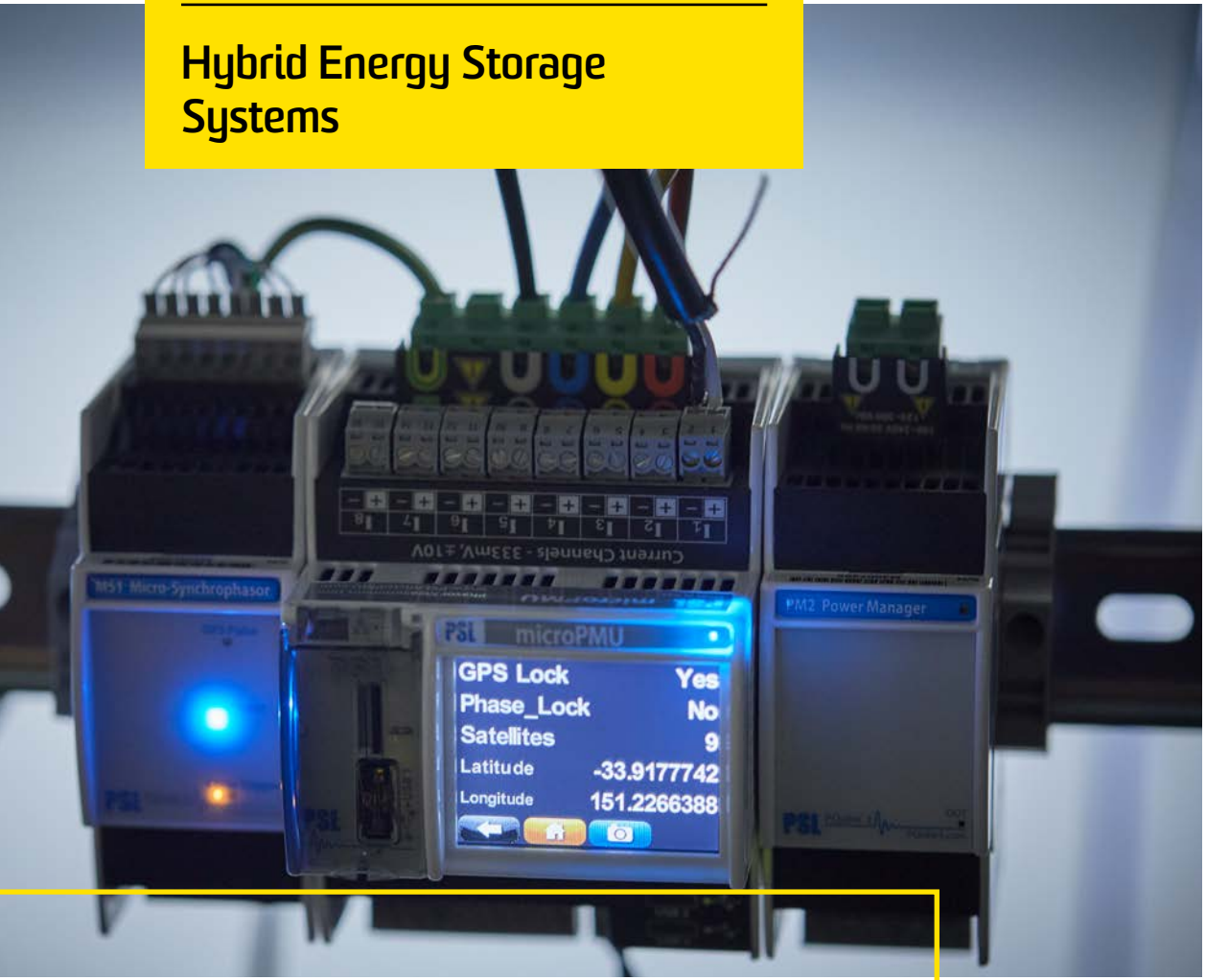
Hybrid Energy Storage Systems



Hybrid energy storage systems (ESS) combine individual advantages of different types of storage to realise a single ESS with both higher power and energy capabilities. Battery-supercapacitor based hybrid ESS help to reduce the battery power rating and extend battery life by minimizing the current variation.

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, provide fast verification and quick adoption by industry for mass production
- World-class 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) energy storage systems. Their main advantages are increased lifetime, improved efficiency, increased reliability and flexibility
- Reconfigurable hybrid ESS that can be adapted online to fulfil different operating modes: feeding the 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 the different operating modes making them more compact

Capabilities and facilities

- Hybrid energy storage system prototypes
- Hardware-in-the-loop simulation for rapid assessment of control techniques
- Hardware testing capability up to 50kVA, 1kV, 400A
- Arbin battery and supercapacitor tester with environmental chamber

Our partners

- ABB Corporate Research, Sweden

More information

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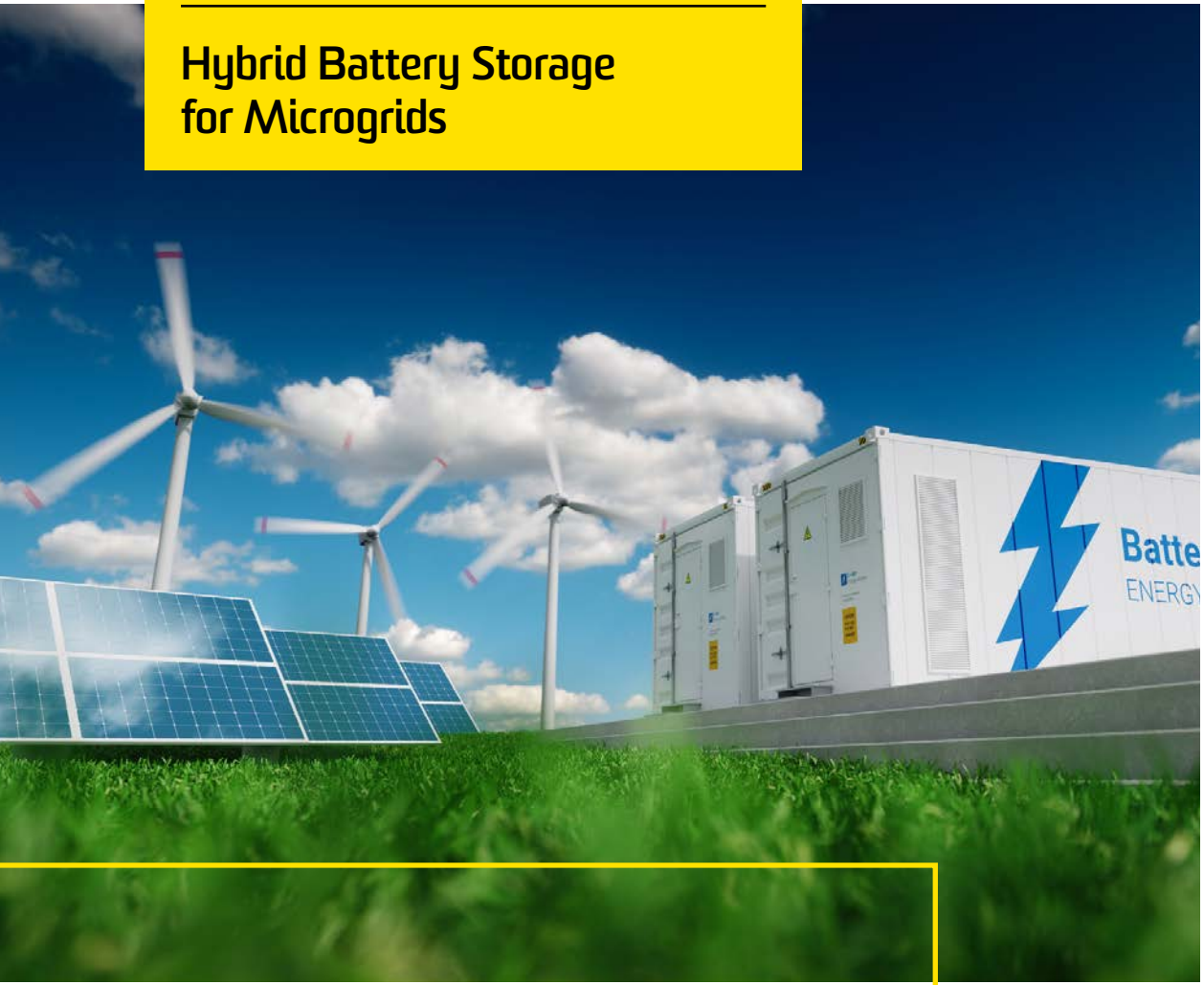
Hybrid Battery Storage for Microgrids



Battery storage plays an important role in microgrids, improving grid reliability and resilience while facilitating effective operation of critical and frequency-sensitive loads. Battery storage is critical both for daily operation of a microgrid, as well as providing for grid redundancy in extreme events.

Competitive advantage

A complete test bed and procedures for assessing battery storage performance under different grid events to:

- Improve the reliability and resilience of grid supply using coordinated microgrid battery storage
- Improve continuous supply for electricity demands and demand side management
- Provide reliable and economical reserve

Impact

- More reliable and efficient microgrid performance

Successful applications

- Development of a hybrid portable mobile microgrid station system
- Microgrid planning tools and capability for urban and remote area
- Hybrid portable mobile microgrid station for Australian Defence Force—a project focussed on hybrid battery storage systems for mobile and reliable power supplies for remote operation activities

Capabilities and facilities

- Energy and power research group with industrial standard software
- Hardware-in-the-loop testing bed for energy storage systems with programmable grid simulations on real time digital simulators (RTDSs)

