SUMMARY OF ARENA-FUNDED HYDROGEN R&D PROJECTS

APRIL 2023

Prepared by Fichtner Australia as ARENA's
Knowledge Sharing Agent for the Hydrogen Portfolio

Australian Government
Australian Renewable Energy Agency

ARENA

DISCLAIMER

This report was commissioned by the Australian Renewable Energy Agency (ARENA). The report presents the findings of *Fichtner Australia Pty Ltd (FA)*, which was prepared to provide a public summary of the aims, funded projects and outcomes of ARENA's Hydrogen Research and Development funding round.

The report is provided as is, without any guarantee, representation, condition or warranty of any kind, either express, implied or statutory. ARENA and FA do not assume any liability with respect to any reliance placed on this report by third parties. If a third party relies on the report in any way, that party assumes the entire risk as to the accuracy, currency or completeness of the information contained in the report.

To the best of ARENA and FA's knowledge, no conflict of interest arose during the course of preparing this report. While FA has previously conducted reports, evaluations and other work for ARENA, FA has not received any grant funding from ARENA.

TABLE OF CONTENTS

1 BACKGROUND

In December 2017, ARENA launched a Research and Development (R&D) funding round focused on accelerating the development of a potential renewable energy export supply chain based on hydrogen, with the topics covering the supply chain as depicted in Figure 1.[1]

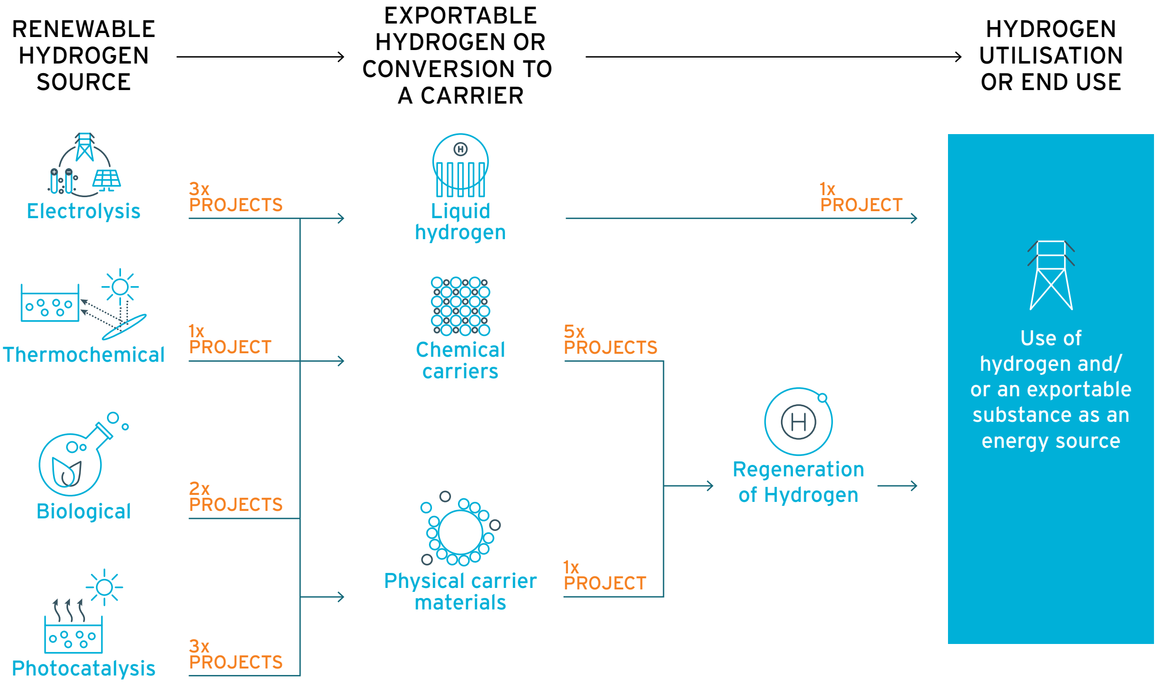

Figure 1: The potential role of ARENA's Research and Development projects in the Hydrogen Export Supply Chain.

