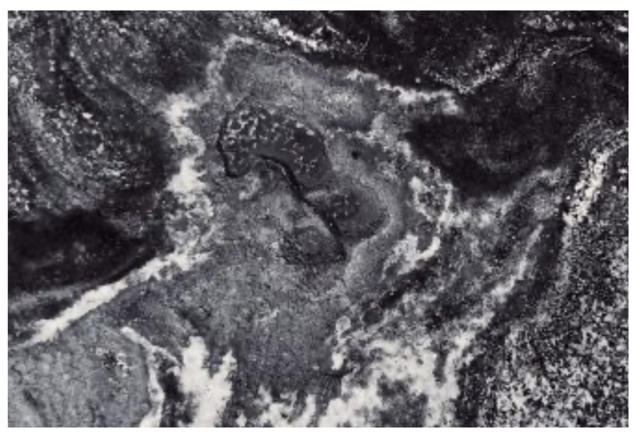
Solar at UNSW

Striving towards 30% solar PV cell efficiencies and 30c per watt capital costs at scale

UNSW is striving to develop solar technology that can deliver 30% photovoltaic cell efficiencies and 30c per watt capital costs at scale. Achieving these goals will maintain Australia's global position as a world leader and record-breaker in solar photovoltaics. We are focused on securing solar photovoltaics as the dominant new energy generation over the next decade by driving down its cost and enabling integration of solar with households, industries and networks. Beyond 2030, we are also exploring solar-powered hydrogen and concentrated solar thermal. To achieve these goals, we are focused on research and development in four key areas:

Improving solar PV manufacturing in partnership with industry to improve the overall performance and reliability of modules

Modules



Exploring new materials that will become the next generation of solar cells including perovskite and organic solar cells

Materials

Developing practical processing technologies to allow for the recovery and recycling of valuable materials from used panels

Stewardship

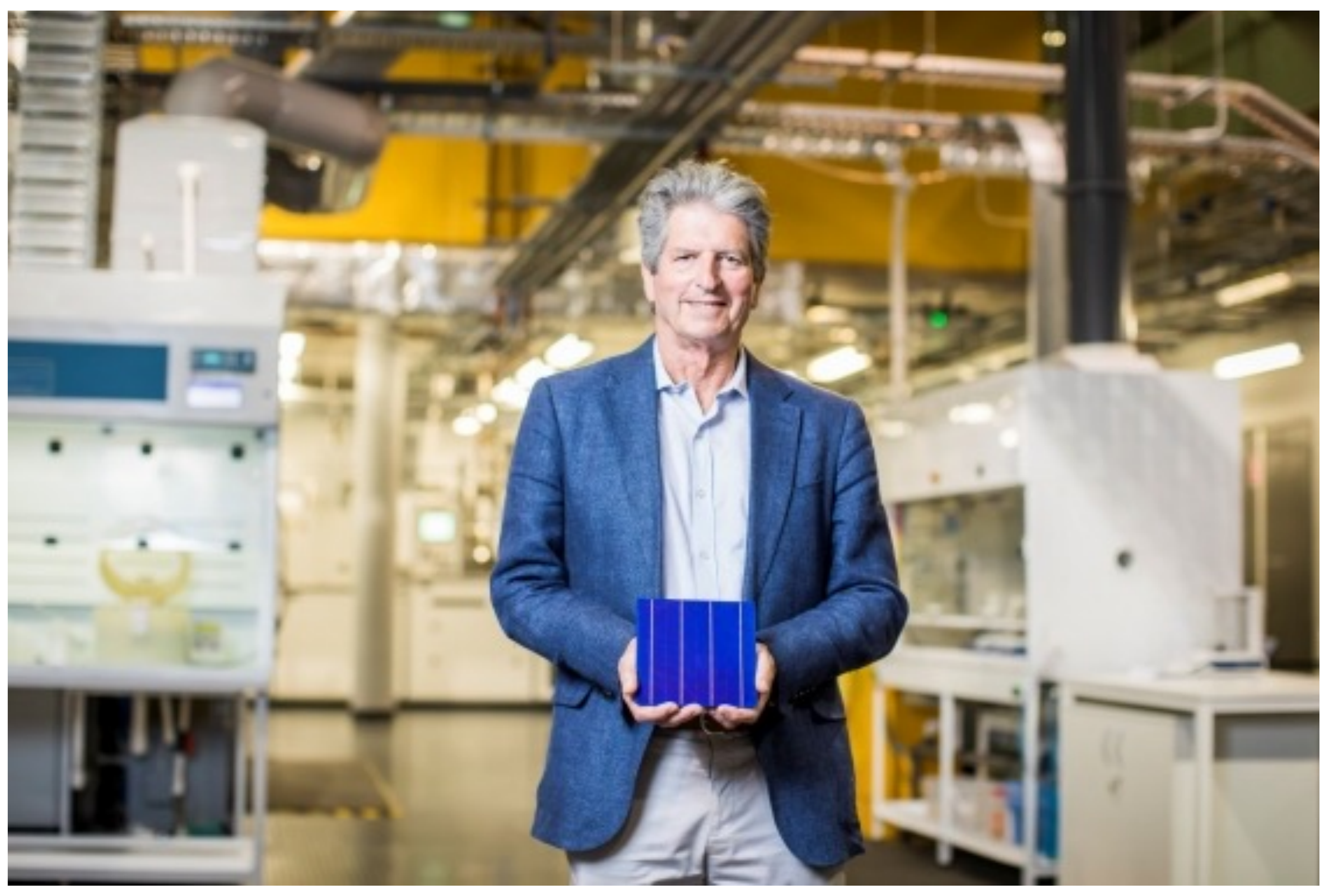
Developing datasets, models and tools to improve planning and operation of electricity grids with high levels of variable renewable energy