Our partners

- Remote energy users including farmers, mining sites and army forward bases

More information

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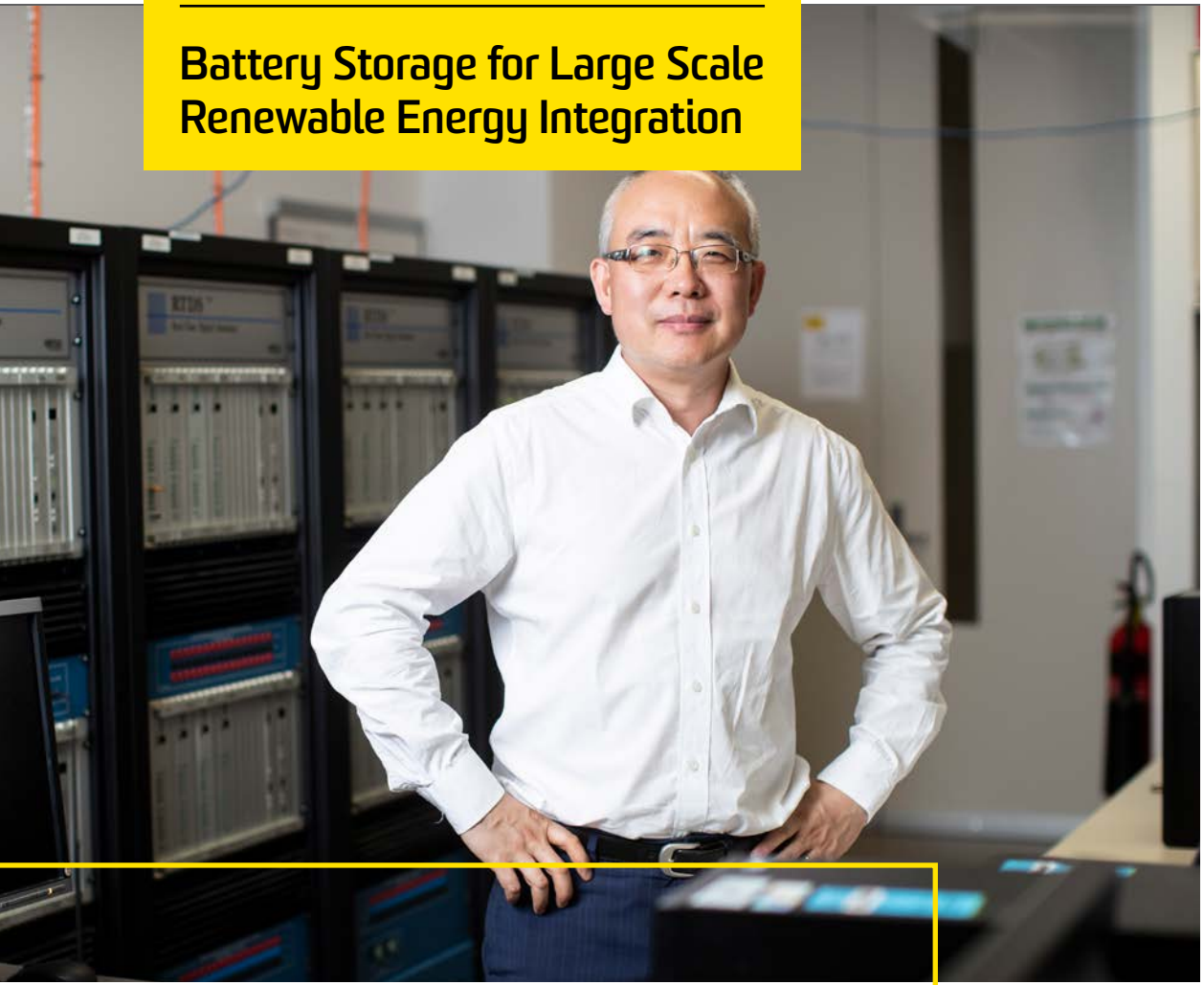
Battery Storage for Large Scale Renewable Energy Integration



Battery storage provides significant advantages for integrating intermittent renewable energy systems into the electricity grid. Battery storage has the potential to become standard in new renewable energy installations, increasing their competitiveness and greater deployment of renewables.

Competitive advantage

- Expertise in grid-integration of battery storage and renewable energy systems
- Experience in mitigating the stability impacts of intermittent renewable generation using battery storage—ensuring stable and reliable power is delivered to consumers, overcoming issues such as network congestion and potentially deferring network capital upgrades

Impact

- More reliable electricity networks with lower carbon emissions

Successful applications

- The Future Grid Research Program—a $13 million research collaboration between CSIRO and four leading Australian universities that aims to develop Australia's capacity to plan and design an efficient and low emission electricity grid
- Grid planning and co-optimisation of electricity and gas networks
- Improved understanding of impacts of different loads, generation sources and energy storage on electricity system security

Capabilities and facilities

- Cross-platform modelling tools for grid studies of the impacts of loads, generation sources and energy storage on system security
- Energy and power research group with industrial standard software
- Grid planning and co-optimisation of electricity and gas networks
- Hardware-in-the-Loop testing bed for energy storage systems with programmable grid simulations on real time digital simulators (RTDSs)

More information

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Energy Storage Modelling and Forecasting

Leaders in research of renewable energy and energy storage for stand-alone, microgrids and grid connected systems, using state of the art simulations based on machine learning models. Analysing and understanding electricity demand, solar irradiance and weather variables leads to the development of accurate models to forecast electrical loads and photovoltaic power generation.

Competitive advantage

- World-class modelling and energy forecasting for the analysis and technoeconomic optimisation of thermal and electrical storage
- Expertise and capability to accurately simulate the operation of storage systems in detail and as part of larger systems (like a grid or a microgrid), to understand their performance, operation and value proposition in different scenarios, including demand management, renewable energy smoothing and firming

Impact

- Optimised deployment of storage systems
- Optimised dispatch of storage systems
- Analysis of degradation of storage systems
- Better understanding of the value generated by storage systems over time

Successful applications

Optimization of the energy use for a residential hot water system with PV using forecasting and storage modelling.

Capabilities and facilities

- Research storage systems from 30 kWh to 500 kWh
- Microgrid research facilities
- World class capability to optimise grid systems and storage using machine learning
- Access to real data for renewable energy and storage systems

Our partners

- Solar Analytics

More information

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POLICY, MARKETS AND CONSUMERS

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City Futures Research Centre

City Futures Research Centre spans the interrelated areas of urban planning, housing, health and well-being, urban development and urban policy. All are underpinned by high-level GIS-enabled urban big-data analytics and modelling.

Competitive advantage

- Australia's leading urban and housing research capability
- Assessed by the Australian Research Council in 2018 as "well above world standard" for urban planning and related research

Impact

Seeking to increase public, government and industry awareness and provide high level strategic advice on the intended and unintended outcomes of city policy, programs and development.

Successful applications

- Internationally recognised research on housing, land-use planning and urban equity issues
- A world-class urban big-data analytics, visualisation and modelling capacity
- A track record of research on policy barriers to energy use in the residential sector and energy efficiency for lower income households

Capabilities and facilities

- High-level policy review and analysis
- Qualitative evidence on impacts of energy poverty on disadvantaged households
- Analysis of energy consumption in the residential sector
- A world class City Analytics Lab and expertise in GIS-enabled urban analytics, modelling and visualisation

Our partners

- Established research partnerships with:
  - CRC for Low Carbon Living
  - National Climate Change Adaptation Research Facility
  - NSW Office of Environment and Heritage
  - Australian Urban Research Infrastructure Network

More information

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Energy and Environmental Markets

Energy and Environmental Markets is a Centre devoted to studying the challenges and opportunities of clean energy transition within market-oriented electricity industries. Key aspects of this transition are the integration of large-scale renewable technologies and distributed energy technologies (generation, storage and 'smart' loads) into the electricity industry.

Competitive advantage

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

Impact

Increase the understanding of the role of storage in the transition of electricity systems and markets to integrating high penetration renewable energy, both centralised and distributed.

Successful applications

- Open source tools including market dispatch, tariff design and distributed energy sharing and aggregation models
- Interdisciplinary frameworks for policy, market and regulatory assessment and design
- Analysis of impacts and value of storage and demand response on networks and power systems, over a range of timeframes
- Assessment of the potential and value of storage and demand response for integration of variable renewable energy

Capabilities and facilities

- High performance computing
- Access to the National Computational Infrastructure, Canberra

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Renewable Energy, Energy Efficiency and Emissions Policy Mechanism Design

Conducting interdisciplinary policy analysis and design—including carbon pricing, renewable energy and energy efficiency certificate schemes, reverse auctions, tariff design and other policy mechanisms—across the technology lifecycle to help determine the trajectory and cost of clean energy transitions, and the impacts on different stakeholders.

Competitive advantage

Working directly in industry, and lead and participate in International Energy Agency collaborations on integration of high penetration DER.

Impact

Assess the effectiveness, efficiency, equity and feasibility of emissions pricing, energy efficiency and renewable energy policy mechanisms.

Successful applications

- Analysis of the effectiveness, efficiency and equity impacts of market-based schemes
- Modelling of policy impacts on electricity industries
- Development of open source tariff modelling and analysis tools
- Submissions to policy and regulatory processes

Capabilities and facilities

- 15 years' experience in the development of policies and frameworks designed to enable the uptake of low emissions technologies
- Expertise in electricity market and distributed energy modelling, data science applications to energy problems and the development of open source tools

Our partners

- All levels of Government
- NEM institutions
- Network businesses
- Industry associations
- NGOs
- Numerous consultants, renewable energy developers, distributed energy businesses and start-ups

More information

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Integration of Large-scale Variable Renewable Energy into the Electricity Market

Although there is a variety of technologies and market design features that can assist with the integration of large-scale Variable Renewable Energy (VRE), delivering reliable and low-cost electricity through the transition will require new approaches to planning, operation and market reform.

Competitive advantage

Working in industry, and lead and participate in International Energy Agency collaborations on integration of high penetration DER.

Impact

- Provide data and tools to improve planning and operation of electricity industries with high VRE
- Inform appropriate electricity market design and regulation for high VRE

Successful applications

Collaboration with many Governments and Regional Authorities, including the European Commission and Government of Greece.

Capabilities and facilities

- 20 years' experience in the integration of VRE into electricity networks
- Expertise in electricity market and distributed energy modelling, data science applications to energy problems and the development of open source tools
- Staff regularly consult to industry and government, and also work in industry, and so bring real-world experience to the team

Our partners

- All levels of Government
- NEM institutions
- Network businesses
- Industry associations
- NGOs
- Numerous consultants, renewable energy developers, distributed energy businesses and start-ups