Following the conclusion of the assessment process, in September 2018 ARENA's Hydrogen R&D Funding Round granted a total of $22.1 million, shared between sixteen separate research projects. The projects were each focused on various parts of the hydrogen supply chain, as summarised in Table 1.

1 See https://arena.gov.au/blog/22-million-to-unlock-hydrogen-potential/ for details of the program launch

TABLE 1: SUMMARY OF ARENA-FUNDED R&D PROJECTS.

PROJECT FOCUS	LEAD INSTITUTION(S)	SUPPLY CHAIN CATEGORY	ARENA FUNDING / TOTAL PROJECT COST (MIL. AUD)	COMPLETION DATE
Solar Thermochemical Hydrogen	CSIRO	Production	2.0 / 4.0	Sep 2023
Direct Water Electrolysis	Australian National University	Production	1.3 / 3.5	Jul 2023
Water Splitting Electrodes	Monash University	Production	1.1 / 3.7	Jan 2023
Hydrogen Generation by Electro-Catalytic Systems	Australian National University	Production	0.6 / 1.8	Dec 2022
Solar Hydrogen Generation	Australian National University	Production	1.6 / 4.3	Mar 2023
Photovoltaic Electrolysis to Generate Hydrogen	University of New South Wales	Production	1.3 / 5.0	May 2023
Biological Hydrogen Production	Macquarie University	Production	1.1 / 2.8	Apr 2023
Waste Biomass to Renewable Hydrogen	University of New South Wales	Production	1.0 / 2.5	Apr 2023
Ammonia Production from Renewables	Monash University	Carriers and Transport	0.9 / 2.7	Apr 2023
Hydrogen Process	Queensland University of Technology	Carriers and Transport	3.4 / 7.7	Apr 2023
Methane Fuel Carrier	CSIRO	Carriers and Transport	1.1 / 2.2	Jul 2021
Hydrogen to Ammonia	CSIRO	Carriers and Transport	1.2 / 2.8	Apr 2022
Hydrogen Storage and Transport	RMIT, University of Melbourne	Carriers and Transport	0.8 / 1.8	Jan 2022
Methanol from Syngas	University of Western Australia	Carriers and Transport	1.1 / 2.9	Jan 2023
Liquid Fuel Carrier	CSIRO	Carriers and Transport	1.0 / 2.5	Oct 2021
Hydrogen Fuelled Reciprocating Engines	University of Melbourne	Utilisation	2.6 / 8.6	Mar 2023

The sixteen projects selected in 2018 for ARENA funding cover a range of hydrogen technologies and combined they cover the full export supply chain. This report provides a high level summary of each of the projects funded including outcomes and next steps.

2 PROJECTS

2.1 HYDROGEN PRODUCTION PROJECTS

The hydrogen production projects included in this round of ARENA funding investigated several different methods for hydrogen production, including some novel hybrid approaches that ultimately aimed to minimise or substitute electrical energy input with direct renewable energy sources. Currently, the cost of electricity from renewable energy sources is the most significant driver of electrolysis cost and is a barrier to reducing hydrogen production costs. Therefore, the improved efficiencies and alternative pathways for hydrogen production developed in this funding round are critical to achieving viable hydrogen production costs.

Key challenges for the next generation of hydrogen production technologies include the increase in system efficiency, the reduction of specific capital costs, and the increase in stability and longevity of the materials used, particularly catalysts. The diverse range of hydrogen production projects involved in this funding round were all focused on solving these challenges. A brief description of each and their key results are listed below.

