Port Kembla Hydrogen Hub

FUTURE MOBILITY DAY #3

4 November 2021

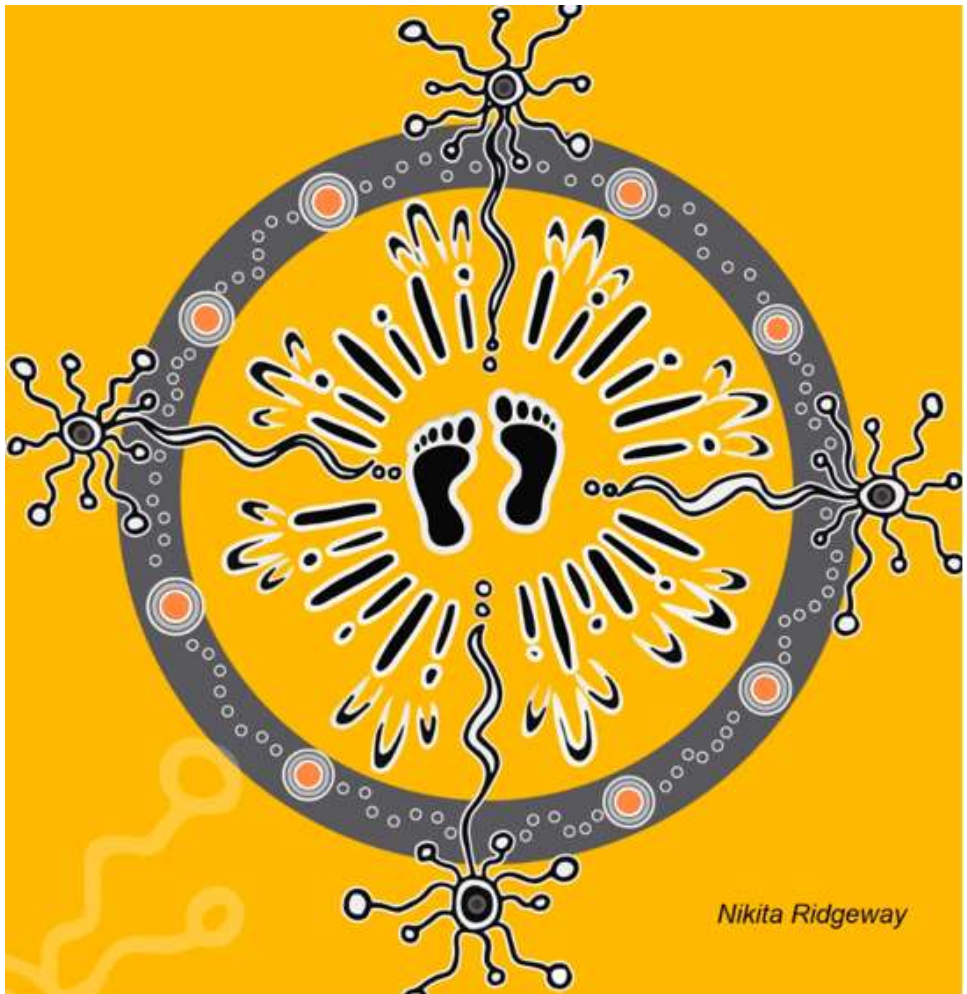
NSW GOVERNMENT

Acknowledgement of Country

I acknowledge that we meet on Aboriginal lands. I acknowledge the traditional custodians of the many lands that we join this virtual meeting from.

We can use this meeting to show respect to elders, past, present and emerging through our thoughtful and collaborative approaches to our work.

I acknowledge our Aboriginal and Torres Strait Islander colleagues joining the meeting today.



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Future Mobility Day #3 Program

- 4 November 2021

11.00am	Welcome + Intro	Nigel McKinnon Dept of Regional NSW
11.05am	Industry Development	Adam Zarth Business Illawarra
11.10am	NSW Hydrogen Strategy + Hydrogen Hubs initiative	Sam Frisby DPIE
11.15am	Heavy Road Transport Trial + Refuelling Station	Wodek Jakubik Coregas
11.25am	Fleet Opportunities	John Feenan Hyzon
11.35pm	Repowering Mining Equipment	Brad Neilson Streamlined Energy
11.45pm	Hydrogen powered ICE (H2ICE)	Shawn Kook UNSW
11.55pm	Q & A	

PORT KEMBLA HYDROGEN HUB

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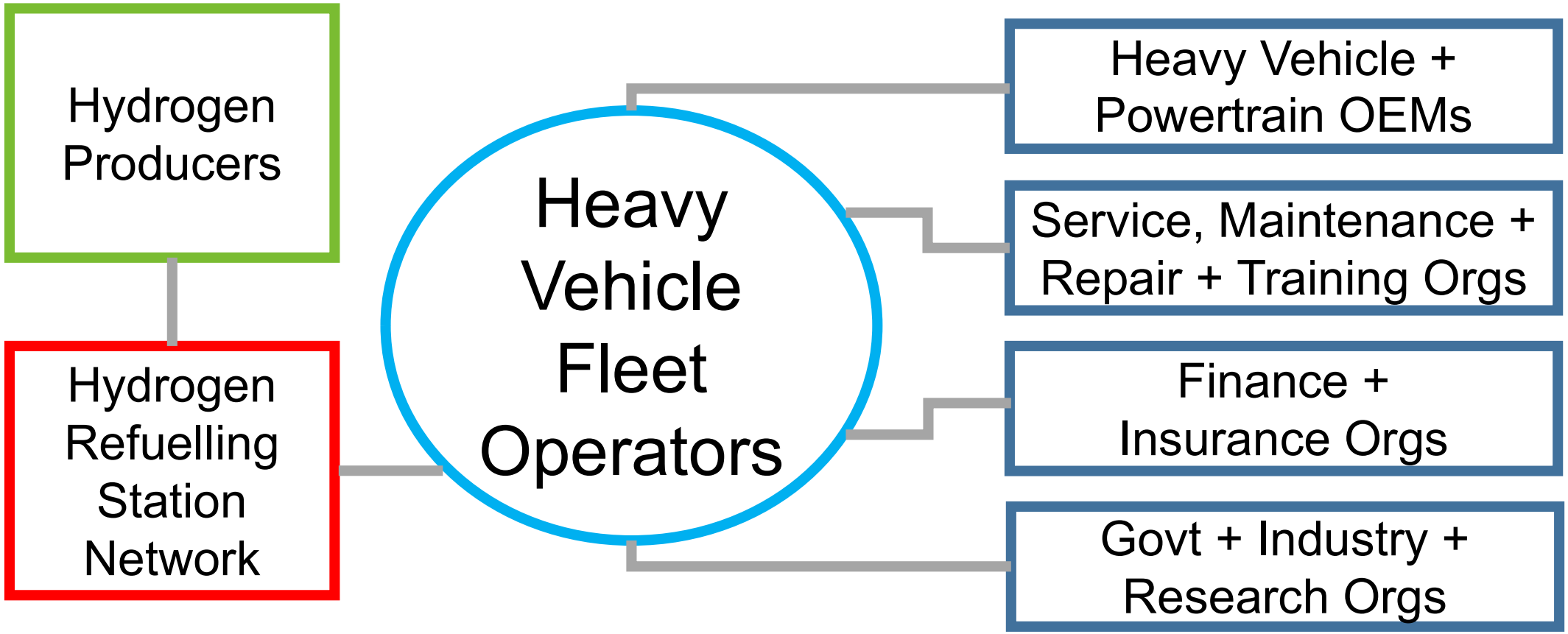
Download Investment Prospectus