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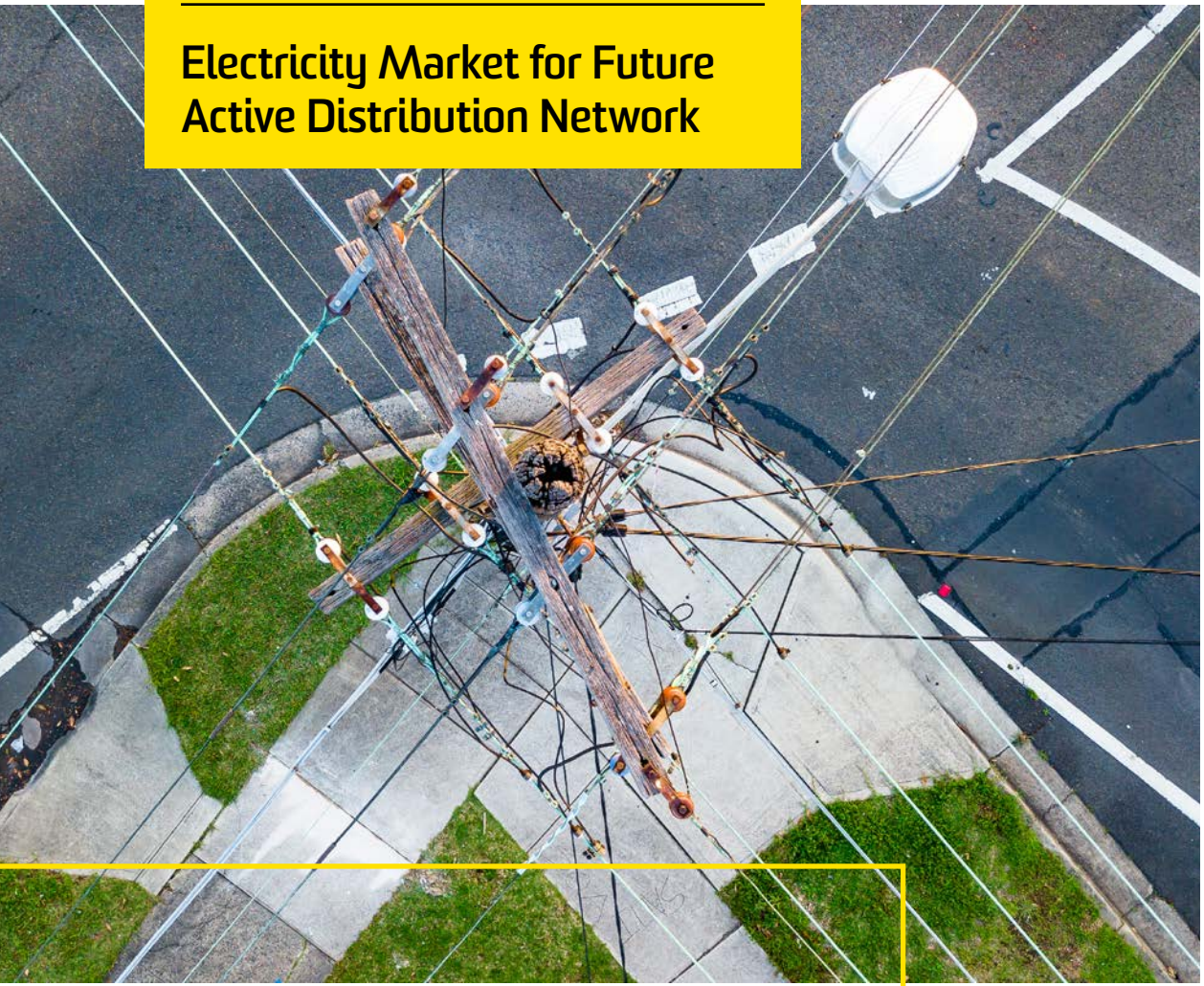
Electricity Market for Future Active Distribution Network



The development of new market-oriented energy systems and mechanisms for future active distribution systems, to respond to the needs and requirements that the increased penetration of distributed energy resources place on the distribution network.

Competitive advantage

- Expertise in facilitating peer-to-peer electricity trading among energy prosumers in the distribution network
- Collaborative filtering technique-based electricity retail plan recommendation system for smart grid end users

Impact

The creation of a decentralized, secure, and efficient electricity trading mechanism in the distribution side that will enhance the experience of sharing for end users.

Successful applications

- Multi-agent based electricity trading negotiation framework for prosumers
- Decentralized electricity trading system based on multi-agent intelligence and Blockchain
- The electricity retail plan recommendation system has been tested on the real “Power-to-Choose” retail plan set and Australian “Smart Grid, Smart City” dataset. The testing results prove the efficiency of the system

Capabilities and facilities

- Java Agent Development Environment (JADE)
- PLEXOS, PSS/SINCAL, and Matlab Simulators

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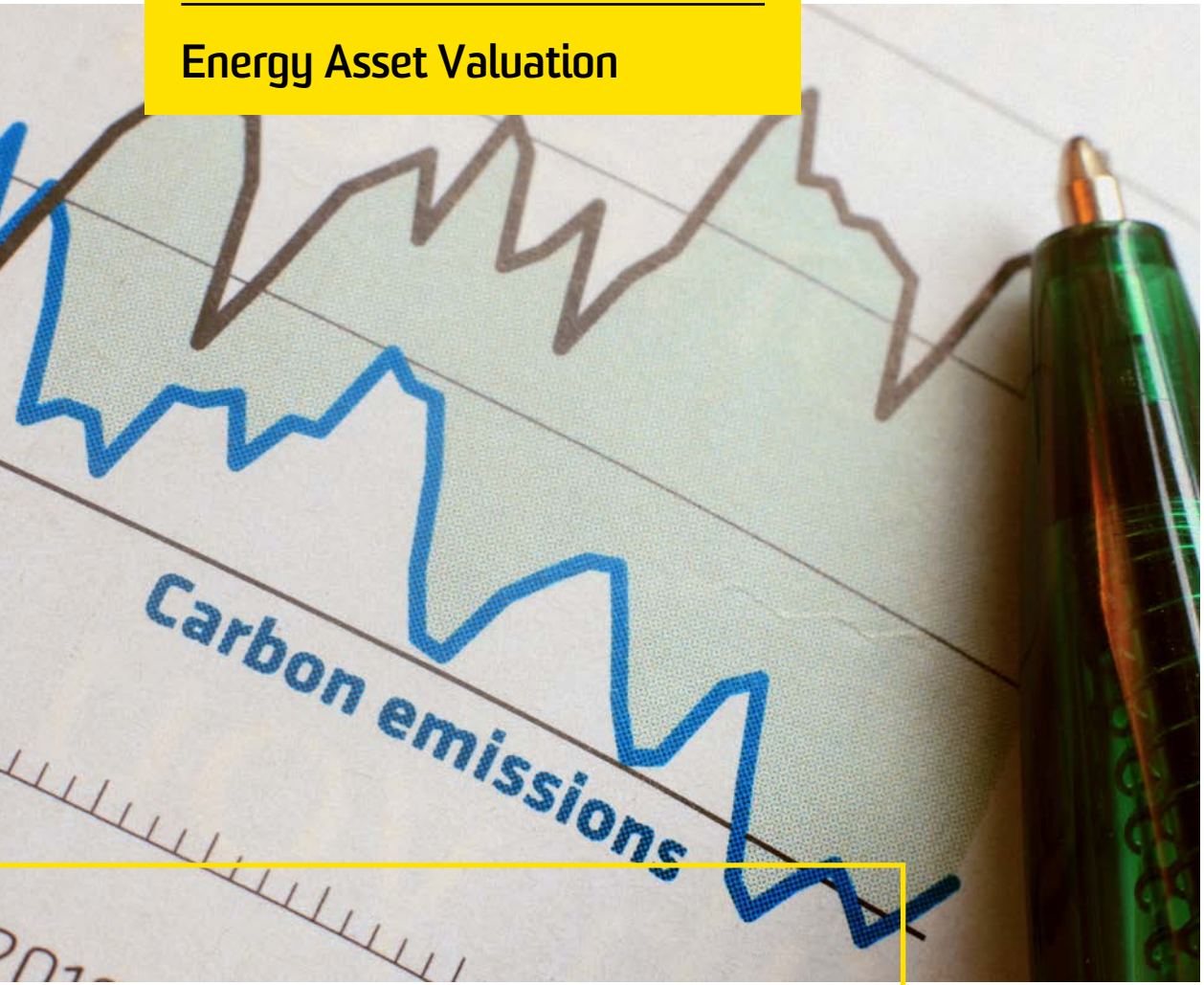
Energy Asset Valuation



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

More information

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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, to ensure that regulatory responses are robust and evidence-based.

Competitive advantage

- A team drawn from around the world which consists of global leaders in regulatory thinking, and renowned experts
- Vast experience in both regulatory and governance design

Impact

At a time when the clamour of calls for regulators to "do something" is a challenge for both those who set and those who are governed by, regulations, robust research and well-considered analysis are essential.

Successful applications

- Research has been used by regulators around the world
- Domestically, the team has worked with the ACCC, ACMA, ASIC and the Treasury at a Federal level, and with many NSW State agencies
- Internationally, they have worked with regional regulators including in Cambodia, China, Laos, Malaysia, New Zealand, Singapore and Thailand

Capabilities and facilities

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

Our partners

- Currently working with Energy Consumers Australia

More information

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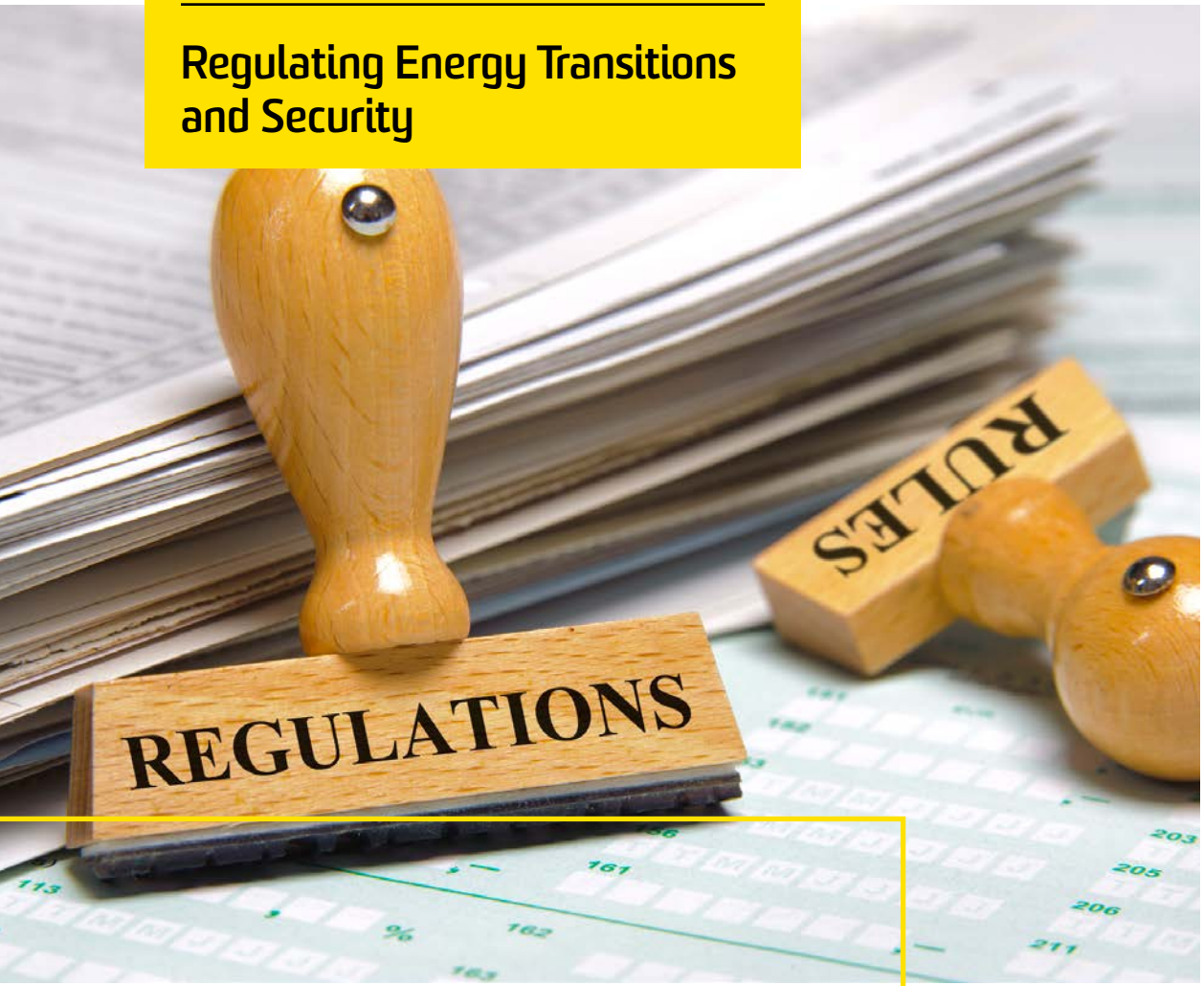
Regulating Energy Transitions and Security



Research to chart the legal and regulatory pathways that will influence the transition to a more sustainable energy regime—notably the choice of technology and its impacts 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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UNSW Law; Environmental Law Group

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A Just Energy Transition

Developing a masterplan for the implementation of a zero net emissions climate transition that combines the best mitigation options with a focus on social justice.