CSIRO – Solar Thermochemical Hydrogen

Focus of Research: Production innovation

Project Partners: Niigata University, and Japan Institute of Applied Energy (IAE)

Overview:

- A team from CSIRO has developed a new thermochemical hydrogen system that utilises a novel beam-down solar concentrator system, next generation catalyst materials and a new high temperature (1,300 °C) fluidised bed reactor design for high efficiency hydrogen production based on highly scalable fabrication methods using flame spray pyrolysis and electrodeposition.
- The project also investigated new redox material candidates for water splitting by using a machine learning-aided process to screen hundreds of thousands of perovskite materials, and synthesising and evaluating them under laboratory conditions.

Outcomes and Next Steps: The project has resulted in commercialisation discussions with three Japanese companies interested in technology proposed in the project. Further detailed engineering design is required to scale-up operation to the kilowatt scale to offer a pre-commercial system for future partners and potential customers.

ANU – Direct Water Electrolysis

Focus of Research: Production innovation

Project Partners: MicroLink Devices, Inc., and University of Michigan

Overview:

- The Australian National University (ANU) undertook research into electrolysis via photoelectrochemical solar water splitting, which is considered to be one of the most efficient ways of producing hydrogen directly from sunlight.
- An integrated and simplified hydrogen cell design was developed that allowed for the thermal integration of solar and catalytic elements and improved solar-to-hydrogen (STH) conversion efficiencies.

Outcomes and Next Steps: The project delivered a novel STH device that has achieved 20 per cent efficiencies with the potential to be expanded even further. To continue development of the technology, commercial partners are being sought after as well as more R&D funding.

Monash University – Water Splitting Electrodes

Focus of Research: Innovation of production components

Project Partners: The Australian National University, and University of Sydney

Overview:

- A team at Monash University investigated the fabrication of electro-materials to engineer efficient, cost-effective electrodes for efficient water splitting from abundant, low-cost elements such as iron.
- As a result of the research conducted, the technology for fabrication of water splitting electrodes via roll-to- roll flame spray pyrolysis was progressed to Technology Readiness Level (TRL) 5, whereby the system can be used to deposit a variety of materials and is suitable for use of different substrates.
- Electrodeposition of catalytic material was used for the fabrication of a noble-metal free anode, which resulted in a thermoneutral efficiency of 80 per cent (among the highest reported performance for comparable materials), which was increased to 87 per cent when combined with a low-cost iron catalyst.
- Techno-economic modelling of different industry sectors revealed that low-cost electrodes for electrolysers will substantially improve the cost-effectiveness of hydrogen production, despite their slightly lower efficiencies than typical electrodes used today.

Outcomes and Next Steps: The successful research outcomes of this project have sparked discussions with commercial entities on a wide range of new projects. An example is a research project to develop sea water electrolysis that's being funded by Woodside Ltd.

ANU – Hydrogen Generation by Electro-Catalytic Systems

Focus of Research: Innovation of production components

Project Partners: University of Wollongong

Overview:

- The Australian National University successfully developed a low-cost, high-performing type of catalyst based on earth-abundant materials such as manganese oxide, calcium, and graphene.
- This catalyst was combined in a multi-cell electrolyser design using the novel "capillary-fed electrolysis" that was first developed from a separate ARENA-funded project included in Section 2.2 in this report (Monash University – Ammonia Production from Renewables).
- The technology currently has a TRL of 4, however it already outperforms industry standard electrolysis using platinum-based catalysts.

Outcomes and Next Steps: This project has developed a high-performing electrolyser design that uses low-cost earth-abundant materials and new "capillary-fed" cell architecture. The next steps include using the working prototype to build a compelling business case for commercialisation of the technology.

ANU – Solar Hydrogen Generation

Focus of Research: Production innovation

Project Partners: Shenzhen Kohodo Hydrogen Energy, and University of New South Wales

Overview:

- A team from The Australian National University investigated direct solar-to-hydrogen generation through the integration of silicon and perovskite cells in a tandem configuration, eliminating the energy conversion involved in standard electrolysis powered from solar power.
- The aim of this investigation was to design, fabricate and deliver low-cost semiconductors and catalysts for the STH process, using the base case of 10 tonnes of hydrogen production per day for a lifetime of 20 years as a basis of design for optimisation.
- The combined use of both types of solar cells (silicon and perovskite) enables a larger proportion of the solar spectrum to be utilised as an energy input for electrolysis, which resulted in a STH energy conversion efficiency of 20 per cent at ambient condition using nickel-based catalysts.

