



R&D Supporting Australia's Energy Transition

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The 4th IERE Webinar: Towards a Carbon Neutral Energy Future
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Australia's National Science Agency





CSIRO

Australia's national science
agency &
innovation catalyst

5,000 people

Across the world
including Australia,
Asia, the US and Chile

AUD4.5b

Value delivered to the
Australian economy
through science and
technology

57 sites

One of the world's
largest
multidisciplinary
science and
technology
organisations

2,400 partners

Turning science into
solutions in industry,
government and research

170+

Start-up companies
from CSIRO science
and technology

697

Patent families

497

Active licenses



Our research and development

We are one of the largest and most diverse scientific research organisations in the world.

Our research focuses on providing solutions in nine core areas.

Key areas of research

Animals and plants

Astronomy and space

Climate

Environment

Farming and food production

Health

Information technology

Mining and manufacturing

Energy

CSIRO Energy: Our research programs

Energy Technologies

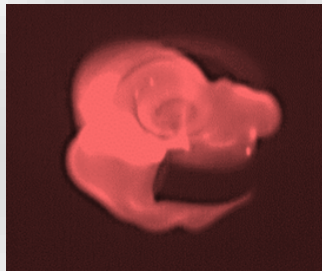
- Solar PV and Solar thermal
- Hydrogen, fuel cells, electrolyzers, storage ...
- Bioenergy, battery reuse
- Ammonia synthesis and use
- CO₂ capture and utilisation

Energy Resources

- CO₂ storage
- Underground energy (inc H₂) storage
- Exploration Geosciences
- Reservoir Dynamics
- Unconventional Gas Engineering

Energy Systems

- Energy, Analysis & Decision Support
- Renewable energy, storage integration
- End use efficiency



Low Emissions Technology Statement 2021



PRIORITY TECHNOLOGIES and their economic stretch goals



CLEAN HYDROGEN

Production under
\$2 per kilogram



ULTRA LOW-COST SOLAR

Solar electricity generation
at \$15 per MWh



ENERGY STORAGE

Electricity from storage for
firming under \$100 per MWh



LOW EMISSIONS MATERIALS

Low emissions steel production
under \$700 per tonne and low
emissions aluminium production
under \$2,200 per tonne



