Future Fuels CRC

Research Programs and Project Overviews

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Research Programs

Research Program 1 Future Fuel Technologies, Systems and Markets

This program addresses the technical, economic and market challenges associated with the introduction of new low and zero carbon fuels.

The major research themes in this program include:

- Integrated planning of fuel systems production, delivery and use
- Techno-economic modelling of fuel production processes and supply chains
- Accelerated development of early stage, breakthrough technologies
- Compatibility of end user equipment with future fuels
- Applied research support of 'Power to Gas' demonstration projects

This program aims to deliver the following outcomes:

- New technology for the cost effective production of future fuels;
- Viable plans for the introduction of new fuels; reducing investment risk in new technology and infrastructure;
- Utilisation of gas networks to deliver decarbonised energy to consumers and providing more flexibility and reduced capital expenditure for electricity network stabilisation and storage;
- New domestic markets for reliable, cost effective low emission fuels and export opportunities in the Asia-Pacific region (where hydrogen transport fleets are being developed);
- Decarbonisation of the transport sector and industries that currently have limited options for emission reduction;
- Improved reliability of the electricity market by supporting cost-effective intermittent renewable generation with gas as an energy storage medium stored in existing infrastructure.

Overviews of approved research projects under this program follow.

1.1 Integrated planning of fuel systems production, delivery and use

RP1.1-01: Scenario and broad-scale modelling dynamics – In Progress
Using well-established scenario development processes and a range of economic and technical models, research is well underway to build the data sets and knowledge necessary to:

- enable quantitative assessment of the socio-economic consequences of introducing hydrogen at both the regional and national level; and
- identify the sectors and industries that may benefit most and/or be most challenged by the development of future fuel technologies and the resultant decarbonisation of the economy.

RP1.1-02: Regional case studies on multi-energy system integration – In Progress
The development of an energy systems model is underway to assist key energy market players in understanding the potential of different future fuel options to decarbonise the energy system. The research includes an assessment of integrated electricity-gas-hydrogen systems in the presence of different coupling technologies and scenarios for different sectors (e.g. injection of hydrogen into the gas network, production of low-carbon fuels for export, electrification vs decarbonisation of heating, etc.).

RP1.1-03: Learning from international roadmaps and strategies - Completed
This project summarised 19 international hydrogen strategies and helped to understand how nations, regions and industries are thinking about opportunities to become involved in this emerging industry. It acts as an important resource to those involved in long-term energy policy planning in Australia.

RP1.1-04: Underground storage of hydrogen: mapping out the options for Australia – In Progress

This project delivers a high-level assessment and mapping of the options for underground storage of hydrogen in Australia. The intention is to provide the basis for more detailed local assessments of hydrogen storage to be carried out by government and industry.

1.2 Techno-economic modelling of fuel production processes and supply chains

RP1.2-01: Future fuels production - status review - Completed
A ‘state-of-play’ assessment of future fuels production technologies has been undertaken. This project has produced a report which summarises the current technology and commercial status of production technologies of future fuels.

RP1.2-02: Techno-economic modelling of fuel production processes – In Progress
This project builds on RP1.2-01. It simulates all possible ways to produce hydrogen and biomethane. These simulations form the core technology and economic process information on which to base project decisions on the most prospective production processes and also integrate with and inform the energy systems modelling activity (RP1.1-02).

RP1.2-03: Assessment framework for bio-methane injection in gas networks – In Progress
This project identifies opportunities for the injection of bio-methane into existing gas networks and pipelines in Australia. This is done via the assessment of the techno-economic viability for two end-user defined case studies. Based on the case studies, a general framework for performing such assessments is being developed by identifying what factors need to be considered by bio-methane projects that want to connect to the gas network.

1.3 Accelerated development of early stage, breakthrough technologies

RP1.3-01: Solar photocatalytic hydrogen production – In Progress
This project aims to develop technology that allows for the production of hydrogen with direct sunlight: A process known as photocatalysis. This process has potential cost advantages compared to other renewable hydrogen production technologies.

