

## GREEN ENERGY

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# POWERING AUSTRALIA'S PROSPERITY

Exciting Australian advances in renewable energy technologies - hydrogen as a clean energy source, battery energy storage, and fuel and solar cell know-how - are setting the scene for Australia to move forward on the global clean energy stage. By Carole Goldsmith.

The field of renewable energy and clean technology is highly diverse, encompassing everything from wind and solar power, through to technologies for improving energy efficiency and electricity storage. One area that is relatively undeveloped and has generated comparably limited media coverage is hydrogen fuel technology, but it is an area with enormous potential.

Hydrogen Mobility Australia (HMA), publicly launched on 2 February, is the voice of Australia's emerging hydrogen industry. With a membership comprising vehicle manufacturers, energy companies and infrastructure providers, it is a national body with a vision of a hydrogen society for Australia built on clean and renewable energy technology, including hydrogen-powered transport. HMA is also working in collaboration with the Australian Government on developing regulations, codes and standards for hydrogen fuel cells and hydrogen production.

The organisation's CEO, Claire Johnson has extensive experience in policy development across the public and private sector. Based in Melbourne, she recently led Toyota

Australia's advocacy for hydrogen fuel cell electric vehicles to Australia, and is very excited about hydrogen as a clean energy source.

"Our aim is to accelerate the commercialisation of new hydrogen and fuel cell technologies for transportation, storage and export," says Johnson. "Our members comprise every part of the hydrogen value chain. We see our key role as advocacy and education."

The HMA board was established in May last year. Eighteen months prior to that, Hyundai Australia and Toyota Australia conducted several informal forums with government and industry. The two auto manufacturers invited interested companies to start talking about hydrogen as a clean energy source and about its commercialisation.

The 10 businesses that expressed interest in developing a strategy on how to maximise hydrogen opportunities in Australia, joined as HMA's inaugural members. Along with Hyundai and Toyota, these include BOC, BP Australia, Caltex Australia, CNH Industrial, Coregas, ITM Power, Siemens and Viva Energy Australia.

According to Johnson, both Toyota and Hyundai produce hydrogen fuel cell vehicles in their home countries - Japan and South Korea respectively, and a small number have been imported into Australia.

"Similar to a battery electric vehicle, fuel cell vehicles also operate on electricity," explains Johnson. "However, fuel cell vehicles are fuelled with compressed hydrogen gas. The electricity is generated in the fuel cell, when this hydrogen gas combines with oxygen resulting in a chemical reaction, creating electricity which powers the vehicle."

A fuel cell vehicle has no carbon dioxide or noxious emissions. Water is created as a by-product during the generation of electricity.

"Hydrogen is mainly being produced using natural gas now, but it can also be made from water using electrolysis," Johnson says. "This is a process in which an electric current is used to separate the hydrogen molecules from oxygen molecules. It takes approximately 10 litres of water to create one kilogram of hydrogen gas. If renewable energy is used in the electrolysis process, then the hydrogen production and vehicle use is environmentally friendly, with no emissions."

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Claire Johnson, CEO of Hydrogen Mobility Australia.

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### Opportunities for Australia

"Ford, Holden and Toyota have all retained research & development (R&D) functions in this country, so potentially hydrogen fuel cell R&D and production could be conducted in Australia in the future," says Johnson.

Toyota is moving its Australian R&D department from Port Melbourne to its Altona site, where it is establishing a Centre of Excellence. Several Australian state and local government departments are also investing in hydrogen production and applications.

"South Australia is leading the way with a hydrogen road-map announced in September 2017," adds Johnson. "Port Lincoln will see a \$117.5m 15MW hydrogen electrolysis project, which is set to be one of the largest in the world. It will be powered by green electricity generated by wind and solar. The hydrogen generated will be supplied to the grid and used to power homes and businesses."

The Federal Government's Australian Renewable Energy Agency (ARENA) is also providing a \$20m Hydrogen for Export R&D fund. Applications for this round are now closed. Johnson says that there are potential opportunities to export clean hydrogen to Asia, especially Japan, South Korea and China. Japan aims to be the first nation worldwide to be significantly powered by hydrogen.

So how can Australian manufacturers make the most of the opportunities that hydrogen fuel cell technology represents and get involved in its production and export?

"The sector is in the early stages and currently most products and equipment are manufactured overseas," says Johnson. "However, as the hydrogen industry grows, we expect there will be opportunities for Australian manufacturers to get involved in the manufacture of equipment across the hydrogen supply chain."

She suggested that manufacturers wanting



The Toyota Mirai and Hyundai ix35 fuel cell vehicles with Toyota Australia's portable hydrogen refueler

to be part of this exciting hydrogen sector should contact HMA.

### CSIRO focuses on Hybrid Energy Systems

CSIRO is also actively working on new ways of generating and storing renewable energy. Dr Christopher Munnings is the project leader of CSIRO's Centre for Hybrid Energy Systems (CHES), and has an extensive background in energy generation and storage technologies such as fuel cells, electrolyzers and batteries. In addition to working at CSIRO, he has conducted R&D within large international organisations such as Rolls-Royce and MEL Chemicals.

Based at CSIRO's Clayton site in Melbourne's east, CHES opened almost two years ago and is a state-of-the-art research/industry hub targeted at assisting local Australian industries develop new products or integrate emerging technologies into their existing business model. In particular it focuses on the development of systems containing battery, fuel cell, electrolysis or fuel processing technologies into solutions for a wide range of commercial power



Dr Christopher Munnings, project leader at CSIRO's Centre for Hybrid Energy Systems (CHES).

applications. It also acts as a showcase for CSIRO-developed technologies and concepts. The breadth of technologies looked at within CHES includes domestic battery storage systems all the way through to large-scale renewable energy export concepts.