For more information about the Port Kembla Hydrogen Hub please contact:

Nigel McKinnon
Deputy Director, Illawarra-Shoalhaven
Regional Development Branch | Department of Regional NSW
M 0418 259 055 | **E** nigel.mckinnon@regional.nsw.gov.au

Heavy Vehicle Technology Cluster



Why Port Kembla

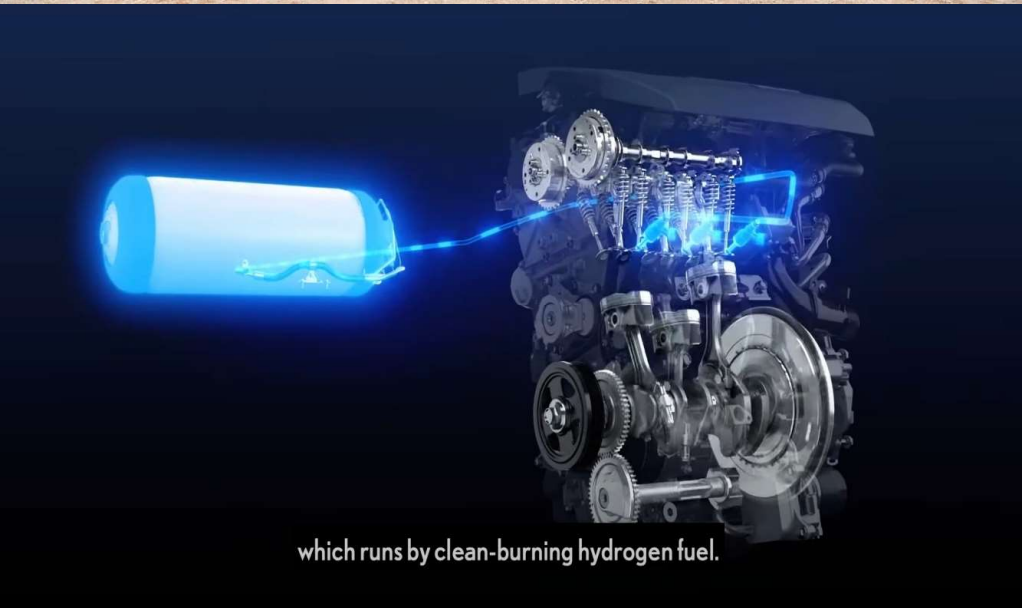
A range of hydrogen powered **zero emission trials** across different **heavy vehicle types** are planned.

- Trucks
- Buses
- Trains
- Mining Equipment
- Materials Handling Equipment

#1 - Superior location for heavy vehicle trials

#2 - Large heavy vehicle fleets with return to base routes

#3 - Low cost hydrogen supply, first refuelling station by mid 2022



H2ICE Technology

Hydrogen can be used to power internal combustion engines replacing fossil fuels such as diesel and petrol. Known as H2ICE, it has several benefits over fuel cell and battery electric technologies.

H2ICE combines internal combustion engine technology with low manufacturing costs, existing supply chains, servicing networks and expertise that have all been developed over the past century.

Most diesel powertrain OEMs have both fuel cell and H2ICE programs running:

- Caterpillar - hydrogen stationary gensets
- Cummins - hydrogen fuelled engine
- CMB – BeHydro dual fuel engine
- Wartsila - hydrogen test program
- JCB - hydrogen internal combustion engine
- Toyota - hydrogen internal combustion engine

Hydrogen Train Trial Feasibility Study

The NSW Government is completing a feasibility study with Alstom on trialling a hydrogen train on the NSW train network as part of our broader objective to decarbonise our rolling stock. The study will improve our understanding of hydrogen fuel for rail and assess what is required for a trial in terms of infrastructure, standards and accreditation.

Source: NSW Hydrogen Strategy

BUSINESS ILLAWARRA

Industry Development

Adam Zarth - Executive Director

Enabling Infrastructure

Develop a network of commercial **hydrogen refuelling stations** to support the transition to zero emission vehicles

- public multi vehicle stations
- on-site private fleet refuellers
- mobile refuellers

Publicly accessible multi heavy vehicle refuelling station

Centre of Excellence

Create a Centre of Excellence based hydrogen powered zero emission **heavy vehicle technologies**.
Develop a world class ecosystem that supports opportunities

- Australian headquarters of OEM heavy vehicle importers
- niche vehicle manufacturing
- repowering of existing diesel vehicles with zero emission powertrains
- maintenance and servicing
- research and development
- LHD to RHD vehicle conversion for domestic use and re-export

Repowered diesel electric freight locomotive with hydrogen powered internal combustion engine

NSW Hydrogen Strategy – policies and initiatives

Sam Frisby - Hydrogen and Clean Energy

November 2021

Department of Planning, Industry and Environment

Our nation leading policy framework

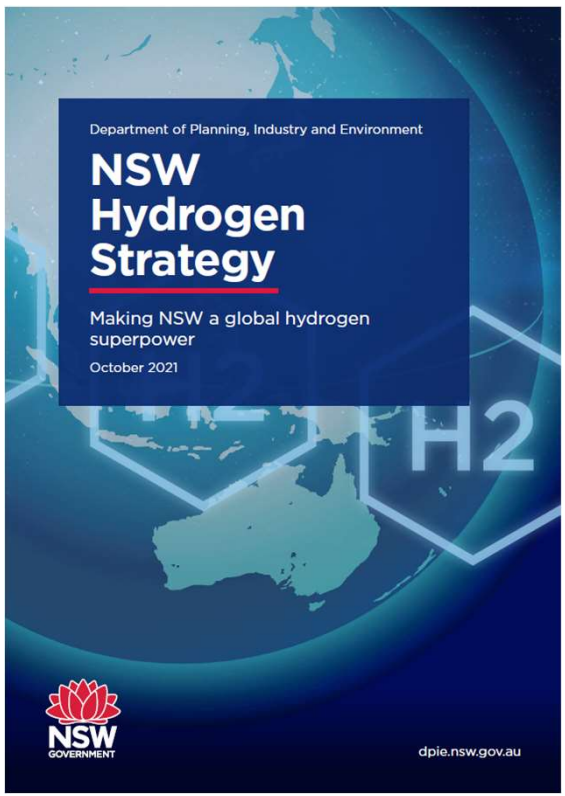
The Strategy brings together the NSW Government's existing and new policies into a framework which will transform NSW into Australia's largest consumer of green hydrogen and:

- sets out clear industry targets, sector priorities and actions to develop the entire hydrogen value chain
- aims to unlock the hydrogen heavy transport market, prepare for export opportunities and host new hydrogen enabled low-emissions industries