Integration

Key initiatives

UNSW leads the Australian Centre for Advanced Photovoltaics (ACAP). ACAP is developing the next generations of photovoltaic technology, providing a pipeline of opportunities for performance increase and cost reduction.

ACAP brings together six Australian research groups, under the leadership of UNSW's School of Photovoltaic and Renewable Energy Engineering. The leading research groups work directly with industry participants for a pipeline of research impact. Major industry ACAP partners are: Bluescope Steel Ltd., PV Lighthouse Pty Ltd., Raygen Resources Pty Ltd. Tindo Solar, 5B Pty Ltd. and Sundrive Pty Ltd.



Our opportunity to leverage a proven solar innovation ecosystem

UNSW is a world leader and record-breaker in solar PV engineering. In the 1980s, Professor Martin Green (left) led the development of silicon solar photovoltaic technologies, which now account for almost 90% of the global solar cell market. Our School of Photovoltaic and Renewable Energy Engineering remains the world's leading school in this field.

A key factor in the commercial success of solar technology at UNSW has been the deep relationships that have been developed with industry both through training students and by housing world-class facilities. In particular, UNSW's Solar Industrial Research Facility is a photovoltaic pilot production line allowing academics to prototype new technologies and bring them to market, faster.

We expect these facilities and our commercial partnerships to continue to drive improvements in solar photovoltaic efficiency and applications for years to come. We are also applying the principles of this innovation ecosystem to other energy capabilities at UNSW.

1) Scientia Professor Martin Green and three former PhD students were awarded the 2023 Queen Elizabeth Prize for Engineering for the development of "PERC" solar PV technology; 2) Professor Xiaojin Hao with Minister Bowen at UNSW SIRF

Energy Storage at UNSW

UNSW SYDNEY

Striving towards 1,000GWh of beneficial storage in Australia by 2050

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

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

Developing and manufacturing electro-chemical and chemical storage technologies that are lower cost and higher energy density