CARBON CAPTURE AND STORAGE

CO_2 compression, hub
transport and storage
under \$20 per tonne of CO_2



SOIL CARBON

Measurement
under \$3 per
hectare per year

Low Emissions Technology Statement 2021

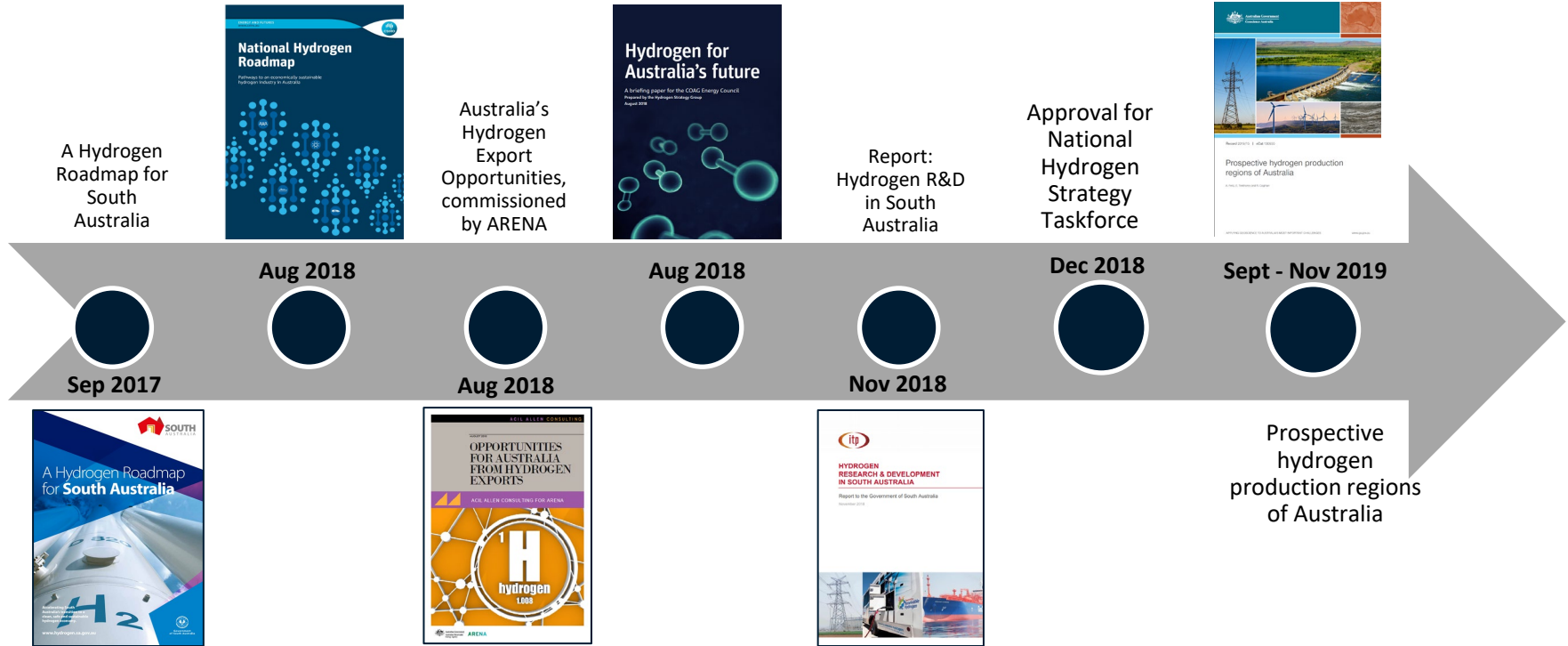
Figure 6: Emerging technologies

Technology Group	Description
Livestock feed supplements	Feed supplements that reduce methane from cows and sheep
Low emissions cement	Cement that uses alternatives to limestone, or carbon capture and storage, or use, to reduce emissions from the cement process
Energy efficiency	Providing the same service with less energy
Waste-to-energy	Reducing landfill volume and emissions by using waste to generate electricity
Low emissions ammonia	Made from clean hydrogen and renewable electricity powered processing plants, for use as a vector for hydrogen exports, and as a fuel
Negative emissions	Early-stage technologies to remove carbon dioxide from the atmosphere such as Direct Air Capture and Removal (DACR), or Bio Energy with Carbon Capture and Storage (BECCS)
Low emissions heat	Methods of producing heat with low emissions, such as solar thermal and heat pumps, in domestic, commercial, industrial and manufacturing applications
Demand flexibility	Moving the demand for electricity to times when low cost and low emissions supply is plentiful, without impacting on the service the energy provides
Raw materials processing efficiency	More efficient methods to process the raw materials mined in Australia
Hydrogen enabled appliances	Commercial and home appliances that can operate with up to 100% hydrogen in the gas network
Electricity sector technologies	Ultra low cost transmission, microgrids for off-grid and fringe-of-grid uses in agriculture or mining, solar thermal for use in manufacturing and mining.
Transport	More efficient and zero emissions drivetrains, public transport, and low emissions aircraft
Abatement of fugitive methane	Capturing the emissions ventilated from underground coal mines, and LNG production
Innovative generation	Small modular reactors and zero emission gas turbines such as Allam Cycle or hydrogen turbines
Buildings	Low emissions building materials, building integrated PV (such as, solar PV tiles), and new refrigerants

Our current priorities, development areas, and growth initiatives are well aligned:

- Industrial decarbonisation, inc CO₂ capture and CST for heat
- Bioenergy, waste to energy
- DAC
- Battery recycling, second life.
- Hybrid and integrated systems
- Options analysis!

National Focus on Hydrogen



Source: Pathways for hydrogen industry growth, Dr V Au: Regional Workshop on Green and Low Carbon Hydrogen Energy in Shanghai, PRC, 26-27th Oct 2019.