Competitive advantage

- The first project to incorporate robust measures of the social justice benefits of a climate transition in Australia
- Delivering a unique and important outcome by combining a focus on the most appropriate infrastructure/technologies for a climate transition with a focus on the social justice dimension of doing so; especially the needs of vulnerable communities

Impact

- Climate transitions will involve significant changes to the generation and delivery of energy, the organisation of infrastructure and to lifestyles. All of these changes involve crucial ethical choices concerning the fairest way to deploy and pay for new technologies, adaptation and mitigation measures
- For a transition to succeed it must, of course, reduce emissions. It must also ensure that the benefits and burdens of any transition—such as its financial cost, lifestyle sacrifices, monetary benefits—are fairly shared within society. This dimension is crucial to ensuring that vulnerable individuals and communities are not made worse off by any transition strategies

Our partners

- Samso Energy Academy, Denmark
- Renew
- Sustainability Victoria
- Central Victorian Greenhouse Alliance
- Little Sketches
- Hepburn Wind
- Hepburn Shire Council

More information

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Fighting Energy Poverty

Energy Poverty is a serious problem for our society and puts the lives of vulnerable and low-income households under threat. Fighting it means developing appropriate low-cost technologies and combining them with advanced monitoring technologies.

Competitive advantage

- Significant experience in developing low-cost, efficient energy technologies that decrease energy needs and provide comfort to low-income households, at minimum cost
- Proven solutions that:
  - Decrease energy consumption by up to 70 per cent
  - Reduce carbon emissions by up to 50 per cent
  - Improve indoor thermal comfort by up to 70 per cent
  - Lower the level of indoor pollutants by up to 90 per cent

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

- Fully-equipped laboratory able to perform any kind of energy and environmental measurements in buildings
- State-of-the-art mobile energy bus with thermal cameras, tracer gas equipment, IAQ sensors and analysers, light and daylight measuring equipment, and a drone to perform aerial measurements
- All types of tools to simulate energy usage in buildings

Our partners

Several companies that specialise in construction and the production of energy systems for buildings.

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 has left many low-income families having to sacrifice daily essentials and social connections in order to keep a roof over their heads. It is a problem that requires strong political leadership and the support of community programs to solve.

Competitive advantage

- Experience to be able to provide detailed, first-hand accounts of the impacts of energy deprivation—from skipping meals and medication, to widespread loneliness and social isolation
- World-class capabilities to review housing and social policies

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 with industry bodies and government agencies for policy development

Capabilities and facilities

- Extensive knowledge of housing and social policies in Australia
- Close working relationships with social and housing development industries
- Links with international experts on housing policy development

Our partners

- The Cooperative Research Centre for Low Carbon Living
- The Salvation Army
- The NSW Office of Environment and Heritage
- Council on the Ageing

More information

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Conserving Energy. Saving Lives.

Modern and intelligent building technologies and design that minimise the energy consumption of commercial and residential buildings in order 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 the instance of heat-related mortality and morbidity
- Bettering health, refining comfort and delivering productivity with minimum energy consumption

Successful applications

- Expertise has been applied successfully in more than 500 large-scale building projects around the world
- Collaboration with major construction companies

Capabilities and facilities

- A fully-equipped laboratory able to perform any kind of energy and environmental measurements in buildings
- State-of-the-art mobile energy bus with thermal cameras, tracer gas equipment, IAQ sensors and analysers, light and daylight measuring equipment, and a drone to perform aerial measurements
- All types of tools to simulate energy usage in buildings

Our partners

Several companies that specialise in construction and the production of energy systems for buildings.

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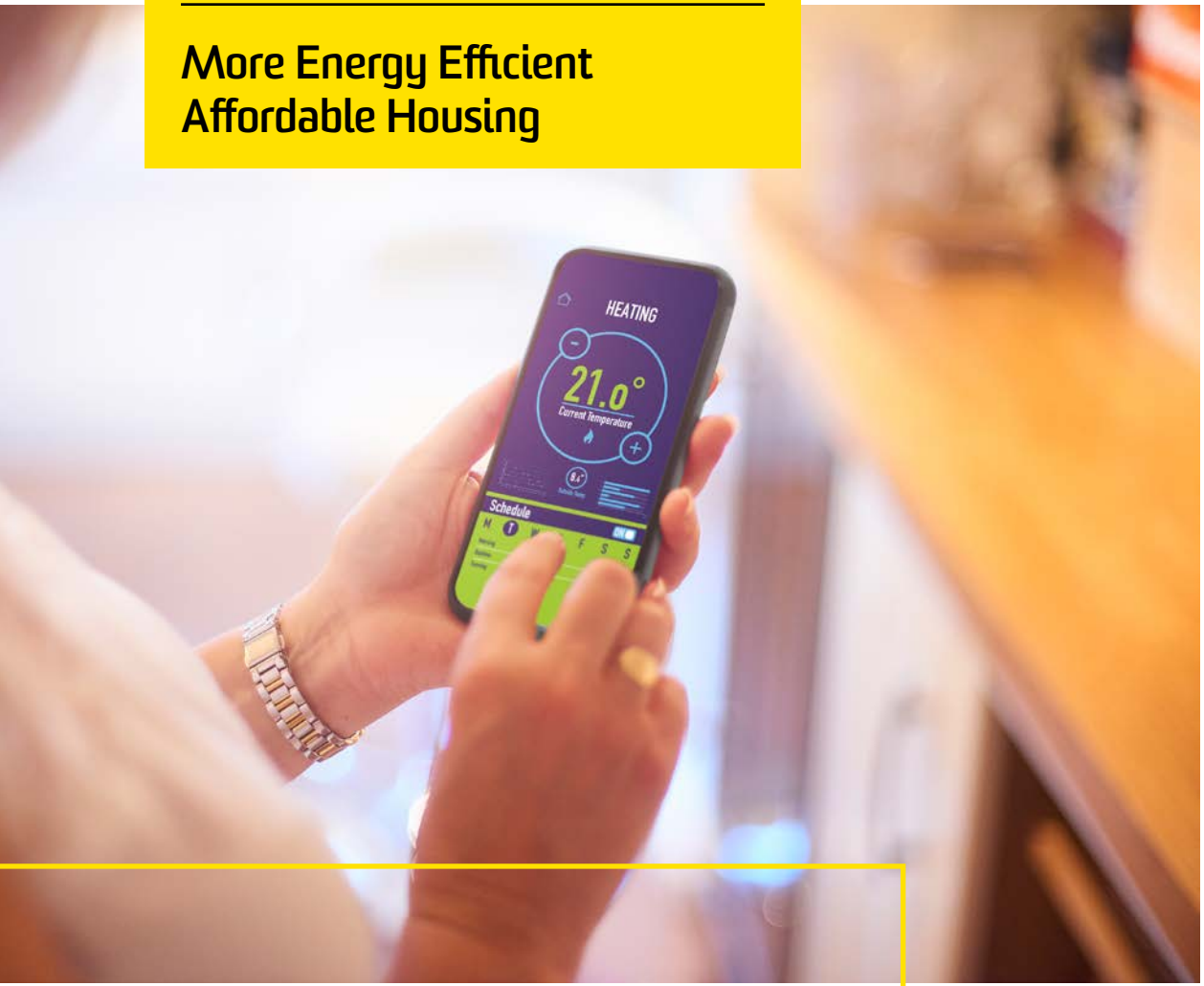
More Energy Efficient Affordable Housing



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 do already exist, barriers continue to constrain the full potential of industry to deliver outcomes.

Competitive advantage

- Long-standing relationships with the affordable housing industries in Australia and overseas
- Cross-disciplinary global collaborations with academic and industry experts
- World-class capabilities in reviewing housing and social policies

Impact

- Policy change to improve industry's capacity to take up 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
- Close working relationships with housing development industries and the community sector
- Links with international experts on affordable housing policy development

Our partners

- The NSW Office of Environment and Heritage
- Cooperative Research Centre for Low Carbon Living
- CSIRO