Outcomes and Next Steps: The project demonstrated the benefits of a tandem silicon and perovskite solar cell as an STH technology. The investigation will now be focusing on the creation of a prototype for pilot scale demonstrations.

UNSW – PV Electrolysis

Focus of Research: Production innovation

Project Partners: Beijing Zhongchao Haiqi Technology, RayGen Resources, and Shenzhen Kohodo Sunshine Renewable Energy Co.

Overview:

- The University of New South Wales developed a photovoltaic (PV) electrolysis system capable of harnessing both thermal and electrical power from sunlight to produce hydrogen with a record solar-to-hydrogen efficiency of up to 30.3 per cent.
- Research into low noble-metal loaded electrocatalysts led to the successful identification and evaluation of inexpensive, high performing electrodes that surpass current state-of-the-art catalysts today, with the ability to catalyse the oxygen evolution reaction with an overpotential of only 180 mV.
- Research into the alkaline concentration and operating temperature of alkaline water electrolysers also identified optimal conditions, which when paired with the newly discovered electrode materials, allowed for high electrolysis energy efficiencies.
- Two small scale (≤1kW) prototype electrolysis systems were designed and manufactured utilising these discoveries and coupled with a concentrated solar PV cell, to ultimately electrolyse water at relatively high energy efficiencies of up to 79.3 per cent.

Outcomes and Next Steps: Harnessing both thermal and electrical power from sunlight to produce hydrogen has the benefit of lowering the cost of hydrogen from electrolysis. The investigation has concluded that the system will require scaling from 1 kW to 5 kW; a process that will be conducted alongside other electrolyser manufacturers.

Macquarie University – Biological Hydrogen Production

Focus of research: Production innovation

Project Partners: Bioplatforms Australia, and BOC Australia

Overview:

- A team at Macquarie University successfully scaled up the fermentation of hydrogen-producing bacteria to a 20 L laboratory scale bioreactor, resulting in a 1000-fold improvement in hydrogen production rate from previous laboratory tests.
- The bacteria strains were engineered and optimised through the CRISPR gene editing technology to maximise the conversion of glucose to hydrogen, and to provide the bacteria with the ability to take sucrose as a feedstock rather than glucose for future investigations.
- The anticipated hydrogen production target of 700 mL per hour per litre of bacteria was significantly exceeded, yielding 6 L of hydrogen per hour per litre of bacteria, translating to approximately three hydrogen molecules per molecule of glucose, or 25 per cent of the theoretical maximum biochemical yield.

Outcomes and Next Steps: The project's biological hydrogen production process has successfully optimised a bacteria strain to enable the hydrogen production from biomass. Scale-up and more experimentation into bacterial genetic reprogramming will enable greater production of hydrogen. The successful demonstration of this technology has spun out into a start-up company, Hydgene, which will further the technology towards the commercialisation stage.

UNSW – Waste Biomass to Renewable Hydrogen

Focus of Research: Production innovation

Project Partners: Beijing Origin Water Technology, and Apricus Energy

Overview:

- A team from The University of New South Wales designed a stand-alone biomass reforming system that generates renewable hydrogen, or hydrogen carriers, from waste biomass and sunlight.
- The waste biomass concentrator, powered from a PV cell, concentrates a biomass feedstock, and produces clean water to be directly used in a flow electrolysis cell. The biomass is then introduced into the same electrolysis cell and hydrogen and other organic products are produced.

