

TOYOTA HYDROGEN

Powering ahead with green hydrogen innovation and design excellence. Carole Goldsmith reports.

The Toyota Hydrogen Centre, Victoria's first commercial-grade permanent hydrogen production, storage, and refuelling facility, is set to use green hydrogen production capabilities for automotive, transport, and even buildings. It is located at the Toyota Centre of Excellence (COE) at Toyota's former car and engine manufacturing site in Melbourne's west. The COE also incorporates product development, design, testing training and other essential functions.

Toyota's global vision for a sustainable hydrogen society recognises the importance of hydrogen as a viable and plentiful source of carrying and storing energy. Toyota's Hydrogen Centre opened five years ago and was Victoria's first commercial-grade permanent hydrogen production, storage and refuelling facility. It is housed at Toyota's former manufacturing site at Altona in Melbourne's west.

"Hydrogen is produced on-site by a 250kW electrolyser that uses electricity to split water into hydrogen and oxygen components and can produce up to 80kg of hydrogen per day," advises Toyota Australia's Carbon Policy Lead, Andrew Willis. "Power for the electrolyser is drawn from the on-site 3.4MW solar array and the grid, depending on what is available.

"An on-site refueller can dispense the hydrogen at medium pressure (35MPa) for machinery like Toyota's fuel-cell forklifts used elsewhere on the Altona site and at high pressure (70MPa) for vehicles like the Toyota Mirai, our hydrogen fuel cell electric vehicle (FCEV). Hydrogen produced on-site can also power a 30kW fuel-cell generator that supplies backup power for the hydrogen centre and can feed into the mains grid."

"Beyond the Toyota Mirai, Toyota is already using hydrogen to power trucks, urban bus fleets and forklifts as well as generators for powering industry, businesses, and homes," explained Willis.

"Mirai is essentially a "plug-less" electric vehicle. While charging, a battery-electric vehicle can take several hours, refuelling Mirai is quick and simple. There is a pump and a nozzle, just like at a petrol station. As you pump in the hydrogen gas, it is stored in the carbon-fibre-reinforced tanks. This takes about five minutes to fill the tanks with the Mirai rated to 650km before it needs refuelling.

"An FCEV like Mirai generates its electricity onboard from hydrogen, with water as the only emission. The process occurs in a polymer electrolyte-membrane (PEM) fuel cell made up of thin plates separated by membranes. The system combines the stored hydrogen with oxygen from the air. A chemical reaction produces electricity directly, powering the electric motor. Like hybrid technology, a lithium-ion battery also allows energy to be reclaimed through regenerative braking," advised Willis.

"Pressing the accelerator pedal yields an immediate flow of electric power from the fuel cell and/or the lithium-ion battery to the rear-mounted AC synchronous electric motor, which drives the rear wheels. The maximum power from the system is 128kW.

"An electric air compressor pressurises the intake air, and a water-cooled intercooler reduces the temperature of the compressed air before it enters the fuel-cell stack," added Willis. "A water-cooled oil cooler integrated with the air compressor helps maximise efficiency. An electrostatic cleaner purifies the intake air, capturing ultra-fine particles while a charcoal filter removes chemical substances."