More information

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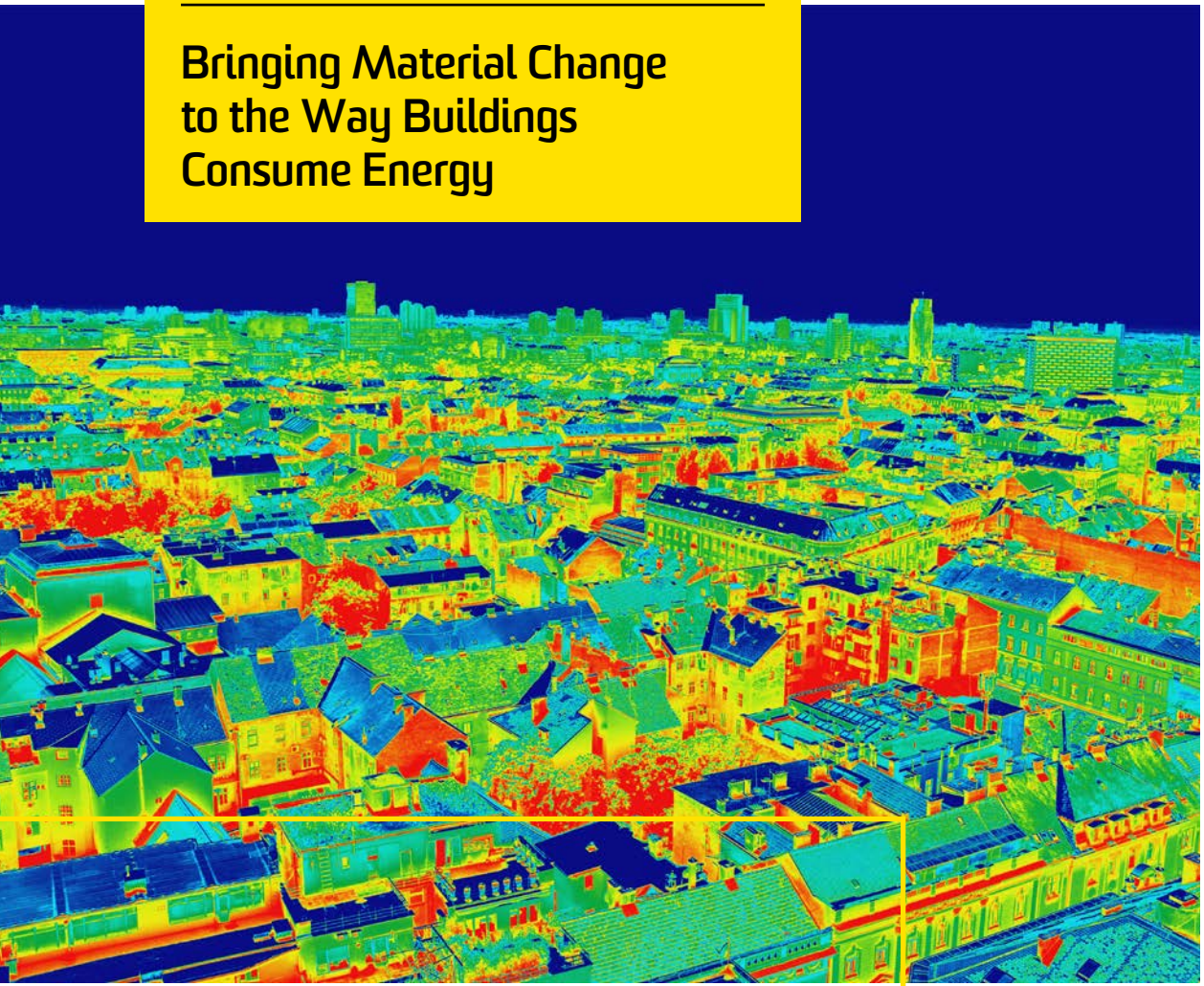
Bringing Material Change to the Way Buildings Consume Energy



More information

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

Competitive advantage

- The 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 15°C
  - Decreasing ambient temperatures by up to 2°C
  - Lowering the cooling energy consumption of buildings by up to 40 per cent

Impact

- High efficiency and low-cost materials reduce the cooling demand of buildings and cities and improve 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

- Industrial products have been commercialised all around the world
- Collaboration and testing of advanced products with many major industrial companies, like Daikin Chemicals and Isomat

Capabilities and facilities

- A fully-equipped laboratory able to perform any kind of energy and environmental measurements for the development and testing of building materials
- The lab includes a spectrophotometer to measure the spectral characteristics of materials
- An accelerating ageing chamber to perform ageing studies
- Equipment to measure emissivity, thermal conductivity and many other optical and thermal parameters of materials
- Thermal cameras and other thermal measuring equipment

Our partners

Several construction companies, and companies producing energy systems for buildings.

Chilling with Lower Billing

Using heat modulation and dissipation technologies to provide thermal comfort in buildings, without the use of air conditioning.

Competitive advantage

- Specialists in decreasing the cooling energy consumption of buildings, improving indoor thermal comfort and environmental quality
- Proven ability to:
  - Decrease annual cooling energy consumption by up to 80 per cent
  - Reduce cooling-related carbon emissions by up to 60 per cent
  - Lower indoor pollutants by up to 90 per cent

Impact

- Producing better thermal conditions in buildings while using significantly less energy
- Reducing heat-related mortality and morbidity across the planet

Successful applications

Numerous worldwide applications in residential and commercial buildings.

Capabilities and facilities

- A fully-equipped laboratory able to perform any kind of energy and environmental measurements for the development and testing of passive cooling technologies
- State-of-the-art mobile energy bus with thermal cameras, tracer gas equipment, IAQ sensors and analysers, light and daylight measuring equipment, and a drone to perform aerial measurements
- All types of energy simulation tools for assessing the performance of buildings

Our partners

- Avax
- Cybarco
- Many international construction companies

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 analysis of energy systems to enhance energy efficiency and renewable energy integration, technical and economic optimisation.

Impact

- Step changes in energy performance through the integration of highly optimised efficient and 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 program for CRC for Low Carbon Living – many successful projects taken up by industry
- Algorithms to predict energy demand and solar system performance for individual dwellings were adopted by an industry partner
- Highly efficient fluid handling systems for HVAC in Buildings – optimised HVAC design, adopted by industry partner
- Highly efficient solar thermal, PVT fluid handling systems – world record COP for solar pool heating implemented with industry partner
- Energy efficient building modelling and designs adopted by industry partners

Capabilities and facilities

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

Our partners

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

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 bring optimum value with minimum capital outlay and operating cost
- Proven ability to:
  - Reduce annual energy consumption and carbon emissions by up to 100 per cent
  - Decrease indoor pollutants by up to 90 per cent
  - Improve indoor thermal comfort by up to 70 per cent

Impact

- Minimising the carbon emissions of residential and commercial buildings around the world
- Reducing heat-related mortality and morbidity across the planet

Successful applications

Technology and design of more than 50 large-scale zero-energy building projects worldwide.

Capabilities and facilities

- A fully equipped laboratory able to perform any kind of energy and environmental measurements in buildings
- State-of-the-art mobile energy bus with thermal cameras, tracer gas equipment, IAQ sensors and analysers, light and daylight measuring equipment, and a drone to perform aerial measurements
- All types of energy simulation tools for assessing the performance of buildings

Our partners

- Several construction companies, and companies producing energy systems for buildings, including:
  - ABB
  - Daikin Chemicals
  - FIBRAN
  - 3E
  - AVAX

More information

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The Science Behind Building Compliance

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 countries around the world
- Specialists in reducing energy consumption in the building sector
- Experts in improving thermal and visual comfort, productivity and environmental quality across the building sector

Impact

- Track record of delivering significant decreases in energy consumption and carbon emissions
- Contributing to the development of legislative codes that define the energy consumption, cost, environmental quality and carbon emissions of buildings across the world
- Reducing heat-related mortality and morbidity across the planet

Successful applications

Collaboration with many Governments and Regional Authorities, including the European Commission and Government of Greece.

Capabilities and facilities

- A fully equipped laboratory able to perform any kind of energy and environmental measurements in buildings
- State-of-the-art mobile energy bus with thermal cameras, tracer gas equipment, IAQ sensors and analysers, light and daylight measuring equipment, and a drone to perform aerial measurements
- All types of energy simulation tools for assessing the performance of buildings

Our partners

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

More information

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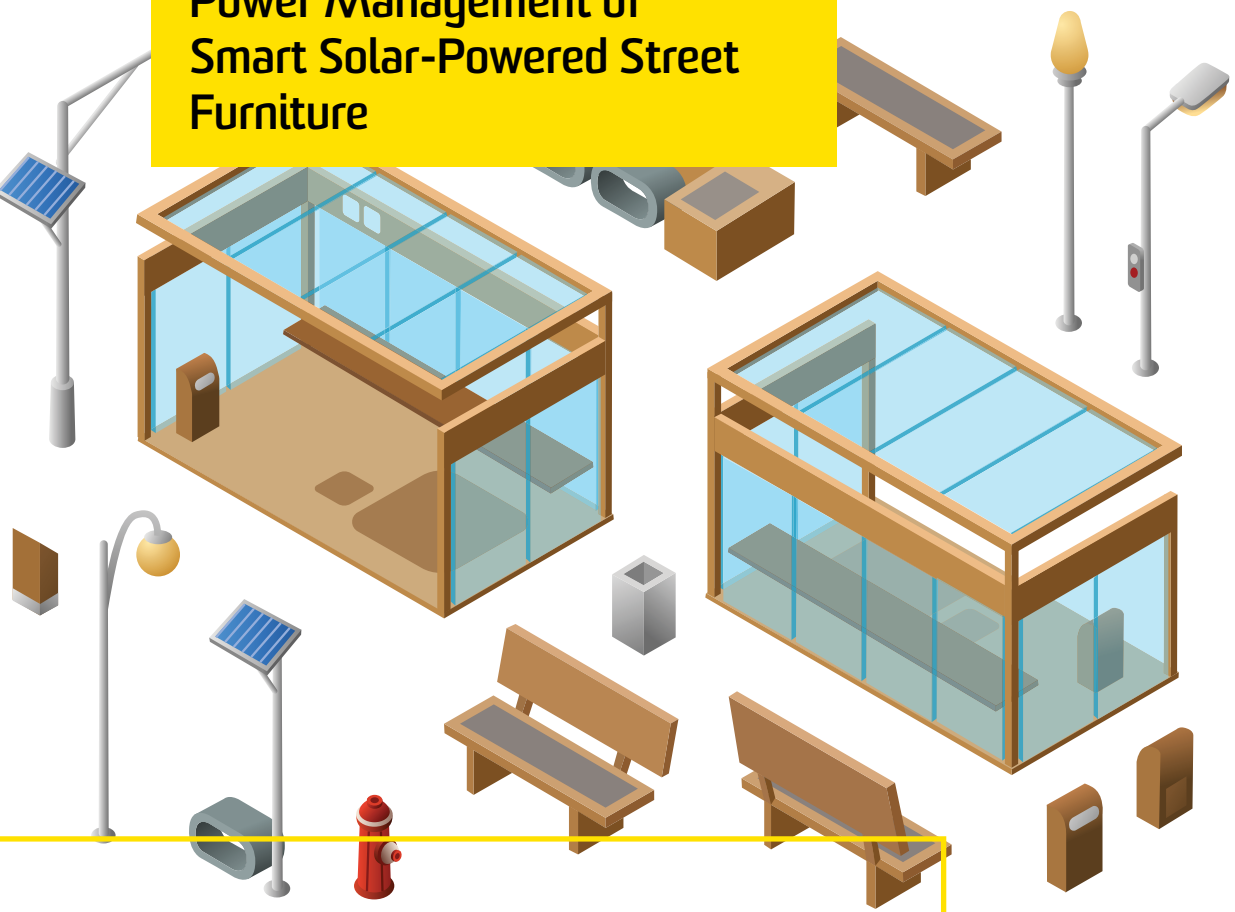
Power Management of Smart Solar-Powered Street Furniture



Developing schemes to manage the power requirements of solar-powered street furniture—such as traffic/warning signs, street lights, 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 schemes for 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 given 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 battery and supercapacitor tester with environmental chamber

Our partners

- Hi-Vis

More information

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Creating Zero and Positive-Energy Communities

Designing procedures and developing technologies to optimise energy conservation and renewable energies in communities across the world.

Competitive advantage

- World-leading expertise in the use of 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 per cent

Impact

Zero-energy communities provide sustainable, healthy environments with a reduced need for capital investment and lower running costs.