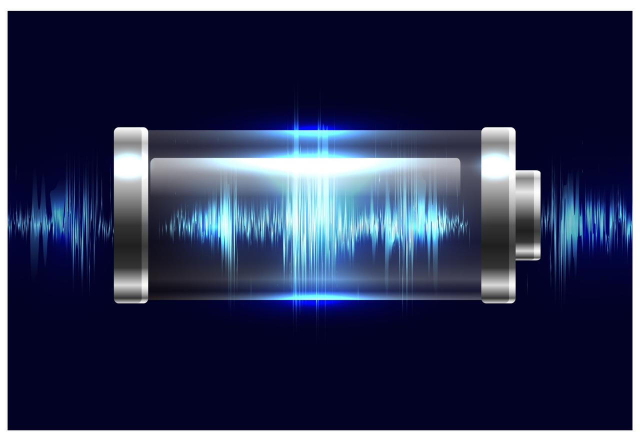
Technology

Exploring control strategies to improve the economic benefits and efficiency of storage systems for individual and grid-scale applications

Control

Exploring the future local and grid-scale needs for energy storage in markets for electricity grids (large and small) and transport

Markets



Promoting better materials, and the recycling of those materials, to reduce life-cycle emissions

Sustainability

Key initiatives

UNSW leads the ARC Research Hub for Integrated Energy Storage Solutions, which is a nationally significant program of collaborative research that applies a highly integrated systems-based approach, focusing not just on energy storage technologies and solutions (batteries, fuel cells, power-to-gas, virtual storage) but also on the monitoring, control, integration and optimisation of storage systems.

UNSW has partnered with the Fraunhofer Institute for Chemical Technology to form CENELEST is a German-Australian alliance for stationary energy storage.

UNSW also leads the ARC Research Hub for Microrecycling of Battery and Consumer Wastes, which is recovering valuable materials from waste batteries (with 90% going to landfill) and other wastes to help create national materials sustainability and accelerate efforts to reduce emissions.

ARC Research Hub for Integrated Energy Storage Solutions

CENELEST German-Australian Alliance for Electrochemical Technologies for Storage of Renewable Energy

ARC Research Hub for Microrecycling of Battery and Consumer Wastes

30kW/130kWh Vanadium Redox Flow Battery installed at the UNSW Tyree Energy Technologies Building

Our opportunity to drive the production of vanadium redox flow batteries

Flow batteries are the likely to be the most commercially viable technology for long-term energy storage in Australia. Vanadium redox flow batteries are particularly promising given the electrolyte's sustainability, durability and recoverability. Australia has some of the richest vanadium deposits in the world. The technology is proven and is ready to scale. We need to build a 10-20MWh demonstration plant, coupled with a neighbouring research facility. With this in place, we will be on track able to deliver a suite of 1-10GWh plants by 2030 that can support our major cities, future industry and regional and remote communities. UNSW holds world class expertise and facilities in Vanadium Redox Flow Batteries, which were invented by UNSW Emeritus Professor Maria Skyllas Kazacos (left) and co-workers in 1985.

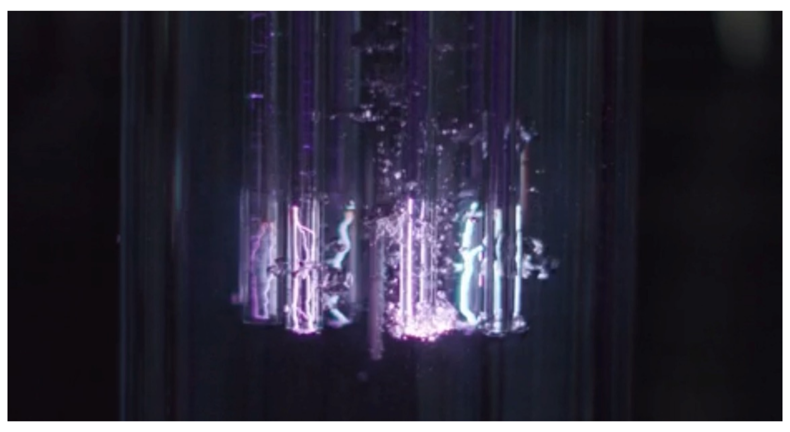
Clean Fuels at UNSW

Striving to drive down the production cost of renewable hydrogen to below $2/kg

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

Developing and manufacturing new catalysts that will drive down the cost of electrolysis for cheaper clean fuels and their derivatives

Catalysts



Investigating alternative manufacturing pathways, including using plasma, for new and existing markets, including green commodities for renewable energy export