- The designed system demonstrated a production rate of 96 L of hydrogen per day from 25 L per day of sugar and achieved a reported solar-to-heat energy conversion efficiency of 58 per cent, as well as a waste sugar recovery rate of 95 per cent.
- The system resulted in an overall energy consumption of 40 to 54 kWh/kg of hydrogen produced, which is up to 15 per cent more efficient than today's commercial electrolysers.

Outcomes and Next Steps: The project designed a micro-tubular reactor for biomass reforming for the generation of renewable hydrogen and hydrogen carriers. Further collaboration with Rio Tinto will look at integrating the reactor system with an organic waste management process.

2.2 HYDROGEN CARRIER PROJECTS

The challenge of cost-effective hydrogen transportation is particularly important for Australia, given the vast distances to most export markets, and between potential production and use locations within the country. A range of hydrogen carriers were included in the R&D projects in this round of ARENA funding, including methane, ammonia, methanol, and hydrogenated carbon. Each of these offer potential advantages for transporting hydrogen, both in terms of cost and other benefits including efficiency and end-use applications. A brief description of the projects and a summary of key technical results are shown below.

Monash University – Ammonia Production from Renewables

Focus of Research: Hydrogen carrier production innovation

Project Partners: University of Wollongong

Overview:

- A team from Monash University, further developed the nitrogen reduction to ammonia process discovered by both institutions. The process synthesises ammonia from atmospheric nitrogen at ambient conditions by utilising the high selectivity of nitrogen reduction in electrolysis cells, where the presence of water in the electrolyte is limited.
- The project introduced a proton shuffling system to deliver protons more effectively from the anode to the nitrogen reducing cathode. Furthermore, a high-concentration of imide-based electrolytes prevented the unproductive consumption of charge, enabling a near 100 per cent Faradaic efficiency.
- The project significantly surpassed the aim of 4 grams of ammonia per hour per square metre by demonstrating electrolytic ammonia synthesis rates of 136 grams per hour per square metre.
- An unintended outcome of this project was the development of a new class of highly-efficient electrochemical cell, known as a capillary-fed cell. This concept was developed by the University of Wollongong for this project. It has since been commercialised by the University of Wollongong for the production of 'green' hydrogen as the Hysata startup company.

Outcomes and Next Steps: The technology developed by the project demonstrated significantly high efficiencies for the electrosynthesis of ammonia from air under ambient conditions. The developed proton shuffling system as well as the use of the highly selective electrolysis cells for nitrogen reduction has been spun out into a start-up company, Jupiter Ionics, which has secured over $5 million in funding. The start up company Hysata has also attracted notable commercial interest.

Queensland University of Technology – Hydrogen Process

Focus of Research: Hydrogen-based technology testing

Project Partners: Swinburne University of Technology, Sumitomo Electric Industries, Griffith University, Energy Developments Limited, and CS Energy

Overview:

- The Queensland University of Technology successfully designed and established a green precinct micro-laboratory that enables researchers to study the efficiency of primary power to electrolysers, energy management systems, digital twins, water purity impact on electrolysis, new materials integration, and testing of electrolysers and fuel cells at near real-world conditions.
- This unique facility will allow for hydrogen system components to be integrated and tested in a flexible range of configurations that can emulate real-world situations. this should accelerate the development of ideas and identification of problems prior to the design and implementation of pilot-scale (or larger) designs.

- Further research was also conducted into cathode coating of lithium-ion batteries, which led to enhanced electrochemical performance, particularly with reference to capacity retention and specific energy delivery of existing batteries.
- Research into bifunctional electrodes for alkaline water electrolysers was also conducted for a pilot scale plant that is manufactured from recycled green steels.

Outcomes and Next Steps: The laboratory-scale green-precinct micro-laboratory enables researchers to study the efficiency of their systems as well as management operations, materials, and other performance conditions. The development of a digital monitoring system for remote management and control of a pilot plant has been identified as a requirement to ensure further project success.