Successful applications

- The design and implementation of technologies for 4 zero-energy communities in Cyprus, Italy, France and the UK

Capabilities and facilities

- A fully-equipped laboratory able to perform any kind of energy and environmental measurements for the development and testing of mitigation technologies
- State-of-the-art mobile energy bus with thermal cameras, tracer gas equipment, IAQ sensors and analysers, light and daylight measuring equipment, and a drone to perform aerial measurements
- All types of energy and environmental simulation tools for cities and building projects

Our partners

- Several construction companies, and companies producing energy systems for buildings, including:
    - OPAC 38
    - British Gas
    - ABB
    - Fibran

More information

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Decreasing 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 3°C
  - Up to 40 per cent less energy consumed to cool buildings

Impact

- Producing better thermal conditions in cities while consuming a great deal less energy
- Significant reduction in heat-related mortality and morbidity

Successful applications

Implemented in about 100 large-scale mitigation projects all around the world.

Capabilities and facilities

- A fully-equipped laboratory able to perform any kind of energy and environmental measurements for the development and testing of mitigation technologies
- State-of-the-art mobile energy bus with thermal cameras, tracer gas equipment, IAQ sensors and analysers, light and daylight measuring equipment, and a drone to perform aerial measurements
- All types of energy and environmental simulation tools for cities and building projects

Our partners

- Energy Efficiency Council
- Government of NT
- City of Parramatta
- Bluescope

More information

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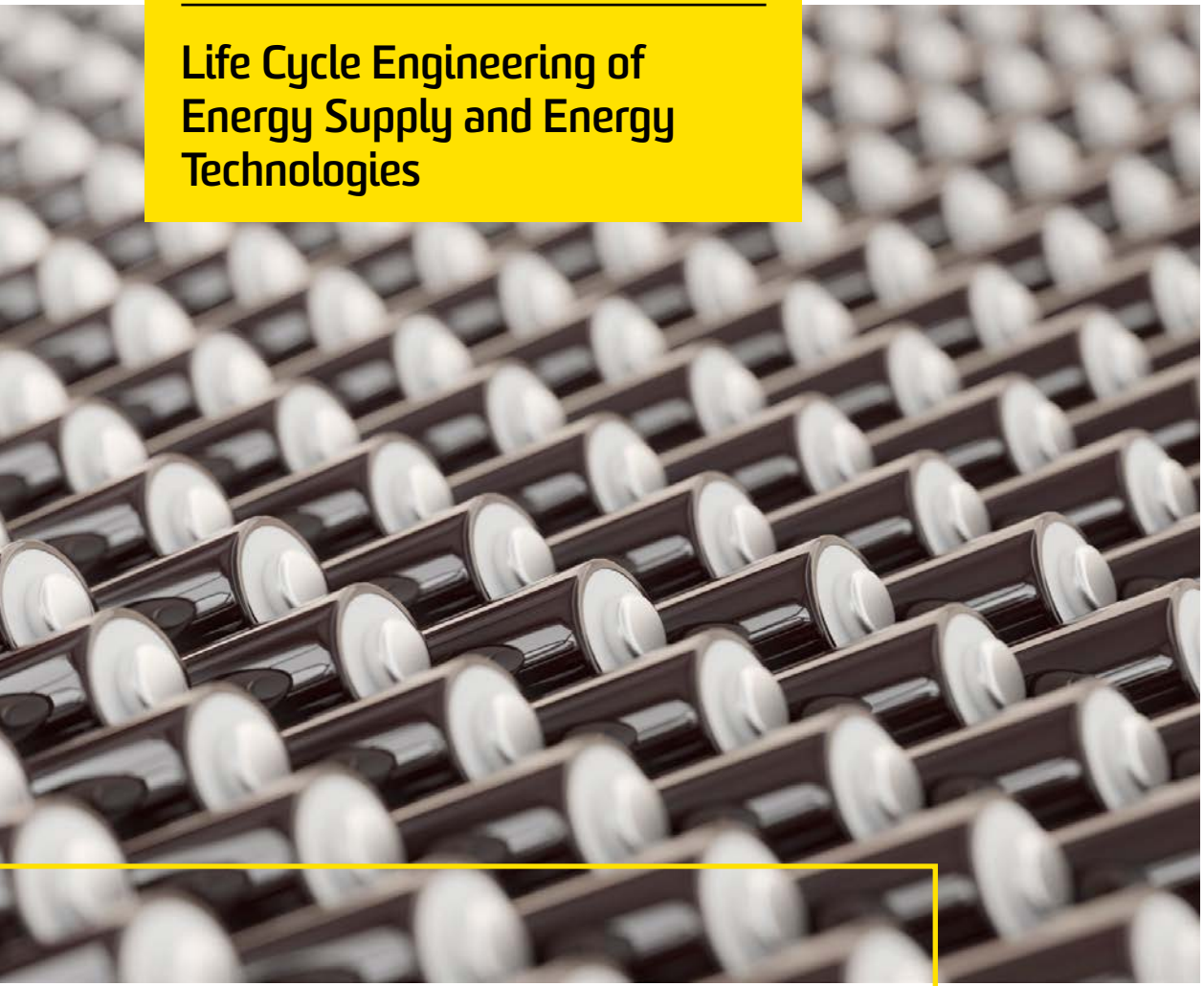
Life Cycle Engineering of Energy Supply and Energy Technologies



Expertise across sustainable manufacturing, sustainable 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 first in the world developing hands-on capability in:

- Holistic energy efficiency assessment in manufacturing
- Renewable energy integration into factories through micro-grids
- 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

Saving of millions of dollars for the manufacturing industry.

Successful applications

- Implementation of energy efficiency technology
- Achieving industry-wide impact through helping NSW government as an invited expert advisor for energy efficiency program
- Contributing technical expertise in the Australian Government industrial energy efficiency program

More information

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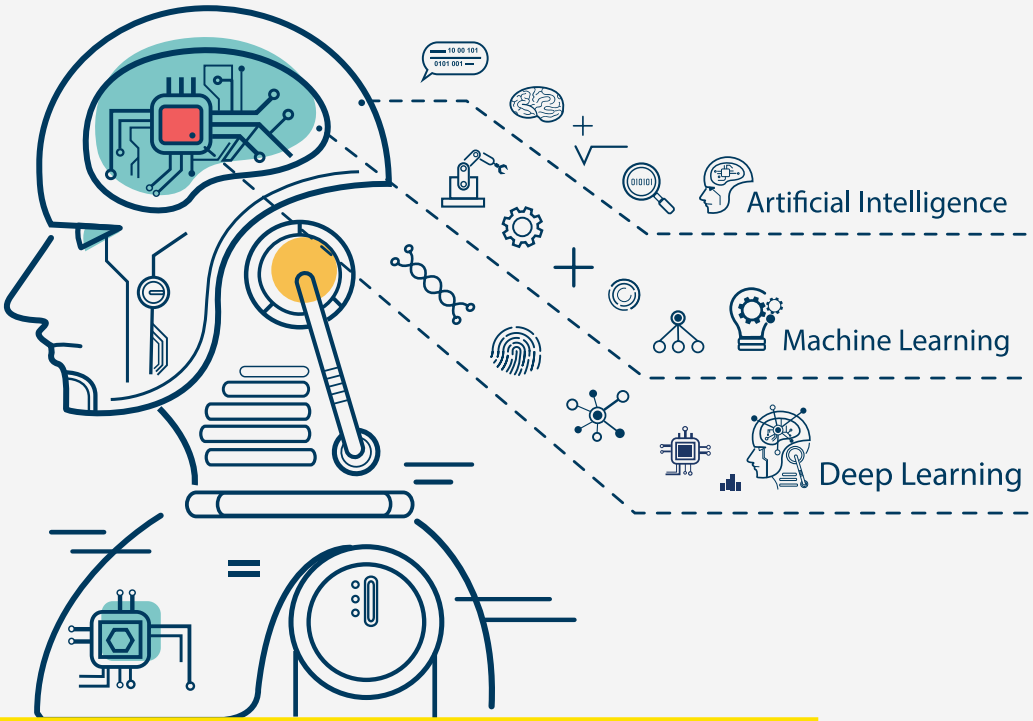
Knowledge Data Analytics



An internationally leading capability in the storage, analytics, visualisation and security of data and models, with vast experience in delivering impactful systems and solutions across multiple domains.

Competitive advantage

- Novel, holistic approach to managing data storage, indexing, querying processing, and optimising
- State-of-the-art solutions to analyse various types of data for descriptive and predictive applications
- Flexible and powerful interface to interact with intelligent applications, including visualisation, and explaining predictive models for enhance understanding and to aid debugging
- Expert in the detection of unknown adversarial attacks, including adaptive white-box attacks, and in 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 who are vulnerable to cyber-attacks

Capabilities and facilities

- Large scale data processing and modelling platform

Our partners

- CRC

More information

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Data-Driven Integrative Intelligent Systems

Expertise in machine learning, data mining and deep learning. Leading in the field of multi-source data analytics, especially on the topics of information filtering and recommending, false online information detection, human activity recognition and prediction and human-machine interactions.

Competitive advantage

- Developing novel data mining and machine learning algorithms to conduct effective data analytics by discovering useful and actionable patterns from heterogenous multi-source data
- Experience in designing and building systems and tools to enable and improve various data analytics applications in health care, cyber security and smart cities

Impact

- Advanced algorithms for improved automation and better support for human-autonomy partnership
- World-class data analysis for improved collaborative reasoning and decision-making process

Successful applications

- Trust-aware distributed AI autonomy
- Context-aware intent prediction for human-autonomy cooperation
- Improving resilience of autonomous cyber defence systems with self-healing
- Opinion fraud detection
- Thing-of-interest recommendation in the Internet of Things

Capabilities and facilities

- GPU-accelerated Data Analytical Platform

Our partners

- Raiz Invest Limited
- Office of Naval Research, US Department of Naval
- Defence Science and Technology Group
- Data to Decisions CRC