60
Actions

$3B
incentives

<$2.80
H2 price



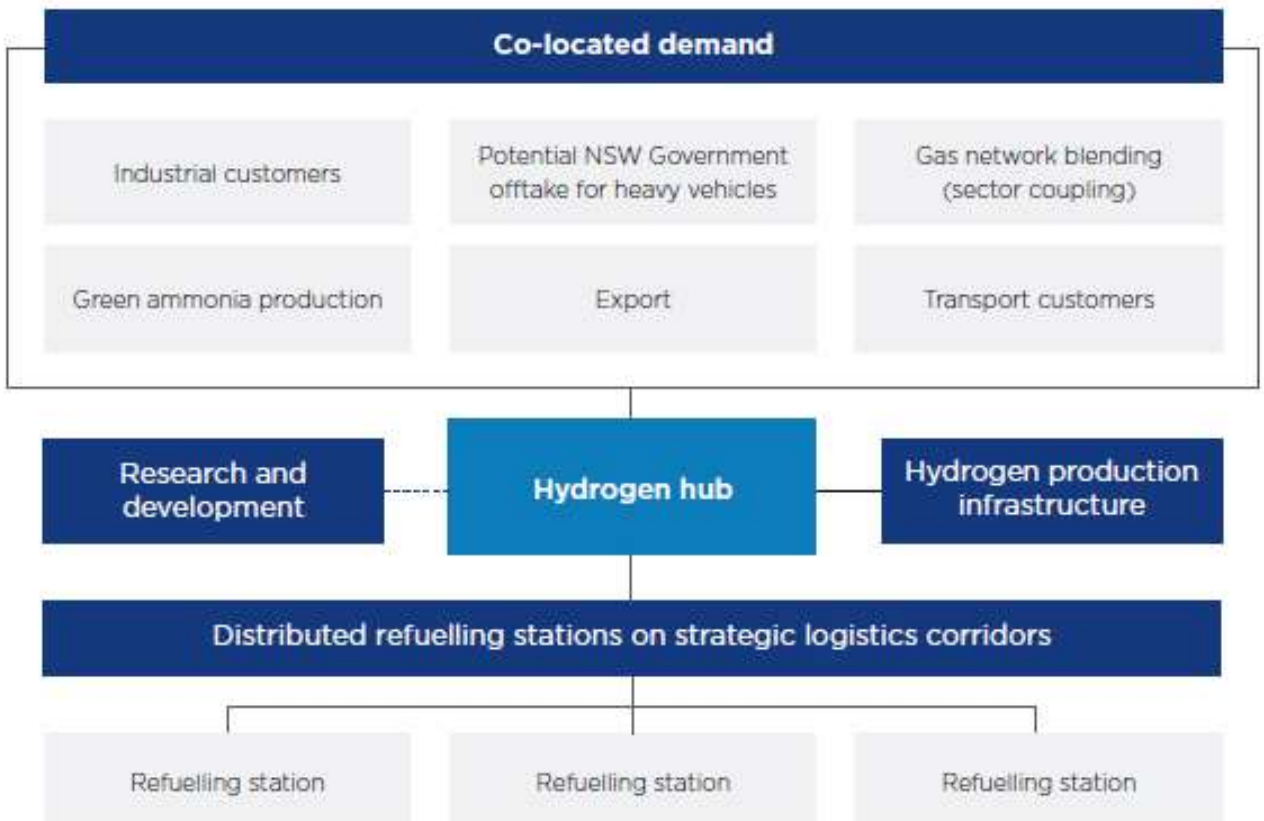
Department of Planning, Industry and Environment

PILLAR 2

Hydrogen hubs initiative

The objective is to lay foundational infrastructure and supply chains, with:

- At least $70 million in funding support
- A focus on the Hunter and Illawarra regions
- Funding support available for full supply chain, including vehicles
- Supporting identification and aggregation of potential hydrogen consumers into the hydrogen hub.



PILLAR 2

Hydrogen refuelling network

The objective is to lay refuelling infrastructure along major highways, with:

- Funding support from $175 million focus area of Net Zero Industry and Innovation Program
- Initial funding for 4-5 scalable refuelling stations along a trial corridor and support for between 25-50 hydrogen trucks
- Funding support available for refuelling stations and vehicles
- Targeting of fleet operators and Original Equipment Manufacturers.

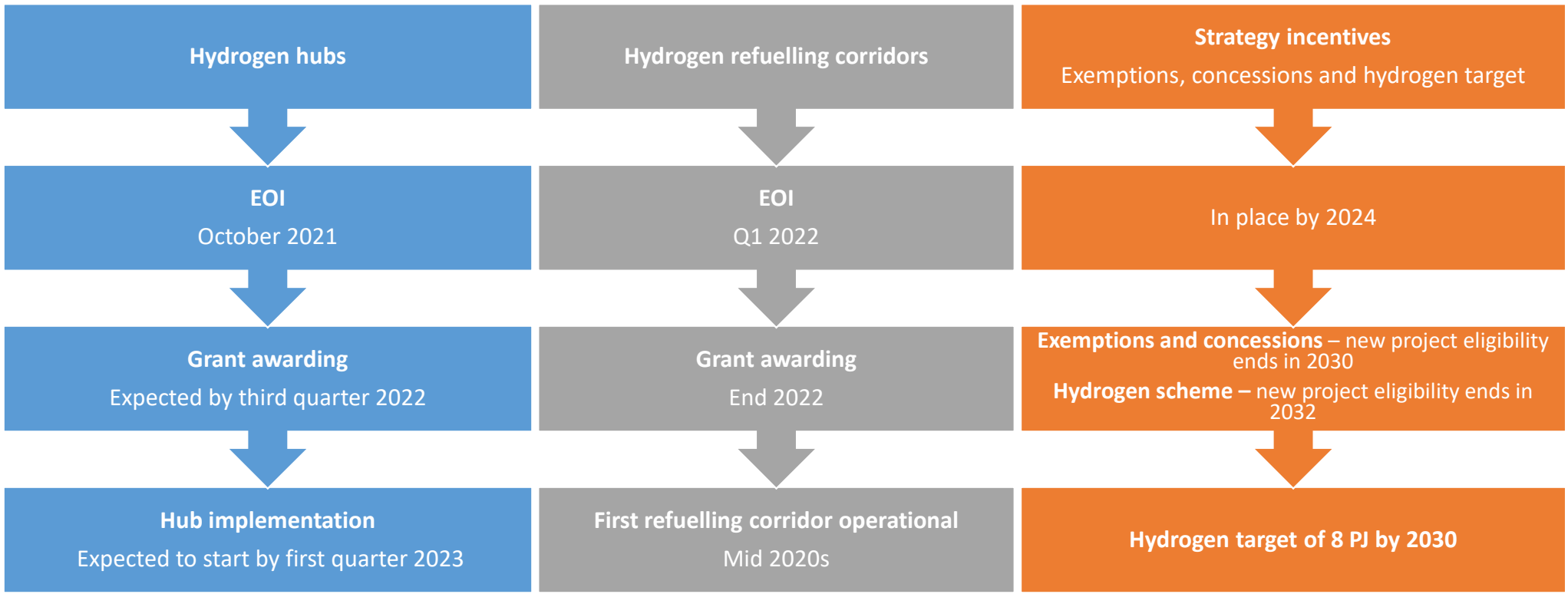
Transport

Transport

The Strategy sets out 11 actions for the transport sector, including:

- Implementing a zero-emissions transition strategy for the NSW Government's fleet of 8,000 buses
- Completing feasibility, trials and testing of NSW Government hydrogen vehicles to achieve our 20% heavy vehicle stretch target by 2030
- Investigating possible incentive structures to encourage the uptake of hydrogen vehicles
- Developing and implementing a NSW Government heavy transport sector market engagement and advocacy plan.
- Identify and make any necessary updates to NSW legislation and regulations relevant to the safe use and distribution of hydrogen in transport applications at scale. This includes the Dangerous Goods Act (Road and Rail) Act 2008, Heavy Vehicle (Adoption of National Law Act) Act 2013 and Transport Administration Act 1988.