Hydrogen now enables cross-sector decarbonisation and a new export industry

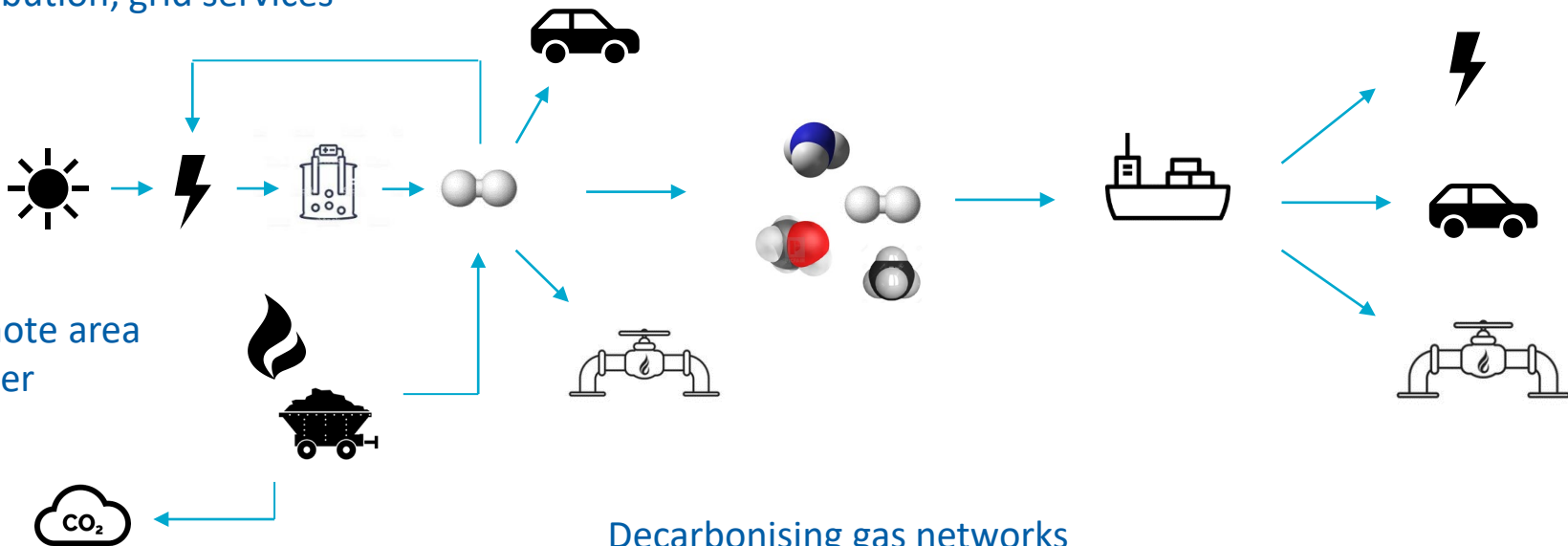
Renewable energy storage,
distribution; grid services

Mobility –
all scales

Renewable
energy export

Remote area
power

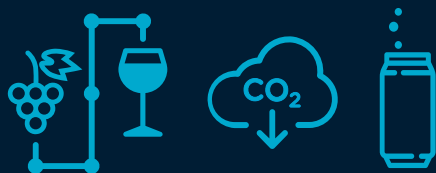
Decarbonising gas networks
and other industries



CO₂ Utilisation Roadmap


CO₂-utilisation Roadmap

Direct use



Mineral carbonation



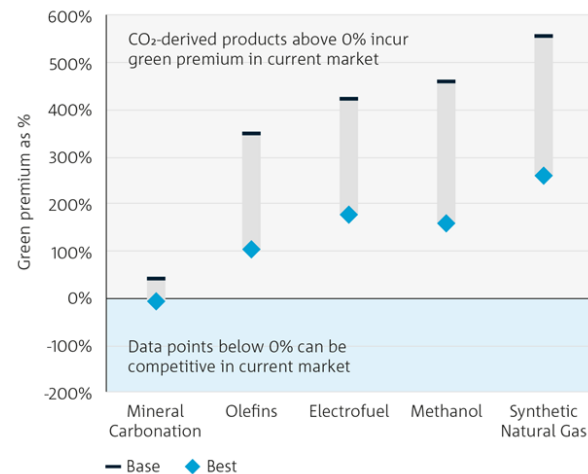
Chemicals and fuels



Biological conversion

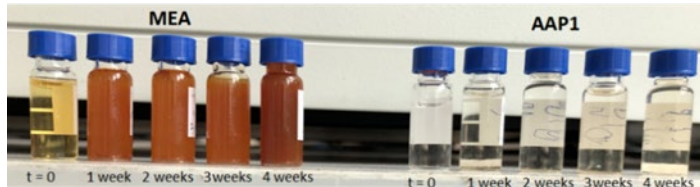


Green premium (or additional cost) of products synthesised from CO₂ compared to current market prices



