The global transition to a zero net carbon economy is a necessary but challenging proposition. As world leaders turn their attention to their commitment to limit global warming to below 2 degrees, there is an unprecedented focus on how we can continue to feed a growing population, power our industries, transport commodities and keep the lights on, all while reducing our climate-related impacts.

Now more than ever, hydrogen is emerging as an integral energy source of the future. Hydrogen represents a significant move away from traditional energy sources — it releases no carbon emissions, has the potential to decarbonise transportation and is a clean feedstock for industry.

With significant natural resources, research expertise and industry experience, Queensland is ideally positioned to lead the nation’s transition to a low carbon future.

For Queensland, the hydrogen industry has the potential for burgeoning impact — mid-range estimates predict a direct gain of $1.068B by 2040 and indirect gains of $3.219B. During the next 20 years, as many as 7100 direct and indirect jobs could be created. UQ has considerable expertise across many aspects of hydrogen including, sustainable production and processing, solar hydrogen, methane pyrolysis and hydrogen storage.

As a leading Australian comprehensive university and ranked in the top 50 globally, we are recognised for our considerable expertise in clean energy research including solar and wind energy, coal seam gas, carbon capture and storage, and battery technology.

Together, this transferable expertise has the potential to help position Australia on the frontier of the hydrogen boom.
UQ is committed to sustainability leadership. We were the first university in the world to generate 100 per cent of our electricity from our own renewable energy assets.

**Solar hydrogen**

**Professor Lianzhou Wang**

Natural gas is an important transition energy fuel, but one of the (many) challenges is determining how to secure the future of hydrogen in a net-zero carbon world.

Photocatalytic hydrogen, where next generation materials harness sunlight to drive the water splitting reaction, has the potential to revolutionise green hydrogen production. Researchers are developing several new classes of photocatalysts and photoelectrochemical systems for efficient solar hydrogen generation, fuel production and electricity storage.

**Blue hydrogen**

**Associate Professor Simon Smart**

Methane pyrolysis – or the splitting of natural gas into the hydrogen and solid carbon components – offers a direct and cost-effective means of producing hydrogen, while the solid carbon can be captured.

While the benefits of blue hydrogen have been understood for some time, UQ researchers are now refining the process by using molten salts to reduce the need for carbon removal, thereby enabling a more efficient, scalable process that can meet domestic and export demand.

**Hydrogen storage**

**Professor Kazuhiro Nogita**

Effective, reliable and affordable hydrogen storage is central to the development of a large-scale domestic and export industry.

In 2002, UQ researchers developed a magnesium alloy that could absorb hydrogen at relatively low pressures, much like a sponge absorbs water.

A recent re-examination of the mechanisms that control the speed with which hydrogen can be absorbed and desorbed has identified that adding trace elements to speed hydrogen absorption in some alloys is not effective.

Significantly, this creates an opportunity to develop alloys that were previously neglected, potentially removing bottlenecks, enabling mass-production of suitable alloys, and leading to affordable solutions to hydrogen storage and transportation in Australia and abroad.
Hydrogen fuel cells
Professor John Zhu
Direct carbon fuel cells are more environmentally friendly than traditional carbon, yet there remains considerable opportunity to further develop the technology.

UQ researchers are studying direct carbon fuel cells to unlock clues that help develop a more sustainable hydrogen industry through the use of mesoporous carbon-related composites in carbon storage and advanced plasma-assisted processes related to hydrogen production.

Social acceptance of hydrogen
Professor Peta Ashworth
Underlying these technical projects, UQ is also leading considerable research into the public perception and societal acceptance of new energy infrastructure developments. Already, researchers have identified early public engagement as one of the key determinants for commercial viability, and argue that understanding the public’s response to opportunities relating to the potential low carbon energy future is invaluable for government, industries and communities alike.