Timeline of NSW Hydrogen Strategy initiatives



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DPIE Hydrogen and Clean Energy

hydrogen@planning.nsw.gov.au

Department of Planning, Industry and Environment

ACTIVATING A REGIONAL HYDROGEN INDUSTRY – CLEAN HYDROGEN INDUSTRIAL HUBS: HUB DEVELOPMENT AND DESIGN GRANTS

Funding to develop and advance hydrogen hub concepts to investment ready projects

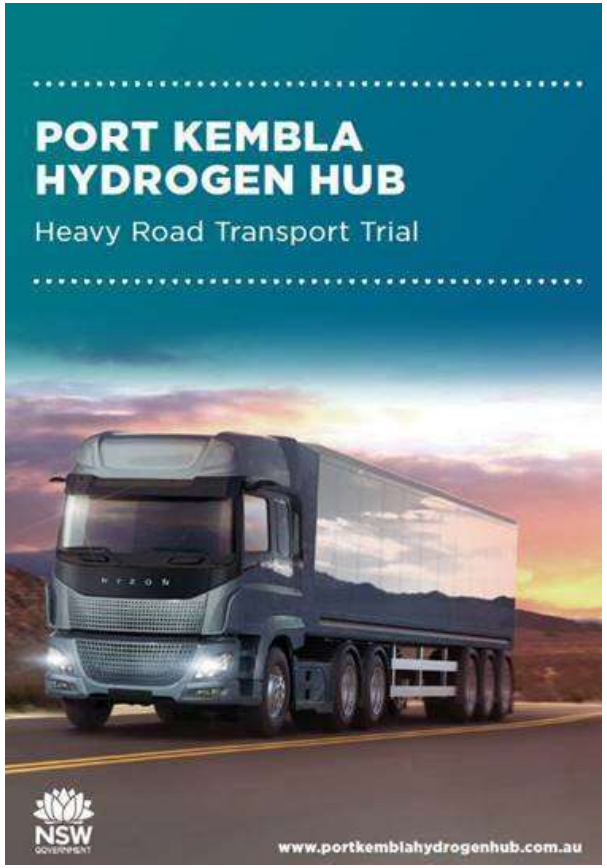
Last Updated: 19 October 2021

Heavy Road Transport Trial + Refuelling Station

Wodek Jakubik, Innovation Manager

Heavy Road Transport Trial Update

- Order placed with Hyzon for two Hymax 450 Prime Movers that represent Stage 1 of the Trial
  - mid 2022 delivery
- Order placed for the Haskel refuelling station
  - mid 2022 delivery, commence earthworks early 2022
- Heavy Road Transport Trial brochure provides details on the Heavy Road Transport Trial.



Exceptional level of media coverage

HOME › NEWS › ENERGY

Australia's first hydrogen-powered trucks to be delivered to Coregas by Hyzon Motors