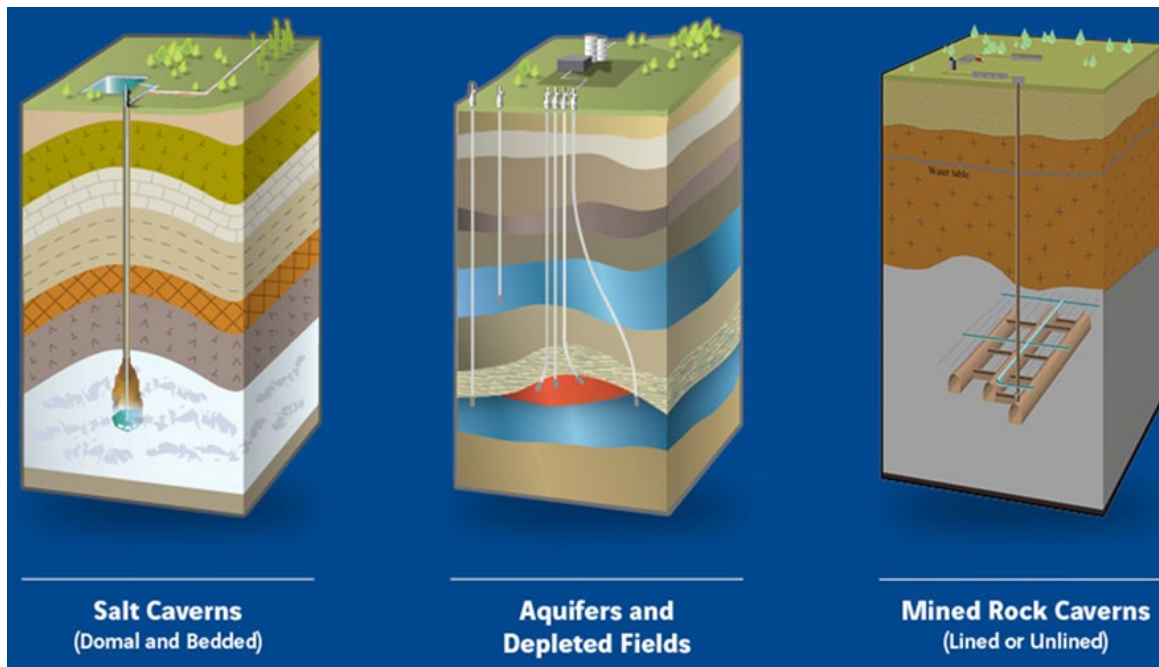
Ambient CO₂-Harvester (ACOHHA)

- Use of robust amino-acid salt based liquid formulations
- Hygroscopicity tuneable for water balance
- Cheap gas/liquid contactors e.g. cooling towers
- Dedicated process & equipment designs
- Regeneration process fully thermal $\leftrightarrow$ fully electrical
- IP under development/registration
- Integrated technology demonstrator is required to achieve TRL of 5/6



4t/a unit

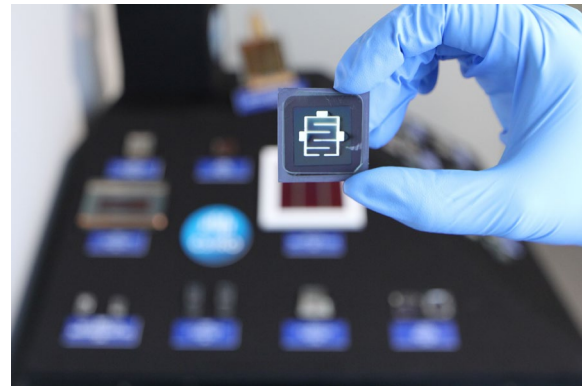
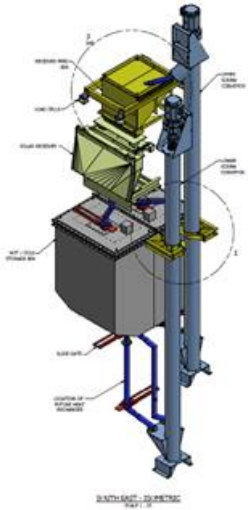