Derivatives

Exploring disruptive low carbon and low-cost fuel technology, which could displace existing supply chains

New Fuels

GlobH2E
ARC Industrial Transformation Training Centre for the Global Hydrogen Economy

PARTCAT
Particles and Catalysis Research Group

Key initiatives

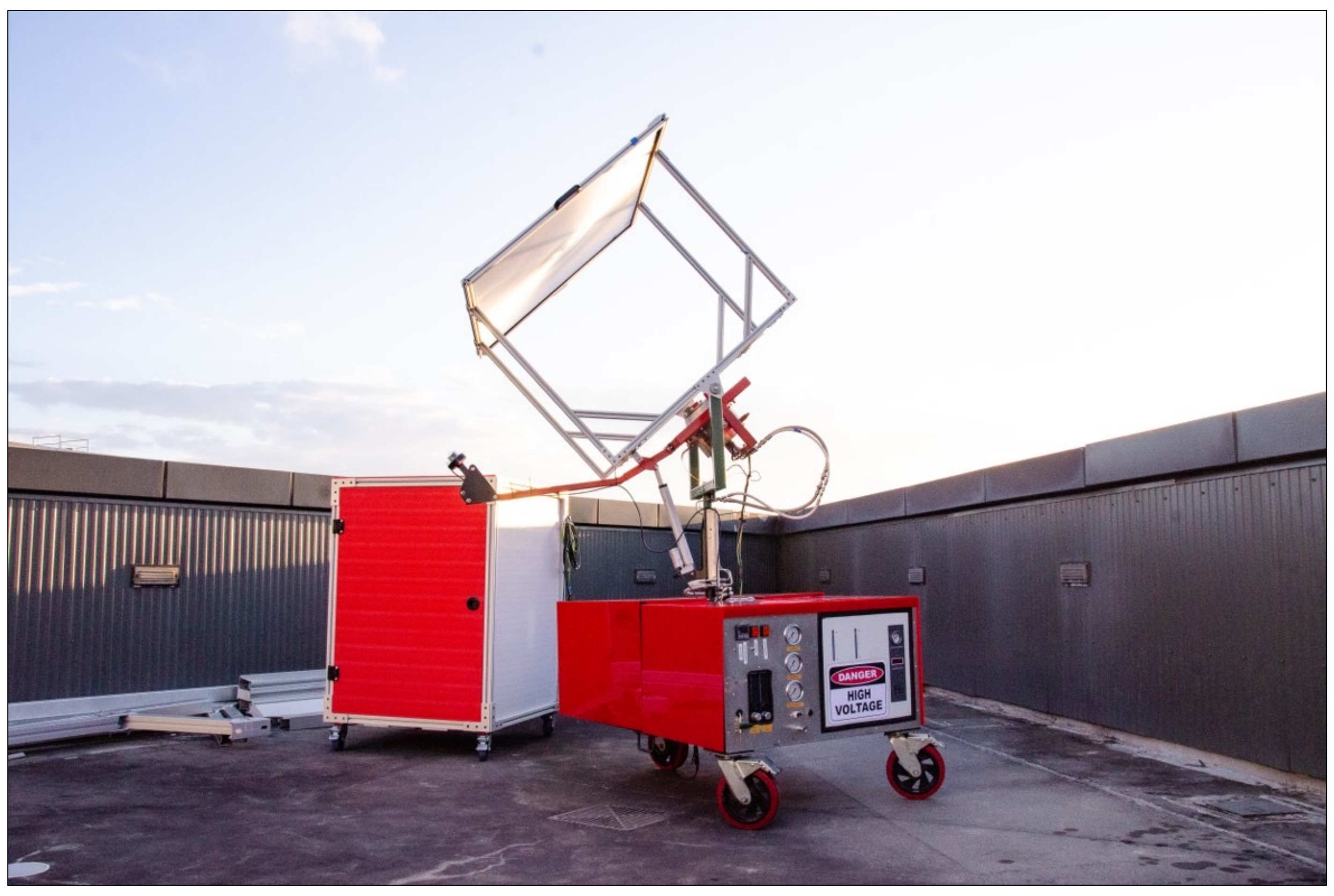
UNSW's Particle and Catalysis Research Group leads the ARC Industrial Training Centre for the Global Hydrogen Economy (GlobH2E), which is an international consortium of research institutions, industry partners, government agencies and hydrogen start-ups. The vision for GlobH2E is to support innovative, cost-effective hydrogen technologies, combined with advanced business skills, to facilitate and support Australia's transformation into a world-leading hydrogen powerhouse. GlobH2E will support the fledgling industry and the professionals who will lead it, through quality training and expertise.