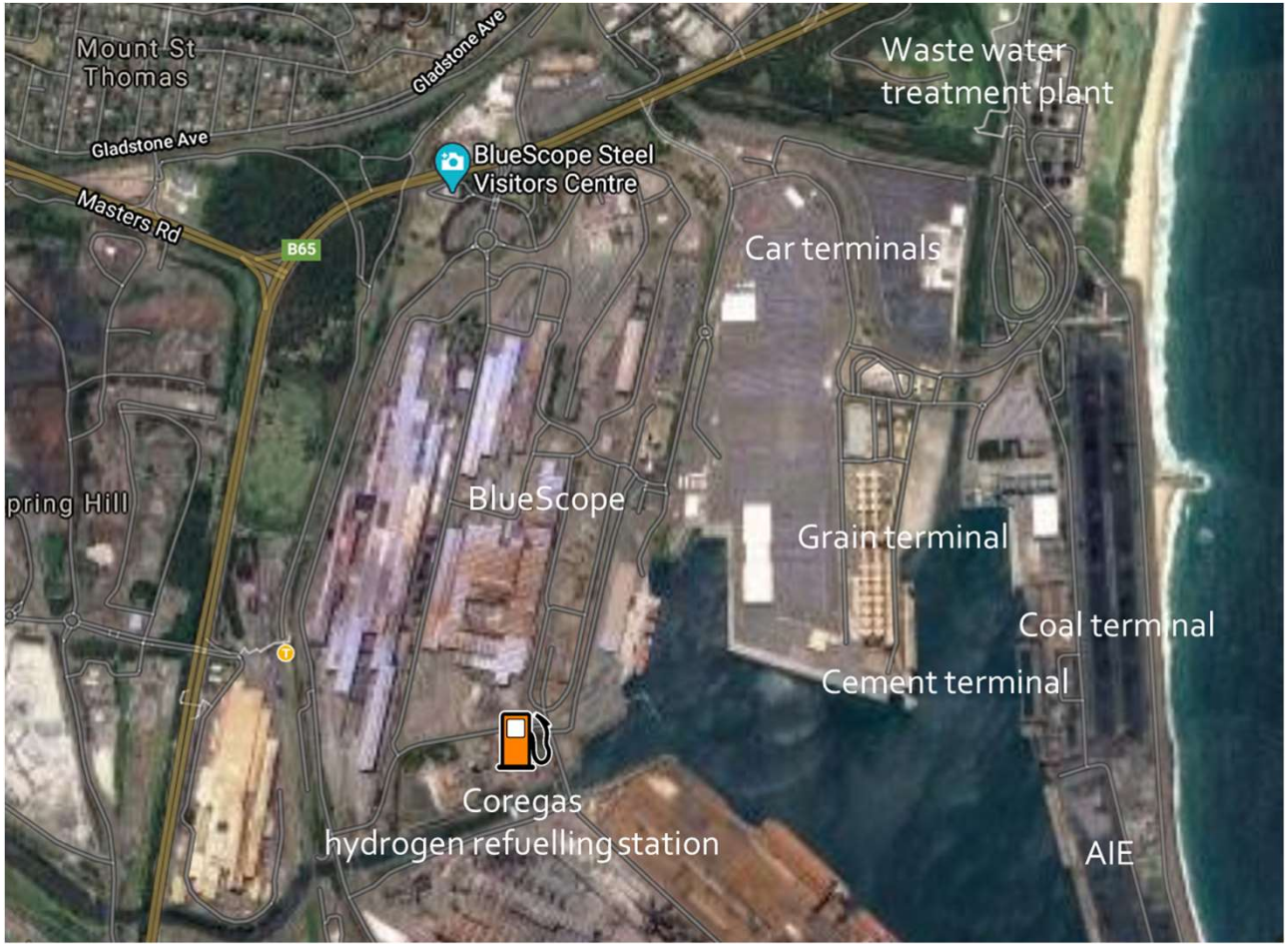
JULY 15, 2021

Coregas Hydrogen Refuelling Station

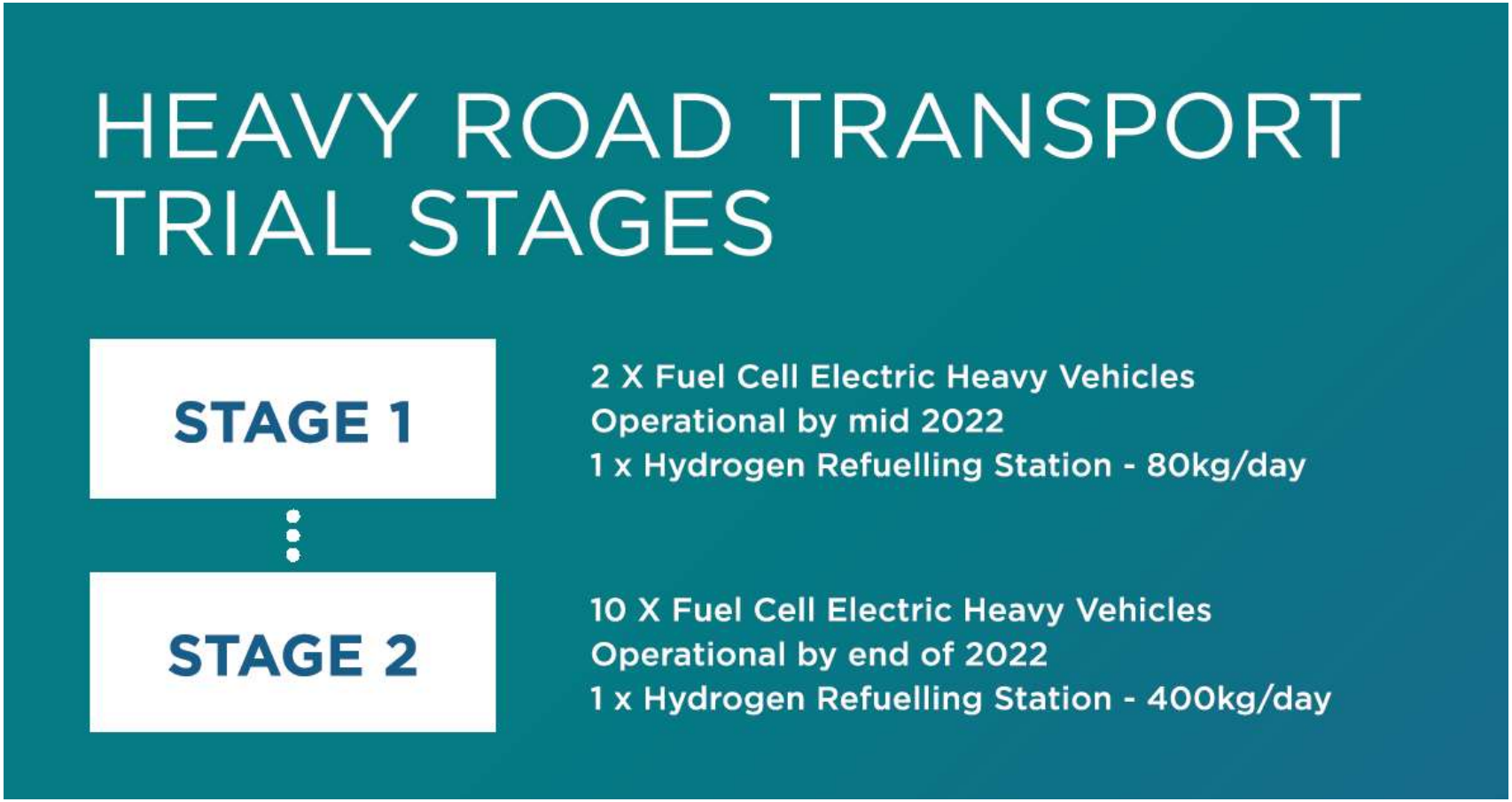
AUSTRALIA'S FIRST COMMERCIAL HYDROGEN REFUELLING STATION

Haskel Hydrogen Systems will provide the refuelling system to be used at Australia's first hydrogen refuelling station for commercial vehicles. The system will take hydrogen from the Coregas plant, compress it to the industry commercial vehicle standard of 350 bar pressure. The compressed hydrogen is then delivered to a dispenser at the vehicle fuelling station 50 metres away. The Haskel system represents the latest in refuelling technology with daily capacity to discharge 400 kilograms of fuel cell grade hydrogen.

Coregas Refuelling Station Location



Be part of Stage 2 - capacity for additional vehicles



Port Kembla Hydrogen Hub
Fleet Opportunities
- John Feenan, Commercial Director

HYZON MOTORS | NOVEMBER 2021

Disclaimer

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Our aim is to provide zero-emission fuel cell technology that reaches **tare weight parity with diesel.**

"… hydrogen will be used for transport mostly in the heavy-duty, long-haul transport sectors."

Dr Alan Finkel, Special Adviser to the Australian Government

Who we are

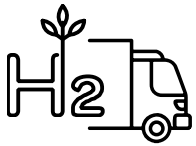
Hyzon is a global supplier of zero-emissions hydrogen fuel cell powered commercial vehicles

Hyzon Motors Inc. listed on the Nasdaq on 19 July 2021

USD 2.7Bn valuation
USD 600M raised

Supplier of heavy-duty trucks, buses and coaches

Built on mature, global OEM platforms



Pure-play, independent hydrogen mobility company targeting heavy-duty vehicle segment

200 +

Employees worldwide

Horizon Fuel Cell Technologies

Formed by parent company Horizon with 18 years experience in commercial fuel cell development

Partnering to deliver the full hydrogen ecosystem for fleet operators

500 +

Vehicles delivered in 2019 and 2020 using Hyzon fuel cell technology

4

Global manufacturing hubs serving local markets

Real trucks on the road or in development

ON THE ROAD IN EU TODAY, IN AUS H1 2022

HYMAX-450
6x4 70t Prime Mover
Other configurations available

HYMAX GSL GARBAGE TRUCK
Cab-over. Local configuration

IN AUS Q4 2021

COACH
57 Sitting, high floor

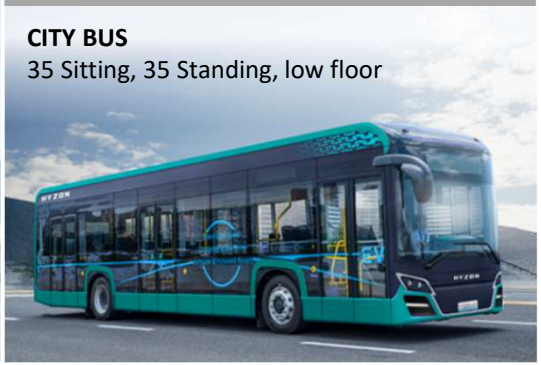
ON THE ROAD IN AUS 2022

ROAD TRAIN
140t Prime Mover

HYMAX HEAVY RIGID
Local configuration

IN AUS H1 2022

CITY BUS
35 Sitting, 35 Standing, low floor



Hyzon Motors' first hydrogen fuel cell electric coach on the roads in Brisbane

- Hyzon has partnered with leading bus and coach chassis builder BLK Auto to produce the 50-seat coach
- The coach serves the unique characteristics of the Australian market - vast distances and sparse infrastructure
- Range of up to 430 miles (700km) and motor power of 350-kilowatt capacity
- Local production of key platforms in Australia will commence 2022

> *"The coach has attracted significant interest since it arrived at our facility, with local bus operators, representatives from various government departments, mining companies and tourism operators coming to see the coach in action and learn more about how these zero emission, hydrogen fuel cell-powered coaches can be adopted in their respective industries."*
>
> Jason Pecotic, Managing Director of BLK Auto

Hyzon signs MOU with Superior Pak for the supply of up to 20 waste collection vehicles

- Superior Pak is a leading Australian manufacturer of waste handling equipment
- Leveraging 25 years of experience in mobile waste collection/compaction equipment and Hyzon's leading fuel cell technology
- First clean waste collection vehicle available in Australia to undertake full operational curb-side collection duties
- First 5 vehicles are expected to be delivered and operational in Q2 2022
- Expectation of 15 more vehicles in late 2022

> *"Clean waste management is no longer an oxymoron. The benefits to the environment, the communities and drivers is enormous, so we are determined to develop a reliable, accessible option within a year."*
>
> Rob Wrigley, Managing Director of Superior Pak

Hyzon provides a complete hydrogen ecosystem to support and maintain your fleet.