RP1.3-02: Novel H2/CH4 separation technology development – In Progress
This project aims to develop novel technology for hydrogen separation in future fuels systems. The technology to be developed in this project looks to change the concentration of hydrogen-methane mixtures and is highly relevant to industry. It allows for an increase in the range of equipment and appliances which can use a hydrogen-methane stream of variable concentration.

RP1.3-03: Methane pyrolysis for hydrogen production – In Progress
The project aims to develop and demonstrate a novel process with strong potential to achieve a step-change in the cost of production of hydrogen from natural gas. Natural gas pyrolysis involves the cracking of methane into solid carbon and hydrogen, allowing the solid carbon to be sequestered, while also offering potential that some of the carbon may yield higher value by-products.

RP1.10-01-3: Grid interaction of electrolyser and fuel cells for utilisation of renewable energy surplus – In Progress
This project investigates: 1) Advanced power converter development to improve fuel cell system performance; 2) Improving the efficiency of the renewable energy-based electrolyser through power electronics optimisation; and 3) An advanced power flow controller for energy flow between the grid and electrolyser to produce hydrogen, and between fuel cell and grid to control the conversion of hydrogen to electricity.

1.4 Compatibility of end user equipment with future fuels

RP1.4-01: Future fuels end-use – Type-A appliances - Completed
This project (a) examined whether a wide range of common household appliances (Type-A) can operate safely on natural gas with a 10% hydrogen blend, (b) determined the maximum level of hydrogen that can be blended into natural gas before flash-back, ignition or other problems occur, and (c) identified potential technical appliance issues associated with natural gas blends that have higher levels of hydrogen than can be accommodated by current appliances. The results of the testing program are of particular interest to companies that are developing pilot projects that involve the injection of small amounts of hydrogen into segments of the gas distribution system.

RP1.4-02: Future fuel use in Type B and industrial equipment – Completed
This scoping study identified the potential technical issues associated with converting Type B appliances (industrial burners, gas turbines and engines, and non-combustion methane users) to natural gas blends with higher levels of hydrogen than can be accommodated by current equipment.

RP1.4-03 Pathways for hydrogen adaptation to industrial processes – In Progress
This project de-risks the adaptation of hydrogen to some Type B appliances which are key to industrial processes through a combined experimental and computational research program at scale. It quantifies the impact of hydrogen blending on the characteristics of the resulting flames including size, stability, heat transfer and emission. The results inform gas suppliers and industrial users of the limits, potential impediments and opportunities of hydrogen blending.

RP1.4-04 Hydrogen gas specification and review of end-user instrumentation – In Progress
This project aims to develop specifications for hydrogen to be used in Australia. It also includes a review and assessment of the impacts of adding hydrogen to natural gas, or using 100% hydrogen, on instrumentation used by industrial and commercial end users. The review will gather information from suppliers, industry experts and literature on the influence of hydrogen on end-user instrumentation and safety equipment.

RP1.10-04 Effects of dopants on hydrogen flames – In Progress
This project assesses the feasibility of doping hydrogen with higher-order hydrocarbons and their effectiveness on visibility, radiation and odour.

RP1.10-05: Impact of hydrogen addition on the performance of premixed gas turbines, reciprocating engines and industrial burners – In Progress
This project aims to understand how pressure impacts the burning of hydrogen / natural gas mixtures. It considers what physical limits there may be to hydrogen addition and how these might be addressed.

Research Program 2 Social Acceptance, Public Safety and Security of Supply

This program is undertaking research into social and policy and regulatory contexts, including public acceptance and safety, within which future fuels infrastructure operates.

The major research themes in this program include:

- Appropriate community engagement to enable change
- Policy and regulatory solutions for new technology governance
- Organisational accident prevention
- Urban encroachment and infrastructure damage prevention

This program aims to deliver the following outcomes:

- Social licence for the adoption and use of future fuels by industry users and the community;
- A neutral, trustworthy source of future fuels information established to allow the industry to move forward;
- Continued world's best practice safety and reliability performance of Australian fuel transmission, distribution and storage infrastructure, through policy, regulation and industry practice;
- Reduced risk of major incidents associated with operation of existing and future fuel infrastructure;
- Optimal outcomes for companies, governments and society in the development and refitting of large energy projects and infrastructure;
- Sound policy to support governance of new fuel technology, infrastructure use to enable successful adoption, implementation and management;
- Effective regulation to enable the safe introduction of new low carbon fuels.