Our opportunity to develop novel "Solar to X" technologies

A major challenge facing large-scale renewable hydrogen production is the cost and sustainability of electrolysis. While the International Energy Agency hopes that economies of scale will drive down these costs, UNSW is investigating new technologies that can achieve step changes in efficiency and productivity. Many of these new technologies are exploring ways to directly harness solar energy to produce hydrogen and its derivatives (including ammonia, green chemical feedstocks and fuels), known as "Solar to X".

UNSW has developed a strong pipeline of early-stage IP in this space:

1. Solar PV to drive production via electrocatalysis
2. Solar heat to activate thermal catalysts, and
3. Solar light to excite electrons, known as photocatalysis.



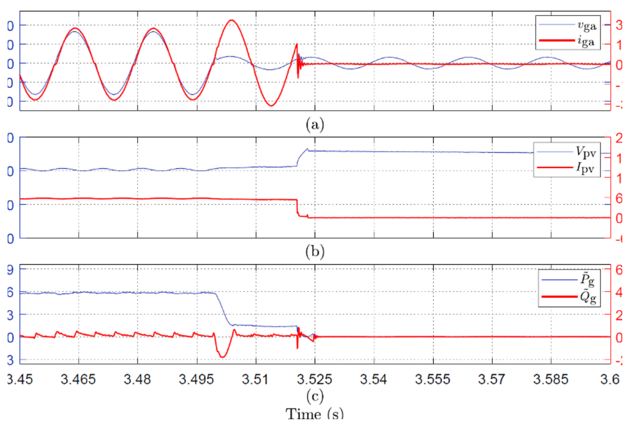
SHINE 2.0 (Solar Harvesting for Integrated New Energy) produces hydrogen using concentrated sunlight to directly heat a methanation reactor beside a solar photovoltaic panel that generates the necessary electricity. The hydrogen is fed with captured carbon dioxide to produce valuable methane.

Early research has shown high promise for harnessing the full solar energy spectrum to enhance water splitting for hydrogen production. The impetus is now to direct strategic investment towards these nascent technologies a commercial reality.

Digital Grid at UNSW

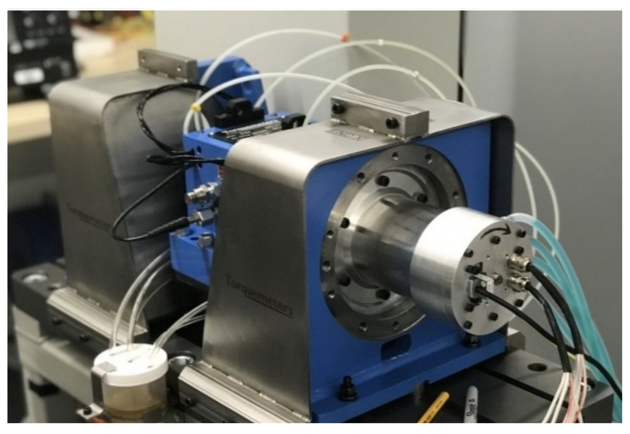
Striving to deliver a power system that can support 100% renewable generation by 2050

UNSW is striving to deliver a future power system that can support 100% renewable generation and the electrification of *almost* everything by 2050. Our focus is on decarbonising energy systems and industry through technology, people and infrastructure. We are developing and commercialising the technology required to displace centralised fossil-fuel generators with energy equity in mind. To support this, we are educating and enabling a future workforce who will be capable to engineer and sustain the future grid. To achieve this goal, we are focused on research and development in four key areas:



Designing and delivering the future grid to prepare electricity networks for high levels of variable and distributed energy