Hyzon globally offers complete turnkey solutions

Hyzon has a number strategic partnerships Australia wide

Hydrogen suppliers	Refuelling solution providers	Customer service centre network	Telematics

Hyzon can collaborate with your organisation to support your fleet transition

Hydrogen supply	Refuelling station	Driver & mechanic training	Servicing & Maintenance	Data collection

Hyzon can supply and support your transition to zero emission vehicles

Complete turnkey solution

Infrastructure to support your operations, end-to-end

Meet your zero emissions target

Vehicle trial expected to deliver emissions reductions of 50%

Industry experts in decarbonisation solutions

Clear guidance to support your fleet transition

Potential access to government support

$90M in funding for hydrogen hubs in NSW including Port Kembla

Become a first adopter

Guaranteed vehicles on the road in 2022

salesANZ@hyzonmotors.com | hyzonmotors.com

Repowering Mining Equipment

Brad Neilson – Principal
Streamlined Energy

STREAMLINED ENERGY

Repowering Mining Equipment

Focus on Underground Mining Equipment

- Repowering of diesel electric LHD Loaders with hydrogen fuel cell technology.
- LHD Loaders are the primary mining machines in underground hard rock mining.
- Each LHD Loader consumes 300,000 litres of diesel annually and generates 800,000 kg of CO2.

Benefits

- Removal of carcinogenic diesel exhaust emissions from the underground mining environment.
- Diesel emissions are the primary driver on a mine's ventilation system.
- Ventilation system is the mine's largest energy consumer.
- Reduction in mine's energy consumption.

The challenge – moving away from diesel

Battery electric

- Major manufacturers are in the process of developing and releasing battery electric LHD Loaders.
- Heavy compared to diesel electric LHDs, approx. 5,000 kg extra weight in the battery.
- Slow charging time - 60 minutes, although swap out battery packs reduce this.
- Diesel LHD has 8,000 kWhr of stored energy (at 38% eff), providing about 3,000 kWhr of energy.
- Battery Electric LHD has 350 kWhr of stored energy (at 85% eff), provides about 300 kWhr of energy.

So the challenge is… a state of the art battery powered LHD has a power unit twice the mass with 1/10th the useable energy on-board…and a charge time of 60 mins compared with 10 mins to refuel a diesel

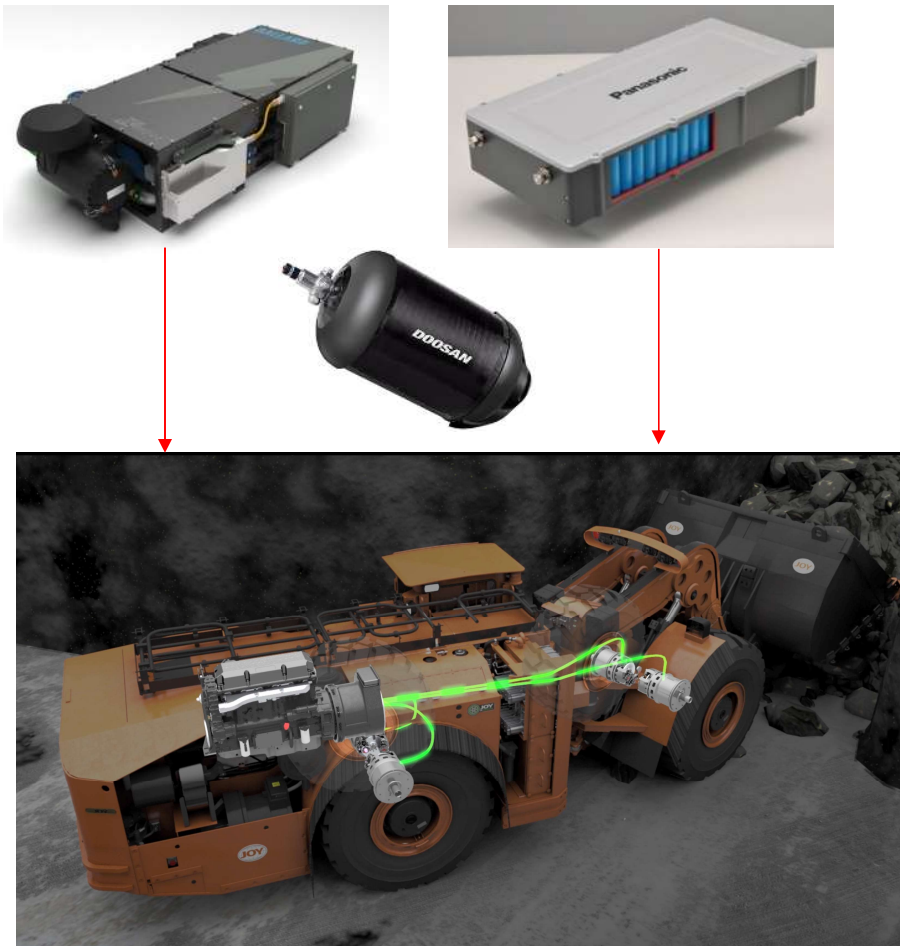
Repowering Options

Pathway 1

- Retain existing diesel engine and retrofit supplementary hydrogen to reduce consumption and emissions – target 30%

Pathway 2

- Replace existing diesel engine with a 200 kW hydrogen powered Fuel Cell.
- Add 50 kWhr / 150 kW Lithium Ion Battery.
- Replace 760 litre diesel tank with hydrogen storage.
- Kinetic Energy Storage System (KESS)* for high power events – braking / accelerating.



Developing a new local industry

- Opportunity to develop a local ecosystem around the fuel cell repowering of existing mining equipment including LHD Loaders.
- A new LHD Loader costs around AUD $1,800,000 (depending on model and options).
- Australian LHD Loader fleet is around 500 vehicles, with approx. 250-300 units in the heavy weight class.
- Existing vehicles would be shipped to the region for repowering and refurbishment to extend their operating life.
- The next logical step is to repower underground mine trucks – population of 500 units and they emit twice as much as an LHD Loader.