CSIRO – Methane Fuel Carrier

Focus of Research: Hydrogen carrier production innovation

Project Partners: None

Overview:

- CSIRO investigated a cost-effective way to make synthetic methane using carbon dioxide (CO2) captured from the air.
- A key part of this project involved development of a suitable "Direct Air Capture" (DAC) technology to supply CO2 need for the process. The technology uses novel amino-acid solution solvents that cost as low as $100 per tonne.
- Heat released from the methanation process was utilised for the regeneration of the solvents used as liquid absorbents in cooling towers, increasing energy recovery, and consequently, system efficiency.
- The overall cost of the production of liquified synthetic methane was $37.40 per GJ, where costs of electricity were the most dominant factor.

Outcomes and Next Steps: The investigation demonstrated that the direct air capture of carbon using an amino-acid salt solution is feasible, advantageous, and has opportunities for greater process circularity. The selection of a technology configuration for the DAC process will aid in the development of a business case for technological application.

CSIRO – Hydrogen to Ammonia

Focus of Research: Hydrogen carrier production innovation

Project Partners: Orica Australia Pty, and Grains Research and Development Corporation (GRDC)

Overview:

- A team from CSIRO investigated the conversion of hydrogen to ammonia at pressures lower than that of the traditional Haber-Bosch process, from the design (in partnership with Orica and GRDC) and operation of a prototype reactor system.
- The reactor operated under different conditions and achieved a peak ammonia production rate of 112 grams per day at 30 bar pressure during 165 hours of operation. The process achieved an ammonia conversion of up to 7.5 per cent by volume, which is higher than the typical 6.5 per cent equilibrium value achieved in the Haber Bosch process.
- The project results demonstrated that a pilot plant capable of producing 10 tonnes of ammonia per day could synthesise the product at a cost of as low as $550 per tonne.

Outcomes and Next Steps: The project demonstrated hydrogen to ammonia conversion rates higher than those typically achieved by the Haber Bosch process and at lower pressure. A proposal has been prepared to successfully implement a pilot plant.

RMIT – Hydrogen Storage and Transport

Focus of Research: Hydrogen production and storage innovation

Project Partners: Eldor Corporation, Institute for Carbon-Neutral Energy Research, and Kyushu University

Overview:

› The Royal Melbourne Institute of Technology conducted research into the development of an integrated system for the storage and bulk export of green hydrogen stored within a hydrogenated carbon-based material, using a novel proton flow reactor (PFR).

› A prototype PFR was successfully designed, constructed, and used as a proof-of-concept to exhibit the selection of a carbon-based material for hydrogen storage. The charge and discharge modes were also demonstrated via electrolysis and the regeneration of electricity through hydrogenated carbon powder, respectively.

› The system achieved a three-fold increase in the gravimetric hydrogen storage capacity on the carbon-based material from 0.8 per cent by weight to 2.2 per cent. This allowed for a round trip efficiency of 15 per cent to be achieved, which is expected to be increased to up to 57 per cent upon a full scaling-up of the system.

Outcomes and Next Steps: This investigation successfully designed and operated a proton flow reactor that demonstrated the technological feasibility of the system and the ability for hydrogen storage in a solid carbon material. The project also discovered an alternate operation mode for the PFR where the hydrogen gas could be generated from the hydrogenated carbon material. Reactor scale-up as well as further experimental work will improve the system's operation as well as confirm preliminary results.

University of Western Australia – Methanol from Syngas

Focus of Research: Hydrogen carrier production innovation

Project Partners: Anergy Pty

Overview:

› The University of Western Australia developed a process to synthesise renewable methanol from a biomass feedstock. This was demonstrated at a small scale, through the identification, design and evaluation of effective catalysts and reactor design to integrate both processes of biomass pyrolysis and methanol synthesis in one.

› Using a micro-tubular reactor design and a new copper-containing catalyst, the methanol production process was optimised in a laboratory demonstration plant to produce 17 litres of methanol per minute from the biomass feedstock.