More information

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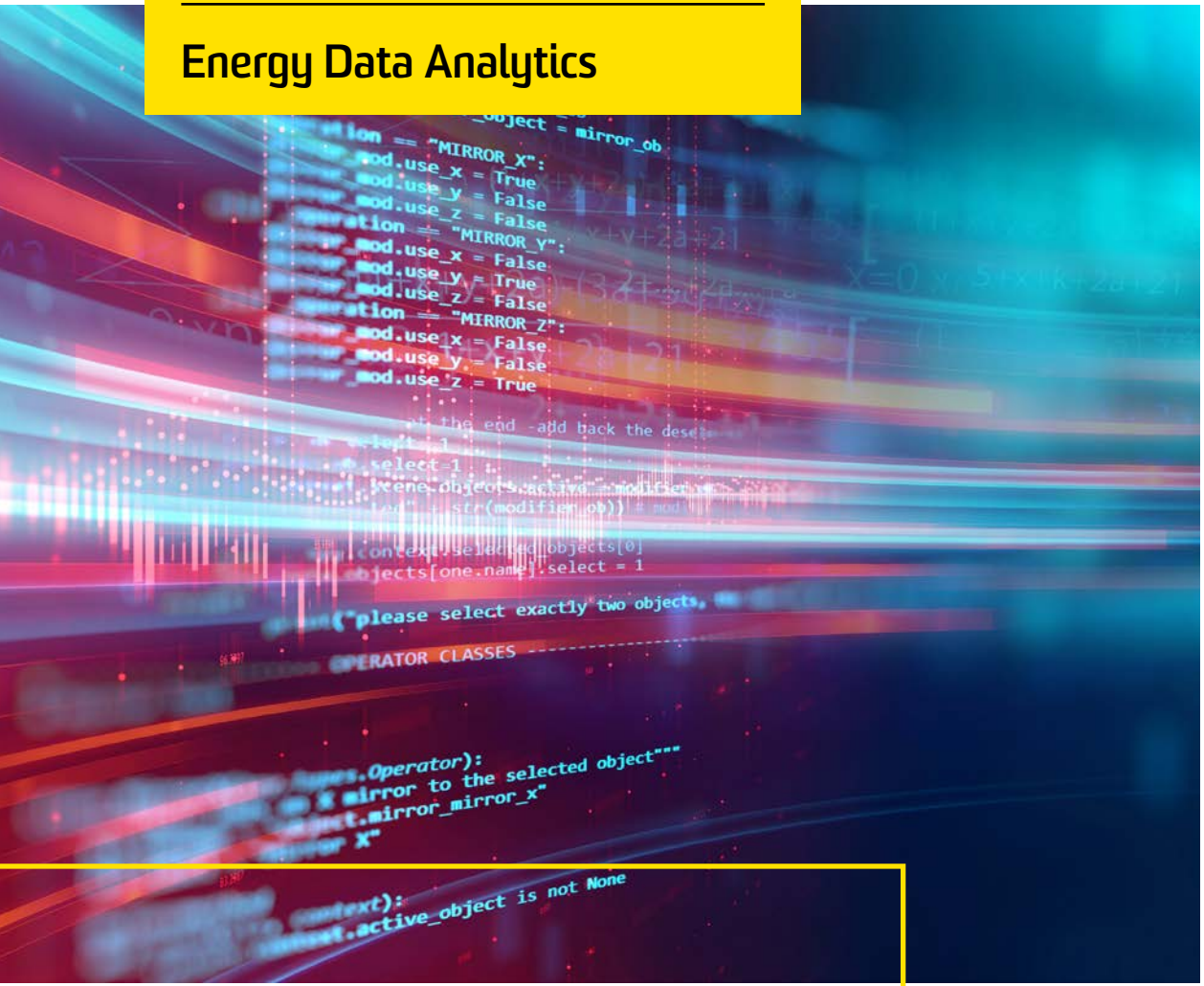
Energy Data Analytics



Using live and historical data we are conducting research into live energy consumption, generation and grid-side voltage and frequency to increase grid stability with increased uptake of distributed energy resources such as rooftop solar.

Competitive advantage

- Australia leads the world in the uptake of rooftop solar, with over 1 in 5 freestanding homes being powered by the sun
- Established relationships with start-up companies, industry associations, networks, the energy regulator (AER) and the market operator (AEMO)
- International award-winning online platform for knowledge sharing

Successful applications

- Reports by the market operator (AEMO) on the response of distributed energy resources in the event of market disturbances
- Research outcomes are being used to inform the establishment of standards and system models by lead organisations (AER and AEMO)
- Research outcomes being used in open source platforms with significant exposure, attracting more than 10,000 site visits per month

Capabilities and facilities

- Open source models
- Online platform for knowledge sharing

Our partners

- The Australia PV Institute
- Solar Analytics
- Australian Energy Market Operator

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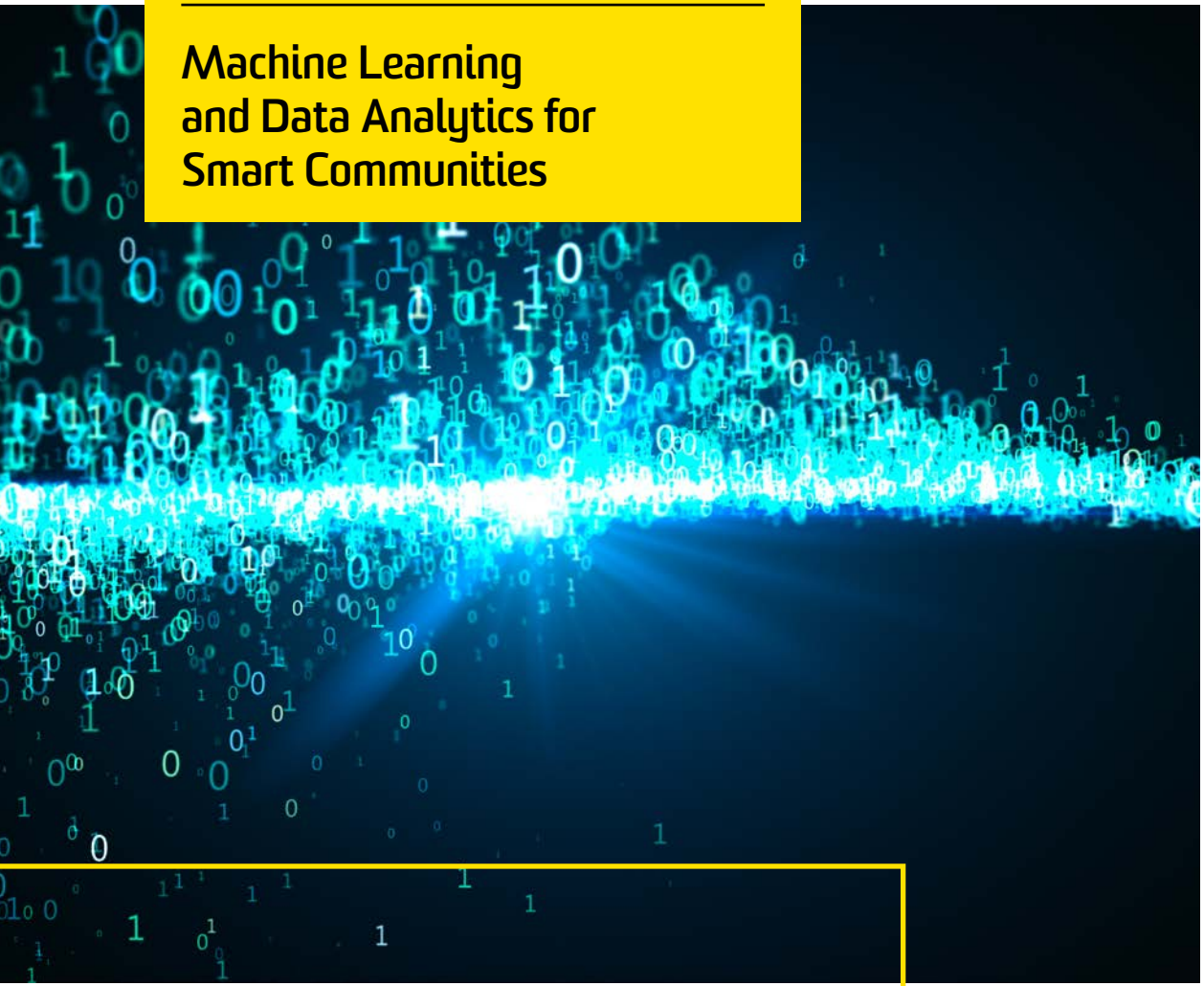
Machine Learning and Data Analytics for Smart Communities



Mining actionable insights from the massive volumes of data in smart communities and using IoT and data analytics to facilitate smart digital health and energy systems.

Competitive advantage

- The most cost-effective way to maximise the value of industrial big data
- Rich and extensive experience in dealing with a variety of problems for smart communities, in particular energy and health
- Agile implementation and flexible deployment
- World-class, high efficiency algorithms, data analytics and cyber-security solutions supported by IoT enabled sensors and cloud technologies

Successful applications

- Smart Grid Smart City national demonstration project
- Energy Internet project
- Customer data disaggregation framework based on IoT sensor systems
- Time-series data forecasting and uncertainty assessment
- Machine learning algorithms and very fast deep learning algorithms for complex system security assessment
- Residential demand simulator based on behavioural models
- Fault diagnosis and monitoring through operational data

Capabilities and facilities

- Package of machine learning and data analytics tools, both opensource and in-house developed
- IoT enabled monitoring hardware devices and associated data management system

More information

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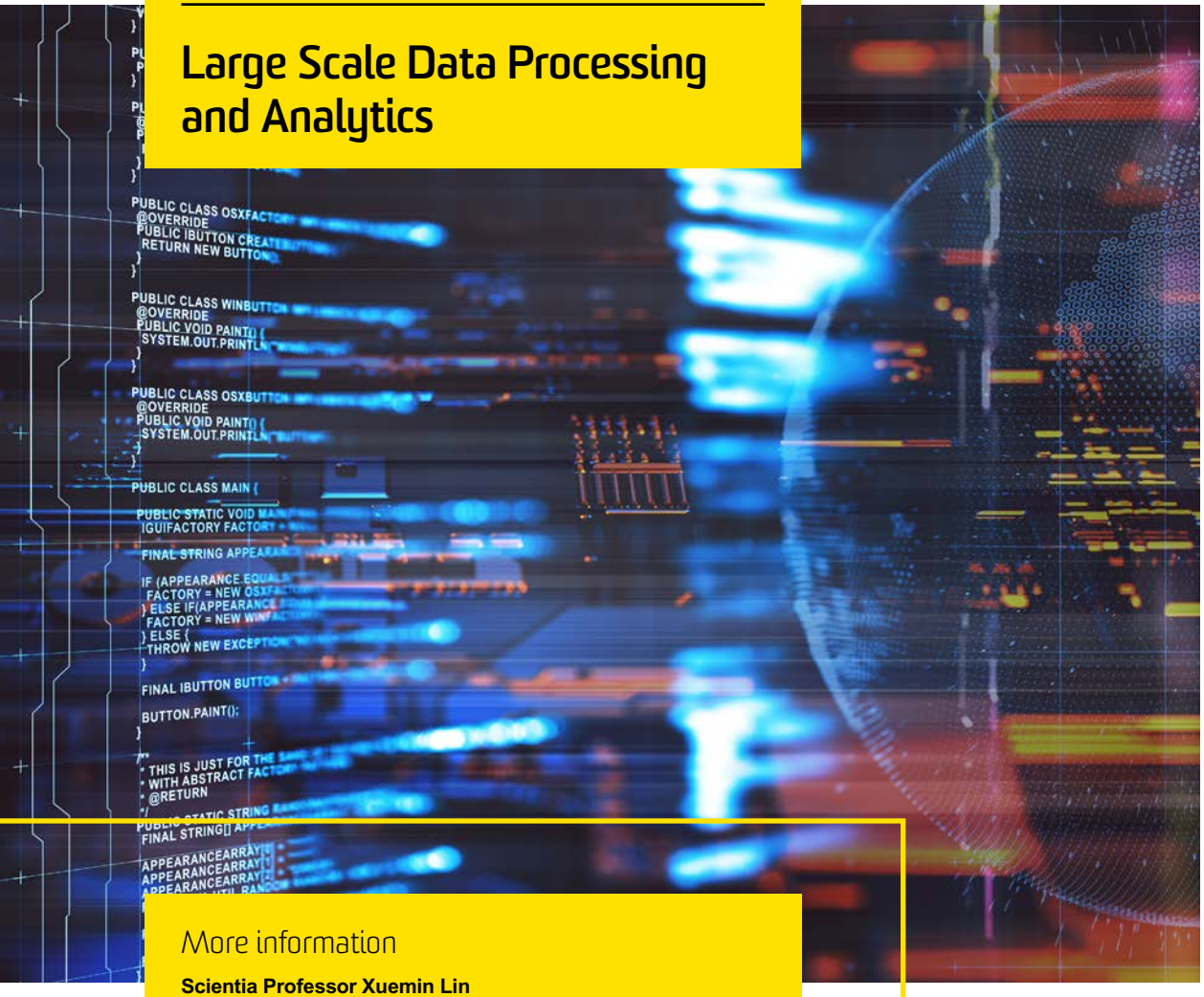
Large Scale Data Processing and Analytics



World-leaders in developing efficient and effective processing and analysis techniques for large-scale data, especially graph/network data, geo-spatial data, streaming data and uncertain data.