Acknowledgement: Financial supports provided by ARENA and MAN Energy Solutions, and a research partnership with The University of Melbourne

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Hydrogen powered internal combustion engine (H2ICE)

Zero carbon emissions, low development cost, low quality H2 usage, high reliability

Professor Shawn Kook

School of Mechanical and Manufacturing Engineering
The University of New South Wales

ENGINE RESEARCH LABORATORY EST. 2009 UNSW

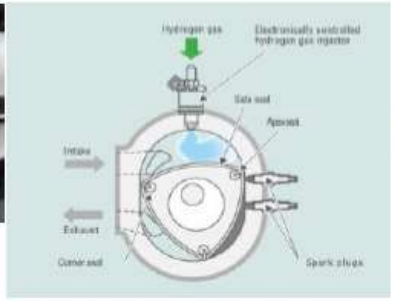
4 Nov 2021

NSW Future Mobility Day #3

Hydrogen internal combustion engine (H2ICE) cars and trucks

First wave (2000s)

Ford Model U (2003)



Mazda RX-8 H2 RE (2003)

BMW Hydrogen 7 (2009)

Second and current wave (2020s)

Toyota Corolla H2ICE (2021)

JCB Hydrogen Excavator (2020)

Westport Fuel Systems

TUPY

AVL

AVL-Westport Dual-Fuel Engine Development (2021)

MAN stationary engine application with 20% H2 in Dessau-Rosslau (2021)

MTU's H2 engine development roadmap (2021)

CMB.TECH H2 Truck 2.0 (2021)

Caterpillar power generator development plan (2021)

Cummins truck engine development plan (2021)

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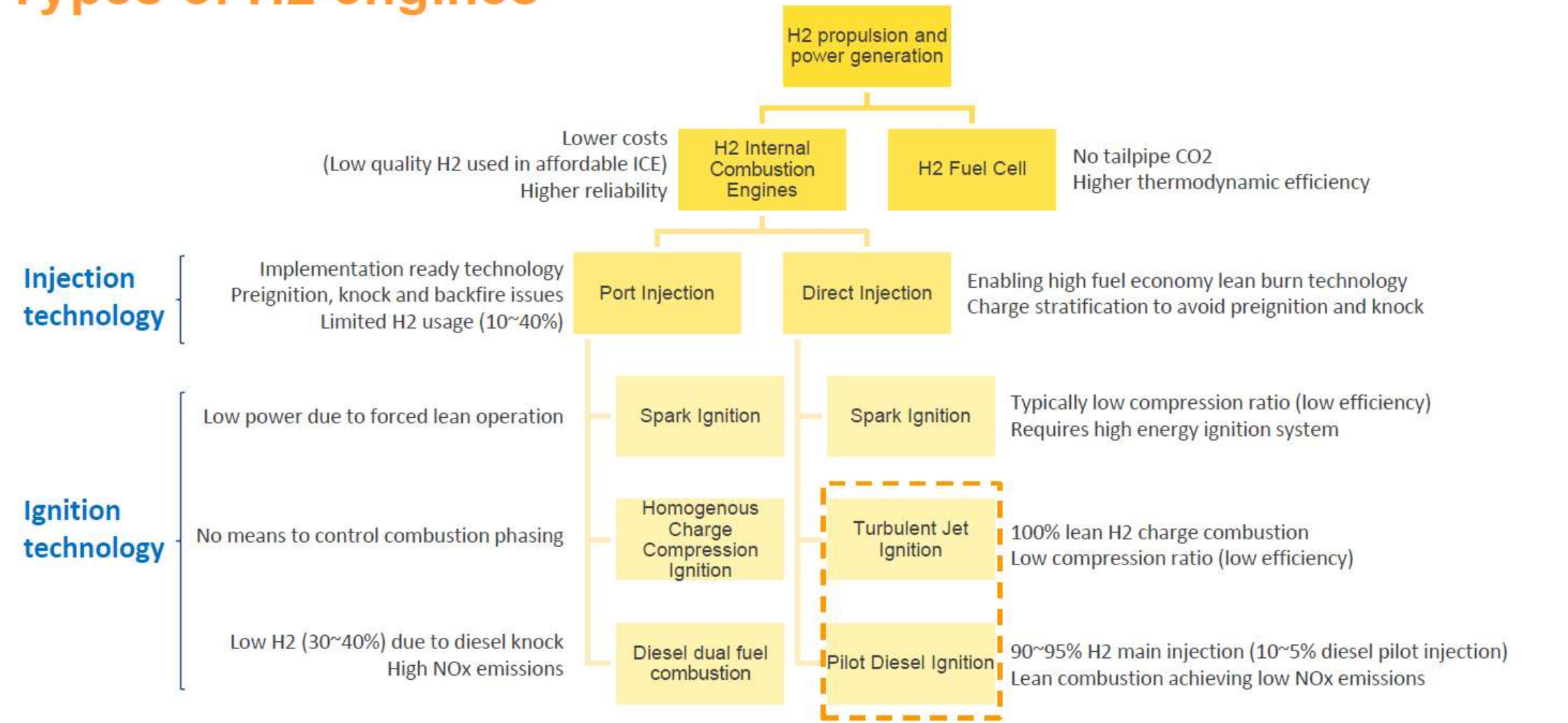
Types of H2 engines



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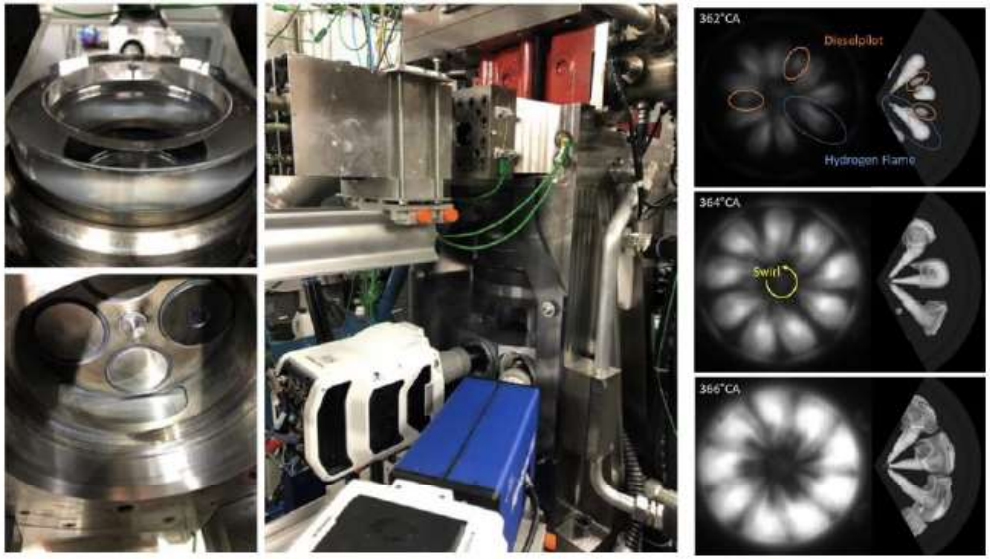
Advanced H2 internal combustion engines

Adaptation of the active pre-chamber in Liebherr's H966 and H964 engines has demonstrated that heavy-duty engines can be operated with hydrogen.