Overviews of approved research projects under this program follow.

2.1 Appropriate community engagement to enable change

RP2.1-01: Lessons Learned from major infrastructure upgrades - Completed
This project documented lessons learnt from earlier major upgrades to national infrastructure and identified effective engagement strategies that can be used in the potential conversion of gas networks to operate with hydrogen and / or other zero carbon gases. Case studies addressed include the transformation from 'town gas' to natural gas and the introduction of ethanol (E10) into the gasoline market.

RP2.1-02: A social licence and acceptance of future fuels – In Progress
The project aims to develop an understanding of various stakeholder attitudes towards future fuels and monitoring changes in attitudes of those stakeholders (e.g. affected local communities, trades and associated workers and emergency service workers and the broader public). A key deliverable is the development of a range of trustworthy information tools for project proponents and policy makers to assist in the safe introduction and use of future fuels.

RP2.1-03: Mapping key stakeholders in Australia's energy transition – Completed
This project mapped key industry, government and civil society stakeholders currently engaged in the dialogue about Australia's energy transition and provides an overview of key messages. Furthermore, it catalogued the range of white papers, reports and websites generated by each stakeholder group.

RP2.1-04: Developing appropriate protocols for naming future fuels – In Progress

This project undertakes a systematic collection of actual and proposed names for current and future fuels. The project team reviews Australian regulation on product naming conventions to crystallise any limits which might exist or emerge towards naming singular and blended products for domestic use and commercial export.

RP2.1-05: Public communication and hydrogen as a fuel in Australia – In Progress
As communication is key to linking people and technologies, as well as stakeholders to each other, research is required to understand how people engage and communicate on the topic of future fuels across public events.

RP2.1-06 Mapping vulnerability to future fuels – A scoping review – In Progress
This project addresses the issue of energy vulnerability and disadvantage within the context of residential energy services. At present, the impact of new fuels on vulnerable customers is unknown. New knowledge is therefore needed to support customer engagement, innovation and adoption of future energy services.

RP2.1-07 Deliberative engagement processes on the role of future fuels in the future low-carbon energy mix in Australia – In Progress
This project aims to hold three deliberative engagement processes in three different Australian capital cities to investigate the role of future fuels in the future low-carbon energy mix in Australia. By hosting three deliberative panels this project aims to: 1) outline challenges, opportunities and priority actions that will help Australia to deliver the full potential of a low-carbon energy future; and 2) identify issues, benefits, drawbacks and trade-offs related to the implementation of future fuels in the future energy mix.

RP2.1-09 Social licence to operate training package – In Progress
This project develops an education and training package directed at Executives working across industry, government and academia. The package has two goals. The first is to build an understanding of the concept of Social License to Operate (SLO). Secondly, it outlines and develops the skills required to proactively manage SLO as it applies to future fuels.

RP2.10-01 Decision making and the role of social licence in natural resources – In Progress
This project aims to explore the relationship between social licence, decision making and economics. Specifically, the research seeks to understand the motivations behind social licence concern and test extended theoretical understanding about community and stakeholder social licence decision-making using the future fuels industry as a case study.

2.2 Policy and regulatory solutions for new technology governance

RP2.2-01: Regulatory mapping of future fuels - Completed
This project has undertaken a regulatory mapping exercise to identify where gas composition (or other gas properties) are mentioned or implied in relevant acts and regulations. Australia's gas infrastructure is subject to a range of regulations that are all designed for facilities that use natural gas. It identified regulatory changes required to ensure that future fuels can be used appropriately, and that regulation remains consistent with public policy objectives.