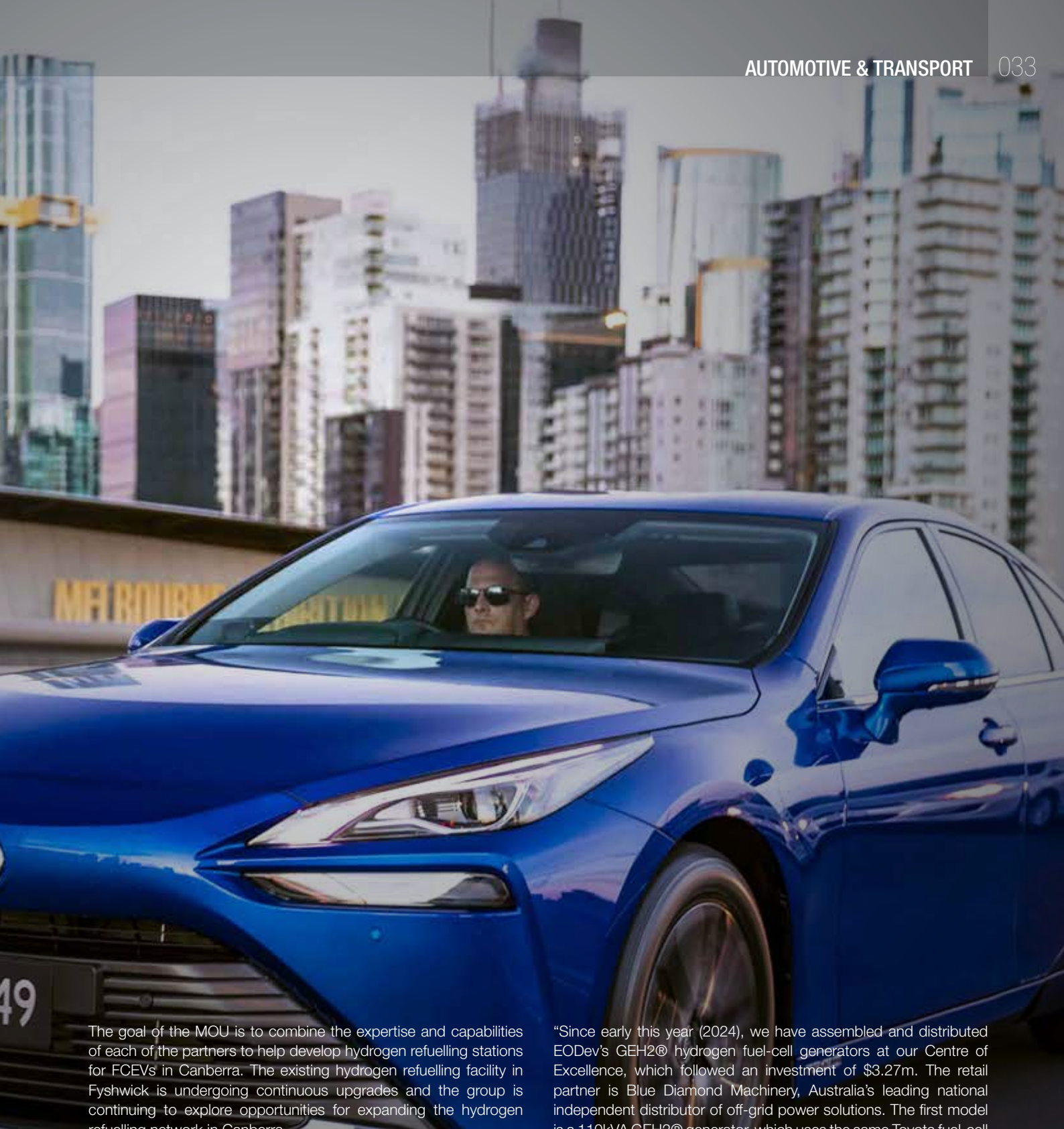
The Mirai fuel cells have a pressure relief device that releases the hydrogen gradually in case the temperature rises abnormally, and this prevents any overpressure.

Mirai is built at Toyota's Motomachi Plant in Toyota City, Japan. As part of its commitment to a sustainable future, Toyota Australia has already been leasing Mirai FCEVs to progressive businesses and organisations further to demonstrate the viability of hydrogen fuel cell technology. CSIRO was its first Mirai lease customer in Australia three years ago, and the vehicle was used to test CSIRO's hydrogen refuelling facility at its Clayton site in Melbourne's east.

Green hydrogen refuelling stations for Canberra

In a combined effort to offer green hydrogen refuelling stations, Ampol, Hyundai Australia, Pacific Energy, and Toyota Australia signed a Memorandum of Understanding (MOU) last October (2023) to explore opportunities for jointly developing hydrogen refuelling infrastructure in Canberra. The agreement brings together the four like-minded companies that are all leading proponents of Australia's growing hydrogen economy and demonstrates a commitment to work together to build a more sustainable future.

Both Hyundai and Toyota currently have FCEV fleets operating in Australia today, while Ampol and Pacific Energy are heavily investing in energy solutions to support customers through the energy transition.



The goal of the MOU is to combine the expertise and capabilities of each of the partners to help develop hydrogen refuelling stations for FCEVs in Canberra. The existing hydrogen refuelling facility in Fyshwick is undergoing continuous upgrades and the group is continuing to explore opportunities for expanding the hydrogen refuelling network in Canberra.

Publicly accessible refuellers are available in Melbourne, Canberra, Brisbane and Perth. There is also a more comprehensive range of refuellers held by companies for their internal use. Additional public-facing refuellers are expected to continue to increase, including Viva Energy's Geelong facility, which is under construction and anticipated to be operational shortly. CSIRO provides a map of Hydrogen Refuelling Stations around Australia.

Hydrogen fuel cell generators powering the future.

In Australia, Toyota is showcasing the broader applications for hydrogen-powered fuel-cell technology beyond the transport sector. "In association with energy provider EODev, we are supporting hydrogen as a clean and efficient source of electrical energy generation," advised Willis.