Carbon capture and storage
Professor Andrew Garnett
As a leader in renewable energy research, UQ has led a major research and scoping study into the potential for carbon capture and storage (CCS) to help reduce emissions.

Researchers developed a low-cost, low-impact methodology to improve estimation of deep aquifer conditions and, in turn, enhanced understanding of deep aquifer properties and general groundwater assessments.

Projects such as this demonstrate UQ’s transferable expertise on sub-surface storage of CO₂ and of natural gas.

Sustainable Hydrogen Production from Used Water
Professor Xiwang Zhang
Green hydrogen production requires water, at least 9L for every kg of H₂ produced. UQ researchers are aiming to overcome this pressing challenge by exploring the novel concept of taking used water as the feed for water hydrolysis. They want to understand how the performance and durability of water
our research

electrolysers is impacted by the presence of impurities. In this way, they then develop the guidelines for electrolyser design and wastewater treatment.

Projects such as this demonstrate whole-of-system thinking and will help Australia become a global leader in the emerging hydrogen economy.

The Andrew N. Liveris Building (above) is the tallest building on UQ's St Lucia campus, and home for the School of Chemical Engineering. The building acts as a hub for industry and interdisciplinary collaboration to address global challenges in areas such as energy, hydrogen, water and sustainable manufacturing. This project was realised thanks to a historic gift from Mr Andrew Liveris and Mrs Paula Liveris.
Professor Peta Ashworth

Prof. Ashworth is globally recognised for her research into public attitudes toward climate and energy technologies including wind, carbon capture and storage, solar photovoltaic and geothermal.  
As Director of the UQ Andrew N. Liveris Academy for Innovation and Leadership and UQ Chair in Sustainable Energy Futures, Prof. Ashworth has been integral in the development of Australia’s National Hydrogen Strategy.  
In 2021, she was appointed Chair of the Queensland Government’s Hydrogen Taskforce, assessing the state’s hydrogen supply chain and developing a plan for a sustainable supply chain, including export, by 2030.

Professor Xiwang Zhang

Prof. Xiwang Zhang is Endowed Dow Chair in Sustainable Engineering Innovation, Director of UQ Dow Centre, and ARC Future Fellow in the School of Chemical Engineering at the University of Queensland. His research focuses on membrane and advanced oxidation technologies for energy-efficient separation, water and wastewater treatment, resource recovery, green chemical synthesis and renewable energy generation.

Associate Professor Simon Smart

A/Prof. Smart is Deputy-Director of the UQ Dow Centre for Sustainable Engineering Innovation in the School of Chemical Engineering, where his research is centred around the sustainable production and use of energy and chemicals. His research is focused on the development of enabling technologies and processes for the production of clean energy, materials and water. In the hydrogen space, his focus is on the use of molten metals and molten salts as liquid catalysts in methane pyrolysis, to reduce the CO₂ emissions of blue hydrogen production.

Professor Kazuhiro Nogita

Prof. Nogita is the Director of the UQ Nihon Superior Centre for the Manufacture of Electronic Materials. His research is focused on the development of materials for alternative power industries and their environmentally friendly application. He investigates various aspects of hydrogen-storage alloys, including the manufacture of magnesium-based storage alloys, testing hydrogen storage properties of those alloys, and analysis of hydride–dihydride mechanisms at a microstructural level.  
From 2017–2020 Professor Nogita held an Australian Research Council (ARC) Linkage on the development of bulk magnesium (Mg) based hydrogen storage alloys with faster activation to inform the mechanisms that govern the activation process, in turn leading to the development of Mg based hydrogen storage alloys for effective and safe hydrogen storage systems.

Professor Lianzhou Wang

Prof. Wang is an ARC Laureate Fellow and Director of the UQ Nanomaterials Centre (Nanomac), an interdisciplinary research centre within the Australian Institute for Bioengineering and Nanotechnology and the School of Chemical Engineering. His research focuses on the synthesis characterisation and application of semiconductor nanomaterials for use in renewable energy conversion and storage systems, including photocatalysts for solar hydrogen. In 2018, his team set a new world record for the conversion of solar energy to electricity using quantum dot solar cells.