Integration



Developing and deploying new power conversion technologies, rapidly deployed by a squad of technology translators

Power electronics

Collaborating to deliver technology solutions that simultaneously support of social, economic, legal and environmental goals

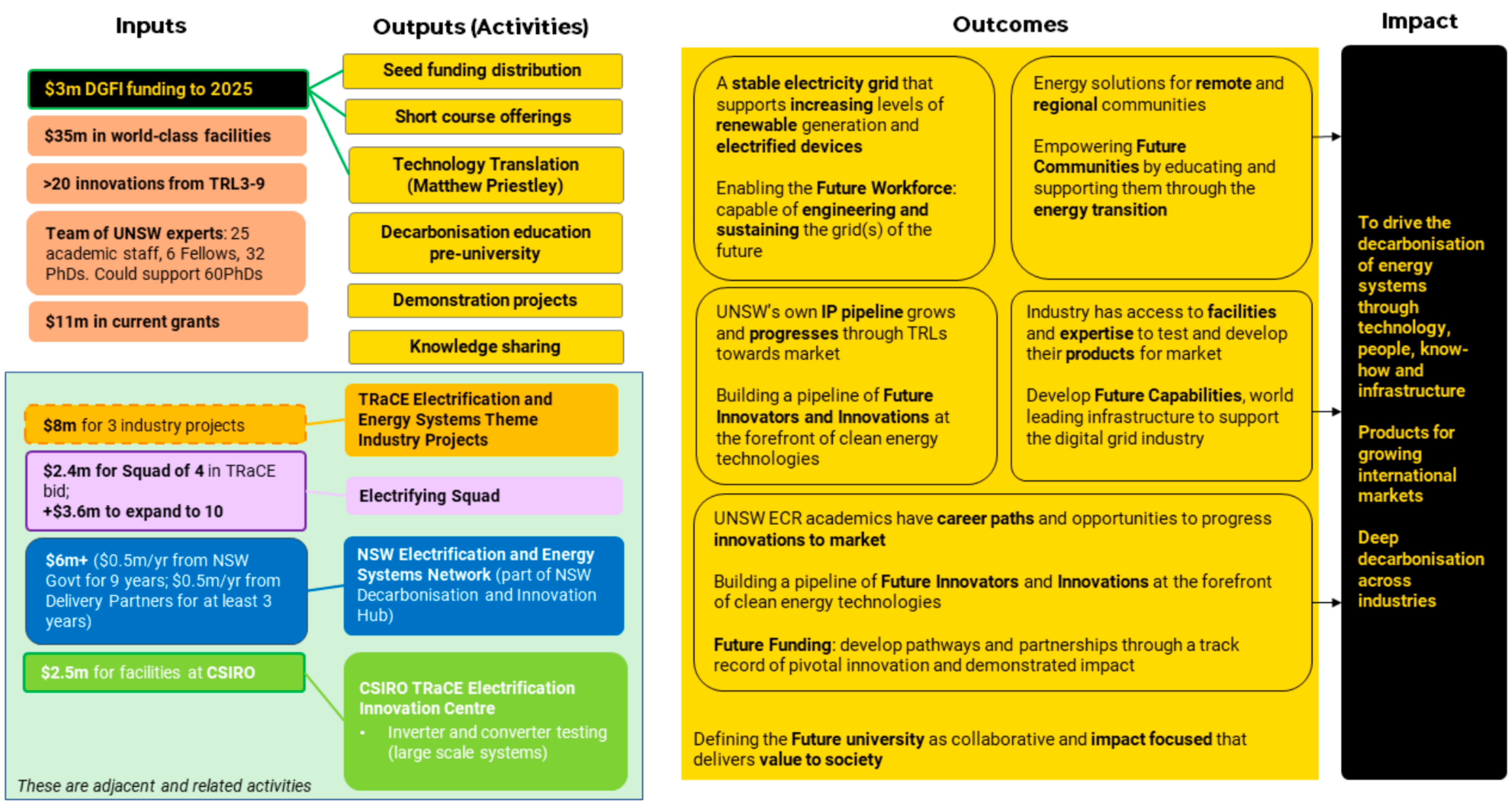
Interdisciplinarity

Upskilling the future energy workforce through diverse education pathways and undertaking research to improve these pathways

Workforce

Key initiatives

The UNSW Digital Grid Futures Institute (DGFI) is funding research, innovation and education across all disciplines and industries to create an innovative new energy grid — helping Australia switch sooner and make the most of this global opportunity. UNSW DGFI is grounded with a clear ”theory of change” to help drive real-world impact from its activities.