"Since early this year (2024), we have assembled and distributed EODev's GEH2® hydrogen fuel-cell generators at our Centre of Excellence, which followed an investment of \$3.27m. The retail partner is Blue Diamond Machinery, Australia's leading national independent distributor of off-grid power solutions. The first model is a 110kVA GEH2® generator, which uses the same Toyota fuel-cell system that powers the Mirai. As the market develops, additional models with differing power supply levels will be considered for assembly and distribution in Australia.

"Our investment in generator assembly will help build Australian skills and capabilities in hydrogen technologies in a rapidly growing industry that will help Australia meet its emission-reduction targets".

Potential applications for the GEH2® power generator include powering remote off-grid sites such as mining sites, construction sites, and battery electric vehicle (BEV) charging sites and for use in events. It can also be used to provide emergency backup power for hospitals, commercial buildings, and anywhere else where a stable power supply is required.

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"In 2022, we used an EODEV generator before and during an AFL game in Melbourne to light the Marvel Stadium sign and a team coach's box. The generator used 6kg of hydrogen, saving an estimated 100kg of CO₂ emissions compared with running the lights off the electricity grid. We have since continued using the generator at other event activations such as the Melbourne Grand Prix and AFL Gather Round," Willis explained proudly.

Global developments

Aiming to expand the line-up of fuel-cell passenger cars, Toyota and BMW announced in September this year (2024) that they are jointly developing a third-generation fuel-cell system and working on infrastructure development co-creation. They announced that the new system will be installed in both companies' models to provide customers with a broader range of FCEVs.

Also, in June this year (2024), Toyota announced that it is evaluating and demonstrating hydrogen fuel-cell prototypes of its HiLux pickup. The program involves ten prototype vehicles built in the United Kingdom. They use core components from the Mirai, such as its fuel cell and hydrogen tanks. This project further demonstrates the broad scope of Toyota's multi-path strategy towards carbon neutrality, applying different powertrain solutions, hybrid-electric, plug-in hybrid electric, battery electric, fuel-cell electric and e-fuels, to suit different user needs and local market needs and infrastructure.

Beyond passenger vehicles, Toyota has expanded its hydrogen focus to commercial applications. The company is testing heavy-duty hydrogen trucks and buses, with prototypes currently being trialled in America, Europe and Japan. In 2023, Toyota and PACCAR expanded their collaboration to develop zero-emission, hydrogen fuel-cell trucks. This builds on a pilot program at the Port of Los Angeles that helped enhance performance and range.

These commercial ventures are part of Toyota's broader goal to accelerate the transition to zero-emission transport, particularly in freight and public transit. In Europe, Toyota has established a Fuel Cell Business Group to oversee its regional hydrogen activities. Based in Brussels, it aims to strengthen the business case for hydrogen and support its introduction into mobility and other fields, making it accessible to new commercial partners. It will enable Toyota to work closely with industry partners, national and regional governments and organisations to stimulate the development of hydrogen eco-systems in more locations and progress towards the goal of a hydrogen society for the benefit of all.

Toyota believes its activities will drive demand for hydrogen, bring down costs and strengthen the viability of the supply infrastructure.

Toyota Centre of Excellence.

In December 2021, Toyota's former car and engine manufacturing site at Altona in Melbourne's west was reborn as its Centre of Excellence, incorporating product development, design, testing, training and other essential functions. "The \$150m invested to develop the centre on the 75-hectare site is a key pillar in Toyota's vision to continually develop world-class facilities and people," Willis advised. "The centre has enabled Toyota to retain and build on the innovations and capabilities developed during our long vehicle manufacturing history, particularly in design and engineering.

"In the spirit of kaizen, or continuous improvement, we always upgrade the site and develop our functions and people. This stems from Toyota's commitment to provide ever-better vehicles and services to our customers. It also means we keep jobs, skills and career paths in Australia," said Willis.

As well as housing the Hydrogen Centre, the Toyota Centre of Excellence includes:

- Product planning functions including local development and evaluation of vehicles and accessories sold here and globally.
- Toyota Design Australia, which is based in a state-of-the-art studio on the site that was previously the engine plant. Its facilities allow creative designers, studio engineers, clay and digital modellers to create ever-better designs and full-size prototypes of vehicles, components and accessories that ultimately become products that can be sold in Australia and around the world.

The fabrication area offers a vast array of prototyping capabilities. There are two 5-axis CNC milling machines. The facility houses ten 3D printing machines. There's CAD metal and wood fabrication and a paint spray booth using the latest waterborne technology.