Underground source & storage options: CH₄, CO₂, H₂, Air, Heat

- Geological energy/fluid storage concepts for large scale, long term options
- *In-situ* laboratories for testing and validation: geomechanics, geochemistry, geophysics
- Techno-economic and other modelling analyses: Hydrogen, CCUS, underground energy storage
- Artificial Intelligence/Machine Learning/Visualisation: Sub-surface structure, plumes and flow
- Prospecting natural hydrogen sources and 'blue' hydrogen 'hubs'

Solar PV, Solar Thermal

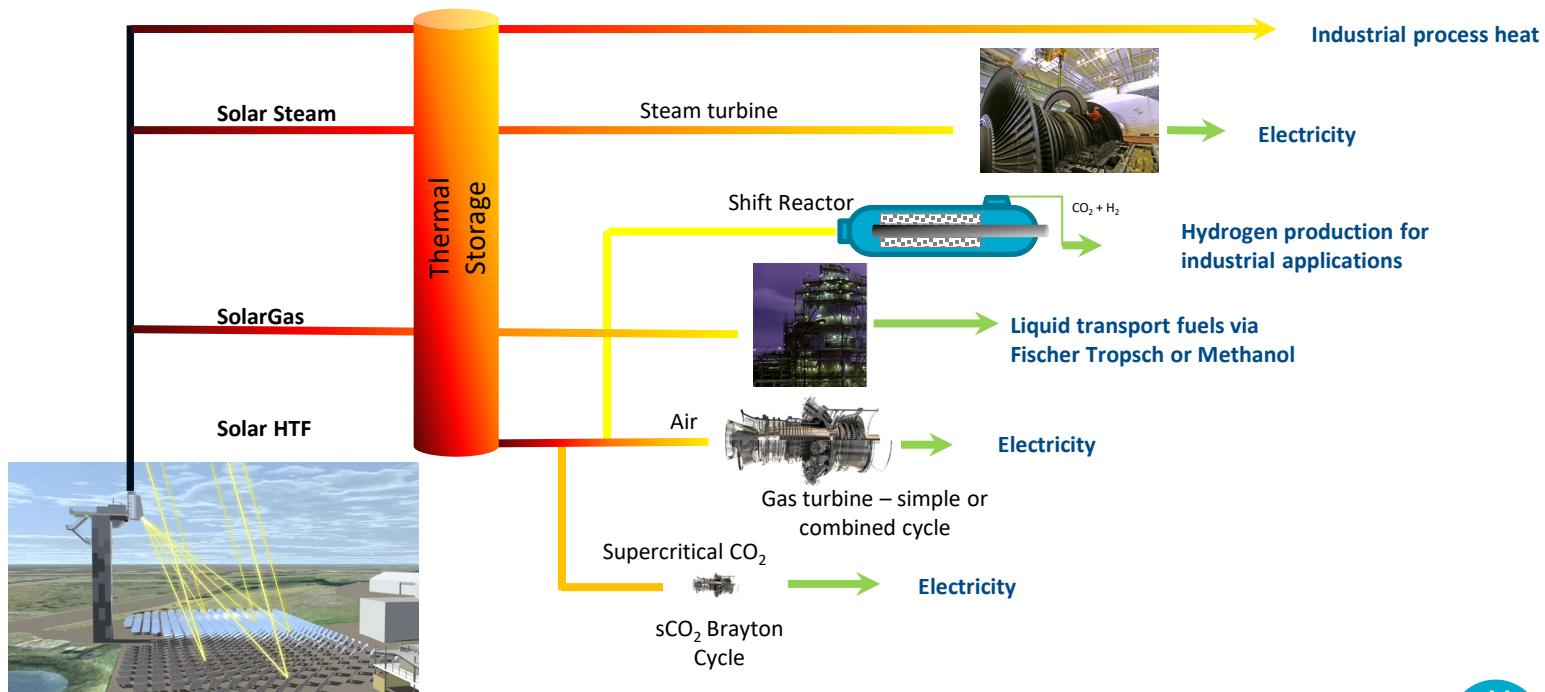


CSIRO – National Solar Energy Centre

Targeted Portfolio of CST Research Activities

System Components

- Solar Receiver
- Steam Reformer
- Solar Air Turbine
- $s\text{CO}_2$ /Advanced Receivers