Our opportunity to design and deliver the future power system

We are approaching a situation where 40% of total power generated will be from inverter-based generators. This scale of inverter penetration is globally untested and the ability of inverters to sustain load across large electricity grid is unclear, particularly in the case of anomalous or fault conditions. We need a coordinated research effort to closely examine how to operate these inverter-based resources when they are scaled up to the levels projected in the Australian Energy Market Operator's Integrated System Plan.

UNSW hosts the largest Real-time Digital Simulation (RTDS) Laboratory in Australia. Real-time digital power system simulation provides an accurate, reliable and cost-effective method to simulate, verify and experiment with multiple technologies, functions, operations and control from individual components to large-scale power systems. UNSW's RTDS and power electronics laboratories are unique assets that could be leveraged by industry to develop the tactics determining the success of Australia's energy transition plan.

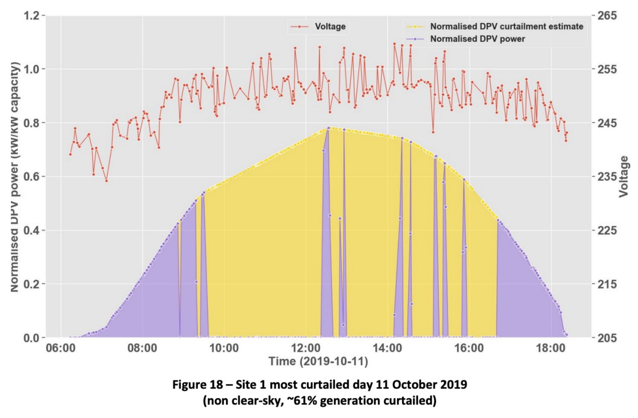
Energy Markets at UNSW

Striving towards least-cost and least-regret integration of renewables into energy markets

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

Investigating emerging markets, regulation and business models for integrating customer / distributed energy resources

CER/DER



Developing open-source modelling of, and tools for, energy markets, tariff design, renewables purchasing and local energy optimisation

Sector transitions

Bringing together engineers, social science, economics and law to inform energy market and policy development

Interdisciplinarity

Supporting the development of new energy markets including partnering with our Pacific neighbours and global energy importers

Global markets

Key initiatives

Our Collaboration on Energy and Environmental Markets (CEEM) has two decades of experience of data-driven research in energy sector transitions with a portfolio of open-source tools including: NEMPY, NEMOSIS, NEMSEER, NEMGLO, and NEMED.

Collaboration on Energy and Environmental Markets

Other projects include:

Project MATCH which is establishing a robust monitoring and analysis toolbox to better understand the behaviour of DER in major grid disturbances and the implications for power system security.

Project CANVAS which developed a tool to understand the impacts and role of solar curtailment in response to power quality issues on the electricity network.

Project ESKIES which is increasing community understanding of the role of solar, batteries, and other DER in maintaining electricity supply to regional and rural communities during extreme weather events.

On 27 January 2023, Minister Bowen and Minister Stark-Watzinger released a joint summary report on the Australia-Germany supply chain feasibility study following two years collaboration between German and Australian consortia to investigate the feasibility of a hydrogen and hydrogen derivatives supply chain between Australia and Germany and identify how such partnership can be facilitated.

Our opportunity to support the energy transition of our Pacific neighbours

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

UNSW has been working with the Australian Government and the International Renewable Energy Agency to explore pathways to a hydrogen economy in the Pacific. This builds on previous UNSW research exploring the opportunity to export Australian renewable hydrogen to Germany, "HySupply: Shipping Australian Sunshine to Germany". Further collaboration and deeper collaboration will allow this plan to become reality