- A 55,000-square-metre Toyota Parts Centre that houses 1.5 million parts and delivers 26,000 parts daily. Its innovations include hydrogen fuel cell and driverless forklifts, autonomous AI-controlled vehicles, smart trolleys, and conveyors.
- Conversion Centre, where Toyota's world-famous production methods are applied to the final assembly of HiLux Rogue and HiLux GR Sport variants for the Australian market. The hydrogen fuel-cell power generators are assembled in this facility. The units are locally distributed by retail partner Blue Diamond Machinery and exported directly by Toyota.

- A 10-hectare Autodrome with a 1.4km test-drive course, unsealed surfaces, a water crossing, off-road hills, and moguls.
- A simulated Toyota dealership that provides practical and theoretical training for showroom and service areas.
- A service centre for training in the Toyota Production System. This training has helped many businesses and non-profit organisations service their communities better.

Making the switch

Why electric motorcycles are the way forward for Australia.

Individuals can feel so helpless in the face of mounting climate change. You've invested in rooftop solar or switched to a greener energy provider. You do your bit with recycling and composting and buy local produce whenever possible. You even ditch the car most days and switch to a crowded train. Fortunately, there are options to 'green' your guiltiest pleasures—including your weekend motorbike ride.

While we've been slow to catch up, Australia is finally embracing electric motorcycles as the responsible choice for the future. With the explosion of home solar systems, more Aussies are also recognising that there are significant savings to be made from a ride that is effectively fuel and maintenance-free. But there are many other reasons for switching to an electric two-wheeler—especially one built in Australia.

Quieter streets, healthier communities

Internal-combustion motorcycles contribute significantly to urban noise pollution. The constant din disrupts sleep, increases stress levels, and can even lead to hearing problems. World Health Organisation studies link chronic noise exposure with tinnitus, heart disease, and even cognitive decline.

On the other hand, electric motorcycles operate at much lower decibels - creating a more peaceful environment for the whole community. Riders can enjoy the sounds of the city or the open road without the constant roar. The quieter operation also allows for better communication between riders and improved awareness - leading to safer interactions on the road.

Less maintenance, more riding

Unlike combustion engines with their pistons and valves, electric motors have a simpler design with fewer moving parts. This translates to less wear and tear, fewer maintenance headaches, and lower overall costs. No oil changes, filter replacements, or spark-plug adjustments are required, simplifying maintenance and reducing the amount of used oil and filters entering the waste stream. With an e-moto, you can spend less time tinkering and more time out on the road.

C-Series passes EMC testing, but, what is that?

EMC stands for Electromagnetic Compatibility. Our testing primarily relates to the safety and compliance regulation ECE R10, which defines precise requirements for the electromagnetic compatibility of components used in motor vehicles. These tests are crucial to ensure that our motorcycles meet strict regulatory standards and don't interfere with or get affected by other electronic devices or vehicles. During the EMC tests, the C-Series was placed in an anechoic chamber (a space surrounded by carbon-loaded foam designed to absorb electromagnetic signals) with specialised equipment monitoring the vehicle's emissions. It was then exposed to electromagnetic energy across a wide frequency range to validate its susceptibility.

There's also an interactive education centre to inform government, industry and students about hydrogen, fuel-cell technology and sustainability.

"Going forward, the Centre of Excellence and the Hydrogen Centre are helping promote the future of sustainability, mobility and connected technology for Toyota, our customers and our Australian community," added Willis proudly. **AMT** toyota.com.au



All devices that emit electrical signals can influence each other when they are connected or in close proximity—including when they're out on the road. Australia's EMC regulations aim to keep these side effects within acceptable limits.

Built to last, designed to recycle

With the Savic Motorcycles C-Series, sustainability goes beyond the electric powertrain. At least 80% of the structural components are constructed from recyclable aluminium. The C-Series' battery packs are also designed not just for performance but for a responsible future, including:

Repurposing for home energy storage: Once our battery reaches the end of its useful life for powering your motorcycle, it still has plenty of life left. The C-Series battery can be repurposed for home energy storage, helping you reduce your reliance on the grid and potentially lowering your power bills.

Battery recycling: C-Series batteries can be recycled down to their core chemical components at the end of their second life. These components, such as lithium, cobalt, and nickel, can be reused to produce new batteries, creating a closed-loop system that minimises waste and further environmental impacts.

By incorporating recycled materials and designing for battery recycling, the C-Series goes beyond being electric - representing a genuine commitment to a sustainable future.

Choose electric, choose sustainable

Electric motorcycles offer an exciting and sustainable alternative to traditional petrol-powered models. With the C-Series, you don't have to compromise on performance or style. Join the electric revolution on two wheels and embrace a cleaner, quieter, and more responsible future! **savicmotorcycles.com**