CSIRO Heliostat and Receiver Technologies

HILTCRC: Heavy Industry Decarbonisation



Program 1 Process Technologies

Streams

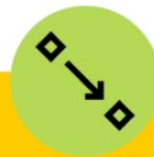
- a. Producing green iron products from magnetite
- b. Producing green iron products from Pilbara ores
- c. Green alumina calcination
- d. Low-carbon lime and cement



Program 2 Cross-cutting Technologies

Streams

- a. Integrating variable energy sources into industrial processes
- b. New energy sources: electrification, hydrogen, solar thermal and biomass/waste
- c. Hybrid technology for multiple energy sources
- d. Integrated capture and re-use of CO₂ in industrial processes



Program 3 Facilitating Transformation

Streams

- a. Heavy industry roadmaps and scenario analyses
- b. Supply chain development and commercialisation pathways
- c. Community engagement and sustainability leadership
- d. Technology commercialisation

HILTCRC Objectives



Ensure long-term jobs, prosperity, competitiveness, intellectual property, ownership retention and self-sufficiency of Australian industry in the global low-carbon economy, while increasing domestic security through strengthened industrial capacity.



Provide professional and technical development for a new generation of highly skilled people, particularly in regional areas, with expertise in growing a sustainable heavy industry sector; this will include re-skilling workers following job-losses from COVID-19.



Create emissions reductions from heavy industry in the global supply chain of energy-intensive processes and products, through integration with renewable energy industries.



Enable integration with the 'new economy' by embedding the industry in circular economy and deep-sustainability principles.

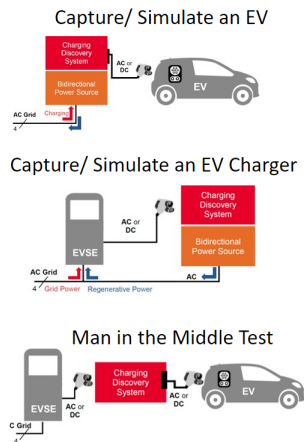


Enhance national and international collaboration through a wide network of researchers, government and industry.

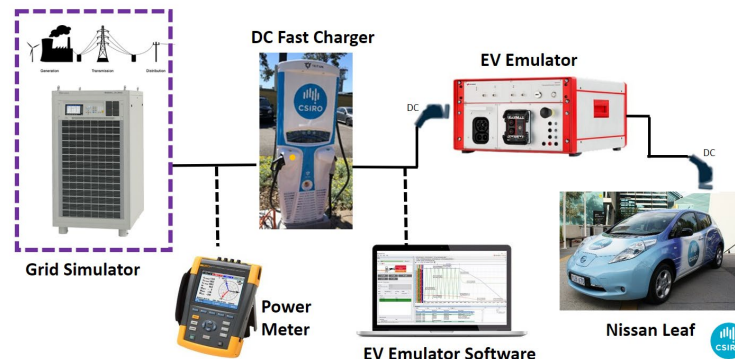
Grids, Electrification, and Storage

EV Emulator

- Hardware and software system
- Captures and simulates EV charging profiles
- Build database of EV charging events
- Test dynamic EV charging systems
- Stress-testing of electricity grids under high EV penetrations



EVE & DC Fast charging –Experimental Setup



Tritium Project – Fast charger development



- Analyse Tritium charging data from around the world
- Electrical testing of grid impacts on power quality using EV Emulator
- Develop strategies to minimise adverse impacts and increase installation opportunities for fast-chargers on capacity-constrained electricity networks



Summary: Supporting the National energy transition



Electricity

enabling reliable, low-emission energy networks with flexible electricity generation, use and storage



Industry

enabling the decarbonisation of Australian transport and industrial sectors



Community & Environment

driving strong community engagement and environmental outcomes



Thank you

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