Competitive advantage

- Large-scale graph/network data storage and indexing
- Innovative, structure-based query processing over graph/network data
- Expertise in social network analysis
- Ability to query multi-dimensional data
- Ability to process queries over moving objects
- Experience with Computing Order Statistics over Data Streams
- Highly skilled at processing probabilistic queries over uncertain data

Impact

- More effective models to analyse large-scale data
- More efficient and scalable processing techniques to process large-scale data

Successful applications

- Spam and fraud detection in E-commerce networks (Alibaba Group)
- Developing Large Scale Distributed Graph Processing Platform (Alibaba Group)
- Anomaly detection in communication networks (HUAWEI)
- Optimal Paths with Multi-sources and Traffic Flows in Road Networks (HUAWEI)
- Taming Uncertainty of Distributed Data (Google)
- Processing of large graphs (ARC Discovery Project 2014, 2015, 2017, 2018)
- Multi-dimensional and spatial data processing (ARC Discovery Project 2012, 2015)

Capabilities and facilities

FIP - High-performance GPU accelerated large-scale data processing.

Our partners

- Google
- Alibaba Group
- HUAWEI

More information

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Consumer Data Right

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

Competitive advantage

Vast experience in both regulatory compliance and marketing response.

Impact

Worked with the ACCC and Treasury in the development of Consumer Data Right thinking.

Successful applications

- Professor Pamela Hanrahan is one of Australia's leading authorities on financial services law and regulation and provided significant support to the Hayne Royal Commission
- Professor Peter Leonard is recognised globally for his work on data governance
- Kayleen Manwaring is a leading thinker on the consumer aspects of data beyond privacy

Capabilities and facilities

- The research network has members across a variety 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 partners

- Energy Consumers Australia

More information

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OUR CENTRES AND FACILITIES

UNSW Energy Institute

UNSW Energy Institute coordinates energy activities across UNSW and collaborates with industry, government, community stakeholders and other research institutions. The Institute draws on the vision and work of UNSW's energy researchers based in the Tyree Energy Technologies Building and the Faculty of Engineering, working together with colleagues around the University from faculties such as Arts and Social Sciences, Science, Built Environment and Law. This allows the space to contribute to the development of new technology, policy advice, and the public's understanding of the challenges and opportunities facing Australia as it undergoes major energy transition. This coordination allows UNSW to take a 'system of systems' multi-disciplinary view of energy.

Tyree Energy Technologies Building (TETB)

Tyree Energy Technologies Building (TETB) is a showcase, award-winning, six-star energy efficient building costing over $130 million. The TETB houses the School of PV and Renewable Energy Engineering, Petroleum Engineering, the Centre for Energy and Environmental Markets, the Cooperative Research Centre for Low Carbon Living, the Particles and Catalysis Research Laboratory, the Real Time Digital Simulation Lab, a vanadium redox flow battery and an 800kW trigeneration plant. TETB is also a "living lab" for researchers studying the building's power production and consumption, water utilisation and human interaction. More than 300 students, academics and researchers use the building each day.

ARC Research Hub for Integrated Energy Storage Solutions

ARC Research Hub for Integrated Energy Storage Solutions, formally launching in 2019, is a 4-year, $12m nationally significant program in partnership with industry and other research institutions. Research projects include: novel and conventional batteries and supercapacitors; novel fuel cells; power-to-gas; virtual storage (demand response); and systems control and optimisation.

UNSW Digital Grid Futures Institute

UNSW Digital Grid Futures Institute launched in 2018 to future-proof global electricity systems, ensuring reliable, secure, affordable, sustainable electricity for economic advancement and transport. Research addresses five key priorities for the electricity grid of the future, including: energy storage; the electrification of transportation; robust physical connections across the grid; open yet secure cyber connections, and supportive socio-political, economic, regulatory and legal frameworks.

Real-Time Digital Simulation (RTDS) Laboratory, UNSW

Real-Time Digital Simulation (RTDS) Laboratory, UNSW is the largest RTDS laboratory in Australia, and one of the largest in the world, with extended simulation capabilities in the areas of high-voltage DC networks, power system protection testing, smart grids, microgrids, renewable energy systems, distributed generation, power electronics, control system testing, and hardware-in-the-loop testing.

Particles and Catalysis Research Laboratory (PartCat), UNSW

Particles and Catalysis Research Laboratory (PartCat), UNSW is one of the best catalyst/ photocatalyst fabrication and characterisation facilities available in Australia. It hosts state-of-the-art equipment dedicated to heterogeneous catalysis/photocatalysis research. It has been funded over $25 million by the ARC programs and industries for research centred on particle and catalysis projects.

Materials Energy Research Laboratory in Nanoscale (MERLin)

Materials Energy Research Laboratory in Nanoscale (MERLin) is an energy research laboratory used to research use of hydrogen as a clean energy vector, and fully equipped for the development and characterisation of hydrogen storage materials and fuel cells.

The Mark Wainwright Analytical Centre (MWAC)

The Mark Wainwright Analytical Centre (MWAC), UNSW houses contemporary instruments for materials characterisation, including vibrational spectroscopy, SEM, TEM, XRD, XPS etc. It features world-leading magnetic resonance facilities, including high-resolution solid-state NMR up to 700 MHz and X-band EPR.

The German-Australian Alliance for Electrochemical Technologies for the Storage of Renewable Energy

A joint international research alliance for stationary energy storage (CENELEST) has been established by UNSW and The Fraunhofer Institute for Chemical Technology (ICT). The alliance aims to strengthen the world-class expertise in redox flow batteries, and concurrently develop other types of batteries and fuel cells in order to cover the entire range of electrochemical energy storage needs for renewable energy.

The Centre for Energy and Environmental Markets

The Centre for Energy and Environmental Markets is devoted to studying the challenges and opportunities of clean energy transition within market-oriented electricity industries. Key aspects of this transition are the integration of large-scale renewable technologies and distributed energy technologies (generation, storage and 'smart' loads) into the electricity industry.

Flow Battery Research Laboratory, UNSW

Flow Battery Research Laboratory, UNSW is a world leading facility for research into vanadium and other flow battery technologies.

Vanadium Redox Batteries

Vanadium Redox Batteries (30 kW/120 kWh) are installed in the Ground Floor of the Tyree Energy Technologies Building, UNSW.

UNSW laboratory facilities of Chief Investigator Da-Wei Wang

The UNSW laboratory facilities of CI Da-Wei Wang for battery testing, demonstration and integration including lab-scale coin cell and pouch cell fabrication.

ARC Training Centre for Fire Retardant Materials

ARC Training Centre for Fire Retardant Materials aims to create knowledge in novel green flame retardants, advanced fire models, innovative fire suppression technologies and new flammability fire tests. It gears to accelerate the transformation of Australia's industries in producing new fire-retardant materials, high-value products and engineering services.

UNSW Electric Vehicles

UNSW has three electric vehicles and electric vehicle charging equipment and research.

SHORT COURSES

At UNSW, we offer high-quality professional education for real-world impact. Through our program of short courses, we deliver learning outcomes to support our partners to deliver excellence.

We work with our partners to identify strategic goals, and then design and develop—or tailor existing—courses to match. This collaboration results in academically rigorous and culturally relevant learning that drives business improvements.

The standard range of short courses we offer can be found online, or if have specific requirements our specialist team is available for discussion and will provide support from concept to completion.

Transitioning to a clean energy future
The Business of Solar and Clean Energy program offers an opportunity for participants to appreciate the status of renewable energy technology, policy and its current state of implementation in Australia. Participants will be exposed to the many unprecedented business opportunities solar and clean energy offer, with a focus on the Australian market. This professional development program investigates renewable energy, the photovoltaic industry, climate change, energy efficiency, policy aspects and the Paris Agreement. It includes visits to world-class laboratories and industrial laboratory facilities, and content is delivered by a wide range of UNSW experts.

Renewable energy technology and renewable energy grid connections
In an era dominated by sustainability and decarbonisation, the power generation sector—responsible for the industry's highest emissions—is transitioning to renewable energy. This course covers the knowledge and skills related to renewable technology and grid connections with which professionals need to be equipped. It combines theoretical knowledge and hands-on practice in key topics such as global emissions review; renewable energy technologies– hydro, wind, solar, geothermal and hydrogen; renewable energy characteristics; and renewable energy grid-connection studies.

Popular energy storage technologies and their utilisation
As the next surge of investment engulfs the energy sector, energy storage—which can provide essential firming capacity and support for the power grid—is gaining momentum. This course will cover the key energy storage technologies, their advantages and disadvantages, suitable application scenarios, technological trends, policy and regulatory development regarding energy storage, and will provide examples of grid support application.

Electrifying industries and transport
Electrification to increase efficiency and lower emissions is becoming a universal trend for industry and transportation systems. In this course, participants will cover electrification use scenarios and system design, electric vehicles and fuel cell technologies, the impact of electric vehicles on the power grid, high energy efficiency ship and aeroplane electrification and major industrial advances in this area.

Policy, markets and consumers
To maintain system security while achieving the highest social benefit and lower costs, the energy industry has been undergoing deregulation. Participants will cover the fundamentals of energy market deregulation; market structure, design, and simulation; risk management; the regulatory framework; peer-to-peer trading; gas and electricity co-planning; and demand side management.

For more information, please visit shortcourses.unsw.edu.au
or email shortcourses@unsw.edu.au

WORKING WITH UNSW

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 Knowledge Exchange 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.


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