2.3 Organisational accident prevention

RP2.3-02: Code of practice for pipeline engineers - Completed
Work has been completed to draft a new 'code of practice' for pipeline engineers under the guidance of an industry steering committee. It will raises awareness and understanding of organisational causes of accidents and how everyday engineering work has a direct impact on public safety outcomes.

RP2.3-03 Establishing a case based learning framework for pipeline engineers – In Progress
The project produces a set of case based learning experiences for professional pipeline engineers based on past incidents with specific resonance for the challenges of public safety and security of supply in a future fuels environment. The ultimate aim is to maintain and promote excellence in engineering professional practice.

RP2.2-04 - Gas fitting practices for future fuels: Opportunities for training and upskilling in Victoria and South Australia – In Progress
Gas fitting is a specialist licensed trade that requires training, accreditation and registration. Despite the differences in certification and professional development that exist across the Commonwealth, ensuring capacity and skills is in the national interest. This project uses Victoria and South Australia as detailed case studies to assess changes in resourcing and education in the gas fitting trade that are required to support the transition to, and ongoing maintenance of, a low carbon economy.

2.4 Urban encroachment and infrastructure damage prevention

RP2.4-01: Pipeline intrusion avoidance solutions – In Progress
Above ground drilling and excavation are one of the main causes of failure of underground gas pipelines and networks. The goal of this project is to advance understanding of the effectiveness of intrusion avoidance solutions, including one-call systems, and to provide industry with tools and recommendations on how they can systematically evaluate solutions.

Research Program 3 Network Lifecycle Management

This program is undertaking novel materials, design, construction and operations-related research to enhance the operations of infrastructure carrying existing and future fuels.

The major research themes in this program include:

- Material properties and performance
- Safe and efficient design, construction and operation of future fuel infrastructure
- Smart monitoring, data management and asset condition prediction
- Advanced infrastructure repair and protection systems

This program aims to deliver the following outcomes:

- Effective design standards and operating procedures for transport and storage of future fuels in new and existing pipeline systems;
- Opportunities to extend the life of existing infrastructure through repurposing existing networks and facilities to support the transportation of new low carbon fuels;
- New materials for effective and safe transport and storage of future fuels;
- Reduced capital costs of new energy transportation infrastructure, and reduced operating and maintenance cost of infrastructure;
- More accurate, real-time assessment of the condition of metallic and plastic pipes through cost-effective sensing technology for detection, monitoring and evaluation of pipe degradation;
- Enhanced asset management decision-making through tools using advanced detection technologies, data analytics and service life-time prediction models covering a wide range of fuels and materials.

Overviews of approved research projects under this program follow.

3.1 Material properties and performance

Steel materials

RP3.1-01: Review of future fuels transport and storage technologies - Completed
This project included a review of industry standards, past and on-going RD&D projects regarding the compatibility of future fuels with metallic components of both pipeline transmission and distribution networks. The project assists researchers and industry to identify typical scenarios relevant to “Australian conditions” for using existing natural gas pipelines to transport hydrogen-natural gas blends.

RP3.1-02: Atom Probe tomography for hydrogen-steel interactions – In Progress
The objective of this research is to gain better understanding of the interactions between metals in the existing gas pipeline network and hydrogen. High strength steels are known to be particularly sensitive to hydrogen embrittlement, which manifests as a reduction in mechanical properties and increased susceptibility to failure. Examining where and how the hydrogen interacts with the microstructure using Atom Probe Tomography (APT) is important to improve understanding of the impact of hydrogen on mechanical performance.

RP3.1-06: Study of hydrogen permeation through the pipe wall – In Progress
This project seeks to answer an important consideration for the development of a fracture control plan for pipelines transporting hydrogen: “How much hydrogen is impregnated into the pipe-wall when hydrogen is pressurised internally?” To answer this, a test system is being deployed to evaluate the level of hydrogen concentration absorbed in pipe materials. Outcomes of the project provide immediate knowledge to industry on the impact of hydrogen on the existing infrastructure and how hydrogen changes the current structural integrity assessment models.