UQ has extensive research expertise across many areas of hydrogen research. Below we present a snapshot of our leading hydrogen researchers.
Through numerous initiatives and partnerships with academia, government, industry and donors, UQ has invested significantly in world-class research infrastructure, facilities and services to benefit our researchers and research partners.

Our world-class facilities are equipped with cutting-edge instrumentation, leading technologies to deliver sustainable advantage in research and consultancy efforts, and expert staff who can provide guidance and training.

Hydrogen researchers work across a number of our central research platforms, including:

- **The Centre for Microscopy and Microanalysis (CMM)** investigates the structure and composition of natural and fabricated materials across different scales. CMM leads the way in microstructural characterisation and has been instrumental in UQ’s solar hydrogen research. UQ has a long history of recognising and responding to research needs and thus enabling industry development, informing government regulation and responding to societal needs – nowhere is this more apparent than in the renewable energy sector. In addition to dedicated hydrogen research hubs, we have a number of established facilities that have transferable skills relevant to the burgeoning industry, including:

  - **The Centre for Energy Data Innovation**: addressing power and energy system challenges including data aggregation and analytics
  - **Industry 4.0 Energy TestLab**: established to help enable the widespread adoption of digital Industry 4.0 technologies into the production and processing of Australia’s energy and resources.
  - **The Centre for Natural Gas**, which conducts research and supports education in key discipline areas including business, petroleum engineering, geosciences, water and social sciences, with much transferable knowledge for the hydrogen sector.

Finally, UQ is committed not only to the research of hydrogen but also its application in our community.

Two hydrogen fuel cell buses will be added to the UQ fleet by 2022, expected to be the first of their kind in Queensland. UQ will produce the hydrogen through electrolysis, using renewable power from the University’s Gatton solar farm, leading to a 60–70 per cent reduction in emissions compared with the diesel-powered buses they’re replacing.
Sustainable Infrastructure Research Hub

Sustainable infrastructure refers to manufactured, digital and nature-based infrastructure that supports human and environmental well-being and function of the economy through all stages of the asset life-cycle. This requires a systems understanding of how infrastructure is built, maintained and interacts with society to inform the urgent transition to decarbonised, circular and resilient industries, to build capacity and respond to unprecedented climate risks in the era of the Anthropocene.

Acknowledging the current trade-offs between achieving these components of sustainable infrastructure, we seek to:

- Increase the objective evidence base to support informed decision making, implementation and measurement
- Facilitate collaboration between industry, government, academia and communities to drive a shared vision for transformational change
- Support industry and government to overcome institutional barriers
- Enhance institutional regulations, processes and capabilities, and
- Develop systems models to inform transition pathways and integration

Research Agenda

Understanding infrastructure systems, capabilities and models for change

- Systems dynamics and life cycle assessment modelling of infrastructure systems,
- Organisational / individual capabilities required for transitions,
- Evaluation of mechanisms and models for transitions including procurement, collaboration and more

Infrastructure Transitions

- Decarbonisation and circular economy
- Digitalisation for a sustainable future
- Resilient infrastructure for life in the Anthropocene

Infrastructure CoLab

The Infrastructure CoLab is a cooperative initiative designed to support the infrastructure industry in its transition to a decarbonised and circular economy. Through co-investment and partnership, we incubate opportunities identified to facilitate new ventures, joint projects and even the creation of new startups. Working with industry leaders, University of Queensland (UQ) and programmed by Business Models Inc (BMI), the Infrastructure CoLab helps to mitigate risk and accelerate success by leveraging the power facilitated through diverse networks.

For each round of the Infrastructure CoLab, as many as 25 companies will be matched in teams of five and guided through a multi-party innovation process to solve challenges across the focus areas.