Mahle jet ignition system (active pre-chamber) applied to Liebherr's H966 and H964 heavy-duty engines (petrol engine architecture)

- Keeping the high compression ratio while applying high exhaust gas recirculation (EGR) for a diluted charge to avoid pre-ignition and knock
- Required high-energy ignition is provided by the pre-chamber ignition technology
- H2 is spark ignited within the pre-chamber to eject gas plasma through small orifices
- Quick and uniform ignition of main H2-air mixture in the main chamber



L'Orange integrated hydrogen/diesel injector applied to MTU 4000 heavy-duty diesel engine (International J of Engine Research 2021, 22(10):3196–3208)

- New injector to replace the existing diesel injector
- Up to 500 bar H2 injection and 1800 bar diesel injection
- Diesel pilot injection occurs between the hydrogen jets to force ignite them
- Stable combustion confirmed and up to 95% H2 substitution ratio achieved

UNSW's H2ICE Research: H2 main injector and diesel pilot injector

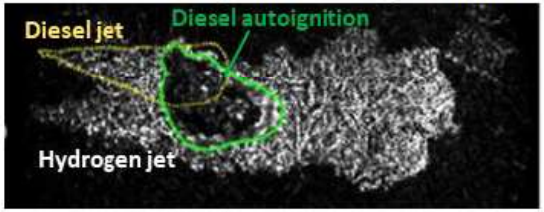
Diagnostics

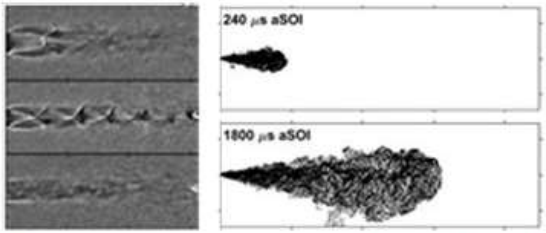
H2 jet combustion*

- Reacting H2 jet measurements with variations in nozzle diameter, injection pressure and ambient temperature, ambient density and O2 concentration

H2-diesel jet dual-fuel combustion

- Measurements commenced for the dual fuel injection configurations



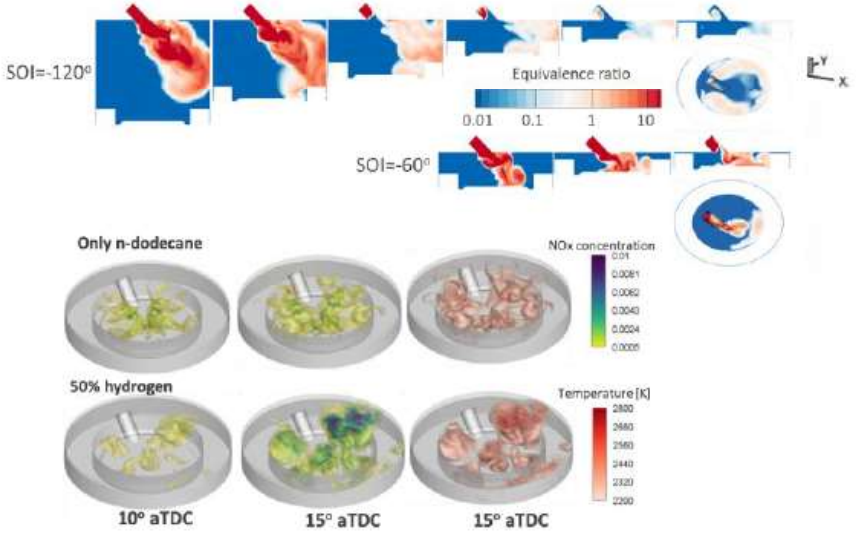


Reacting H2 jet research has achieved fundamental knowledge required for engine testing.

Modelling

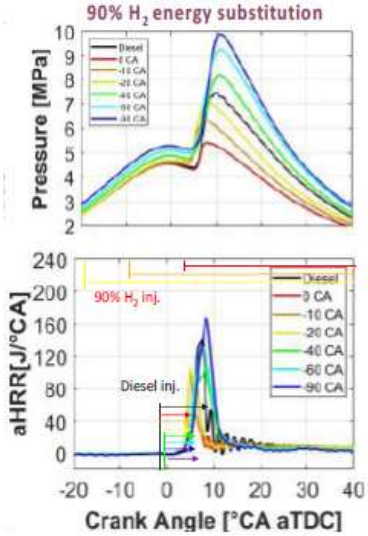
CONVERGE CFD

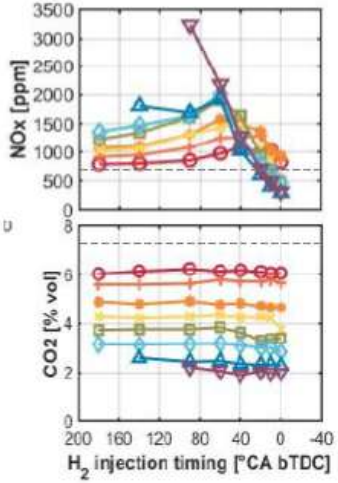
- H2 gas direct injection and mixture distribution specific to the UNSW engine testing cases
- Reaction cases with no H2 direct injection (n-dodecane injection into the H2 diluted in-cylinder gas)



Engine testing

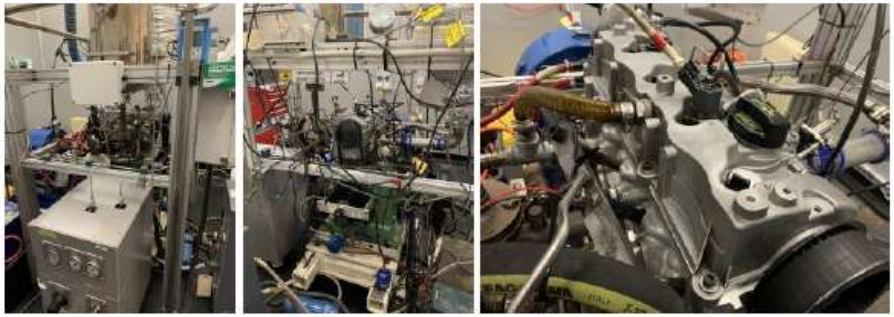
- Single-cylinder automotive size common-rail diesel engine facility
- H2 high-pressure direction injection system
- In-cylinder pressure, heat release rate and emissions analysis





UNSW research impact and future applications

UNSW Hydrogen Engine Facility



71.4% CO2 reduction

- Compared to a baseline diesel-only operation, the engine-out CO2 emission is reduced from 7% by exhaust gas volume to 2% at 90%H2/10%Diesel operation.

Retrofitting benefits

- Existing diesel engines can be converted into H2 dual-fuel engines by installing an additional H2 direct injector
- A broad range of applications: marine, agriculture and mining.

Large-bore engine applications (diesel power generators and marine engines)

- Green marine propulsion to meet future IMO standards
- Replace or retrofitting diesel power generators in mining and agriculture
- Application of our two-injector approach to existing engines

Contact: Prof. Shawn Kook
email at s.kook@unsw.edu.au or internet search “UNSW engines”

UNSW SYDNEY

Future Mobility Day #3 Program

- 4 November 2021

11.00am	Welcome + Intro	Nigel McKinnon Dept of Regional NSW
11.05am	Industry Development	Adam Zarth Business Illawarra
11.10am	NSW Hydrogen Strategy + Hydrogen Hubs initiative	Sam Frisby DPIE
11.15am	Heavy Road Transport Trial + Refuelling Station	Wodek Jakubik Coregas
11.25am	Fleet Opportunities	John Feenan Hyzon
11.35pm	Repowering Mining Equipment	Brad Neilson Streamlined Energy
11.45pm	Hydrogen powered ICE (H2ICE)	Shawn Kook UNSW
11.55pm	Q & A	