Outcomes and Next Steps: This investigation successfully designed a micro-tubular reactor for catalyst screening. The reactor synthesised renewable methanol for a biomass feedstock at a small-scale and demonstrated the technical feasibility and economic viability of the process. The successful implementation of the technology will enable widespread deployment of small-scale renewable methanol production.

CSIRO – Solid Oxide Electrolysis to Produce Liquid Fuel Carriers

Focus of Research: Hydrogen fuel carriers production innovation

Project Partners: Johnson Matthey, and BG Negev Technologies and Applications

Overview:

› CSIRO conducted experimental research into a next generation solid oxide electrolyser (SOEC), as well as new bifunctional electrode materials to simplify manufacturing and reduce overall costs.

› A prototype solid oxide electrolyser stack was designed and created, which achieved steady state operation during a 350-hour test period operating at 800 °C using super-heated steam from a solar test furnace apparatus.

› New cathode materials were developed for the prototype that gave greater efficiencies than conventional materials, allowing the stack to produce hydrogen at a rate of 12 L per hour.

Outcomes and Next Steps: The development of new cathode materials for a prototype solid oxide electrolyser stack was successfully conducted throughout this investigation. The system requires further optimisation and testing of longer scale operation. A techno-economic analysis will be carried out to include alternative fuels and other downstream processes.

2.3 HYDROGEN UTILISATION PROJECTS

The Hydrogen Fuelled Reciprocating Engines project from the University of Melbourne was the only project that focused on the utilisation of hydrogen and produced the following key results.

University of Melbourne Hydrogen Fuelled Reciprocating Engines

Focus of Research: Technology adaptation and hydrogen innovation

Project Partners: University of New South Wales, MAN Diesel & Turbo SE, Energy Power Systems Australia Pty Ltd, Continental Automotive Systems Inc, and Energy Australia

Overview:

› A team from The University of Melbourne conducted research into hydrogen fuelled reciprocating engines of different types (spark ignition and compression ignition), where hydrogen was found to be significantly more knock-resistant than standard gasolines when providing similar amounts of energy to the premixture of the fuel prior to combustion.

› A prototype spark ignition (SI) engine was developed with a thermal efficiency of 47 per cent when fuelled by 100 per cent hydrogen.

› Additionally, a commercial diesel compression ignition (CI) engine was successfully retrofitted to build a hydrogen diesel dual-fuel direct injection engine that was able to achieve a thermal efficiency of 57.2 per cent when fuelled by a mixture of hydrogen and diesel. The engine demonstrated the ability to substitute 90 per cent of the energy content of diesel with hydrogen gas without pre-ignition or knocking, reducing carbon dioxide emissions by 85.9 per cent.

› The project revealed that the American Society for Testing and Materials (ASTM) octane rating method is not suitable to provide meaningful ratings for hydrogen-rich fuels for combustion engines.

Outcomes and Next Steps: The project researched the effect of fuelling reciprocating engines of different types with hydrogen. A prototype spark ignition engine was developed, and a commercial diesel compression ignition engine was retrofitted to operate with 90 per cent of the energy content originating from hydrogen. Investigations and analysis into two pilot plants will be undertaken as a step to then form a start-up company with the developed technology.

3 OTHER OUTCOMES

3.1 INTELLECTUAL PROPERTY & KNOWLEDGE SHARING

In addition to the existing intellectual property brought into the sixteen projects in this round of ARENA funding, half of the projects have either drafted, filed, or been granted at least one new patent. A total of two patents are in preparation, six applications have been filed, four applications have been provisionally granted, and two have been successfully granted. Additionally, over the projects' duration, at least 62 academic papers have been published or have been submitted for publication, and 73 presentations have been delivered at conferences around Australia.

3.2 COMMERCIALISATION

The projects in this funding round have addressed a broad range of technology types, each at varying maturity and technology readiness levels (TRL). Most projects directly identified specific use cases for their field of research to add value or as a potential pathway for commercialisation in the near future, with some key examples including the green steel industry, management of organic-containing waste streams in remote areas in Australia, and the supply of high-quality hydrogen to the transport sector. Furthermore, several projects saw the commencement of one or more subsidiary R&D projects to further develop the technologies from this funding round. Most of the projects progressed the TRL of their technology by more than two levels during the course of research, and have initiated discussions with local or international industry partners to improve the TRL further.