"Australia has an abundance of renewable energy and this can be used to produce hydrogen via electrolysis," Dr Munnings explains. "That hydrogen can be recombined with oxygen from air to produce electricity. The challenge in this space, and where CSIRO is focusing its effort, is the efficiency of the cycle and how to export the hydrogen."

"Hydrogen can be exported as a liquid in the same way as LNG, but at a far higher expense, due to the colder temperatures required to transport hydrogen and its lower energy density. One of the alternatives is to turn the hydrogen into a synthetic fuel, such as ammonia, which can be easily transported. Where CSIRO is working in this chain, is the development of new ways of making ammonia and, rather paradoxically, ways of breaking it back down into hydrogen and nitrogen, as these are the most energy-intensive steps."

He adds that the Australia's hydrogen market is fairly modest and in general not energy-focused. The big opportunity is the East Asian energy markets, namely Japan and South Korea, that are currently reliant on coal, oil and LNG imports. If the challenges around storage and transport of hydrogen can be solved, then Australian renewable hydrogen could be used by these export markets to power their economies.

Exporting renewable energy is only one of the opportunities that CHES is exploring, with the facility also containing a range of hybrid energy systems, being powered by the building's solar renewable energy.

"We provide advice and work with industry on safe adoption of new hybrid energy technologies," Dr Munnings says. "At CHES we can test batteries, electrolyzers for hydrogen generation and fuel cells under a



Hydrogen stores at CHES.



The Greatcell Solar glass team with an array of six perovskite solar panels.

wide range of conditions. This can help our industry partners to develop hybrid energy systems using renewable energy or just to understand what the next big opportunity is on the horizon.”

### Revolutionising renewable energy storage

Dr Munnings adds that there are many opportunities for Australian manufacturers to produce components and devices relating to emerging storage technologies such as batteries. These are high-value, high-tech products that can be built in advanced manufacturing plants. This has been recognised by international players such as German battery manufacturer Sonnen, which plans to set up a battery manufacturing site in Adelaide later this year. Sonnen's battery production plant in Adelaide will create 430 manufacturing and installation jobs. According to the Adelaide Advertiser, the company plans to produce 50,000 energy storage systems over the next five years with prices ranging from \$7,000 to \$30,000. Sonnen's Australian Managing Director Chris Parratt says that site is still to be selected, but it will only take six to nine months, until it is up and running. Western Australian company Carnegie Clean Energy announced on 21 February that it had been awarded a \$3m government grant to design, construct, operate and maintain a 2MW/500kWh Battery Energy Storage system (BESS) at the General Motors Holden Site in Elizabeth, South Australia. The grant has been awarded from the Renewable Technology Fund, part of the South Australian Government's Energy Plan. Carnegie is a solar energy, battery storage and wave energy project developer. It is the sole owner and developer of the CETO Wave Energy Technology intellectual property and also fully owns the leading Australian battery/solar microgrid engineering procurement

and construction company Energy Made Clean (EMC).

Greatcell Solar takes lead in high-tech solar Queanbeyan-based manufacturer Great Cell Solar Limited (GSL) is a global leader in high-tech solar, specialising in solar cell materials and photovoltaic (PV) panels. The company is currently finalising the design of its glass-based third-generation perovskite solar cell (PSC) prototype development centre at CSIRO's Advanced Manufacturing Centre in Clayton.

GSL's Chief Technology Officer Dr Damion Milliken explains: “Our state-of the art-facility in Melbourne will be fitted out with clean rooms and equipment for large PSC panel prototypes to be produced. This will be completed by the end of this year and several of our engineers will be working at the facility.”

Dr Milliken adds that GSL engaged Netherlands-based company VDL Enabling Technologies Group to assist in designing the new facility and process line: “Among their many projects, VDL has designed automated lines for BMW and for the aerospace industry.”

ARENA provided \$6m to GSL in late 2017 to accelerate the new printable PSC development. This funding was part of the company's \$17.3m Major Area Demonstration project to develop a new world-class prototype facility to scale up fabrication and commercialisation of high-quality, large-area perovskite devices.

Dr Milliken says: “PSC uses an exceptionally strong light harvesting perovskite crystal structure which can absorb sunlight, with 100 times thinner active layers than silicon solar cells. The fastest advancing PV technology of all times, PSC technology has in just five years improved in efficiency to levels that took half a century for silicon solar cells to reach.

“PSC can be integrated into glass, cement, steel, polymers and other substrates to generate energy and improve energy efficiency. This is the ‘holy grail’ of PV – building integrated photovoltaics.”

Dr Milliken adds that GSL will be working in partnership with CSR Building Products at the new Clayton facility: “CSR has a large glass production line at its nearby Dandenong factory. Together with CSR, we will be researching and developing PSC for integration in CSR glass building materials.

Previously known as Dyesol Limited, the business was rebranded to GSL last year. It was founded in 2005 to develop, scale-up and commercialise the rapidly emerging third-generation PV technology known as Dye Solar Cells (DSC). Dr Milliken, who has been with the business since 2007, explains that GSL employs 50 people, with around 35 in Australia, and the rest located in the UK, Europe and South Korea. At its Queanbeyan factory, GSL uses advanced manufacturing processes such as 3D printing and CAD systems to produce materials and precursors that are used for its DSC and PSC.

“We use around 10% of that ourselves and export the rest to our customers globally. These sales support our R&D for panel commercialisation activities,” advises Dr Milliken.

GSL's Managing Director Richard Caldwell told shareholders in August last year: “The future for GSL is very exciting. During 2016, the global PV market grew by approximately \$70bn, a growth rate of 50%. Our commercialisation schedule plan is: glass-based products in 2019 and steel-based products in 2020.” **AMT**

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