The most promising commercialisation outcome of this funding round is the establishment of new startup companies to help accelerate development of the technologies into viable products and projects. Two commercial start-ups have been created as a direct result of the research conducted in this funding round: Jupiter Ionics Pty Ltd from the Monash University project on Ammonia from Renewables; and Hydgene Renewables from Macquarie University's project on biological hydrogen production.

Hysata Pty Ltd was formed by the University of Wollongong to commercialise the "capillary fed electrolysis" concept first identified in the Monash University project and also used in the ANU project as described in section 2 of this report. **Hysata** has attracted over $40 million in investment from the Clean Energy Finance Corporation (CEFC), Kiko Ventures (UK), IP Group Australia, Vestas Ventures (Denmark), Hostplus and BlueScope, and is now seeking to commercialise their high efficiency electrolyser technology. ARENA also recently announced funding for **Hysata** to develop and pilot a 200 kW stack as part of the HyGATE initiative along with German partners.

3.3 CHALLENGES & LEARNINGS

All projects included in this round of ARENA-funding faced technology specific, as well as organisational challenges, which ultimately fostered valuable learnings for the projects and the wider hydrogen industry. The COVID-19 pandemic combined with other force majeures, such as the 2019-2020 Black Summer bush fires, saw significant delays to all sixteen projects as a result of periods of laboratory unavailability and substantial global procurement delays. Other significant organisational challenges recognised by different projects included the lack of commercialisation resources available to academic institutions and a general mismatch in the scale of government grants to the requirement from specific academic project stages, meaning often funding for accelerated commercialisation is inaccessible for projects in the early stage of development, such as R&D, where it is most needed.

Additional economic challenges were identified for project commercialisation, including high sensitivities to the price of electricity and the sell price of green hydrogen. These challenges are particularly relevant for the quantification of key economic metrics, such as the levelised cost of hydrogen (LCOH) produced or delivered (for hydrogen carriers). A common barrier to commercialisation for these projects was the inherent uncertainty in any forecasts for the development of the green hydrogen market. Furthermore, a number of projects recognised a resistance from Australian industry for active engagement with academia, further inducing uncertainty for commercialisation prospects in the R&D stage of project development.

Key learnings from the sixteen projects included the need for prolonged testing periods for particular technologies to validate experimental results, and the importance of understanding the effects of scaling-up technology size prior to pilot plant demonstration. A project led by CSIRO also identified the need for the formation of a consortium of strategic and professional investors for one or more end-users of hydrogen and hydrogen carriers in the future to aid in the development of such project scaling and to help strengthen business cases in the future.

3.4 NEXT STEPS

The next steps identified across the sixteen projects included generic technological improvements, such as the need to increase efficiencies, reduce system costs and advance technology readiness levels. From an economic perspective, most projects also included prospects for further techno-economic analyses and the subsequent development of business cases. Many projects identified the need for further R&D activities prior to or in parallel with up-scaling technology to the demonstration stage, and also for continued testing periods at the current stage.

The research conducted across the sixteen projects included in this round of ARENA funding has cultivated a large potential for new and improved hydrogen technologies in Australia and has led to the beginning of some promising commercialisation prospects. ARENA's investment into the accelerated research and development of novel and existing hydrogen technologies is an important and effective step towards establishing a strong hydrogen economy and value chain in Australia.

Further information is available at
arena.gov.au

Australian Renewable Energy Agency
Phone +61 1800 804 847

Postal Address
GPO Box 643
Canberra ACT 2601

Location
2 Phillip Law Street
New Acton ACT 2601

Engage with us

ARENAWIRE

Australian Government
Australian Renewable Energy Agency

ARENA