RP3.1-08 Full-scale fracture initiation test programme – Phase 1: Project execution plan – In Progress
This project is the first phase of a full-scale fracture initiation test program. Full-scale testing of fracture initiation in hydrogen service will be an essential contribution to determining the safe operating window for high-pressure steel pipelines in hydrogen service. This project will review options for conducting full-scale initiation tests, and provide a project execution plan for subsequent project phase(s).

RP3.1-09 - Deployment of the SAFE(TI) Lab for characterising the mechanical properties of line-pipe steels exposed to high-pressure gaseous H2 – In Progress

This project establishes a state-of-the-art testing laboratory to characterise line-pipe steels exposed to high-pressure, gaseous hydrogen. The laboratory is named the SAFE(TI) Lab – an acronym for the Structural Assessment of Future Energy Transport Infrastructure. The laboratory centralises testing ranging from permeation testing, to high-strain rate testing, to fatigue testing of line-pipe steels intended for the transmission network. The laboratory allows for researchers and industry to explore the limits of existing pipeline networks for their maximum potential to transport pressured hydrogen/methane blends.

RP3.1-10 - Hydrogen embrittlement of pipeline steels, subcritical crack growth (formation) and critical crack growth (initiation) – In Progress
The research aims to elucidate the hydrogen embrittlement (HE) manifestations of gas pipeline steels based on recent research which has shown that the influence of hydrogen (for a large range of equivalent hydrogen pressures up to 2,000 bar) on steels can be determined by the use electrolytic (cathodic) hydrogen charging combined with mechanical testing. The proposed research addresses knowledge gaps identified in the “Hydrogen in Pipelines Research Roadmap” focussing on sub-critical crack growth (formation) and critical crack growth (initiation).

RP3.10-01 Molecular dynamics investigations of hydrogen-induced plastic deformation and failure – In Progress
This research conducts molecular dynamics modelling studies on the effect of hydrogen on grain boundary activities for various material.

Plastic and composite materials

RP3.1-03: Future proofing plastic pipes – In Progress
This project has started development of a standardised suite of tests to identify polymer/elastomeric compatibility with hydrogen and its blends and generates an understanding of the capacity for current pipeline materials (plastics and elastomeric) to transport future fuels.

RP3.1-04: Multi-channel hydrostatic pressure test kit - Completed
Hydrostatic pressure testing is a method to assess the performance of various types and grades of plastic pipes. This method has been standardised under ASTM D1598-2004 and ISO1667-2006 to evaluate industry-wide pipeline performance. The test equipment has been incorporated into existing and future research projects, including RP3.1-03.

RP3.1-05: Compatibility of plastic piping with future fuels – In Progress
This project focuses on the compatibility of plastic piping systems with future fuels other than hydrogen, including biogas, methanol, syngas, etc. The compatibility is being evaluated by quantifying structural change to the various plastic materials (e.g. polyethylene, nylon), including swelling, tensile strength change, delamination, as well as determining if the fuels permeate through the materials.

RP3.1-07: Hydrogen test bed - plastic pipe network – In Progress
This project implements a dedicated hydrogen field test bed to enable long-term compatibility of typical gas distribution network components to be evaluated. A specific focus of this project is to evaluate the impact of hydrogen on the performance of junctions and welds which are currently used by the industry.

3.2 Safe and efficient design, construction and operation of future fuel infrastructure

RP3.2-01: Proximity and ventilation requirements for distribution networks adapted to future fuels – In Progress
This project aims to undertake experimental, analytical and numerical studies to provide clear guidance on ventilation requirements in enclosed gas metering stations and the safe proximity distances between gas mains and buildings for gas distribution networks in Australia. These guidelines are particularly relevant for situations where the fuel is changing from natural gas towards hydrogen.

RP3.2-02: Future fuels decompression behaviour – In Progress
The control of running ductile fracture in high pressure transmission pipelines is supported by models, experiments and regulatory standards. Transportation of future fuels in pipeline systems raises questions on the applicability of the prediction methods used by these existing models (developed for natural gas). This research project places particular focus on the decompression characteristics of future fuel compositions. As the major contributing factor of the driving force to propagate the fracture, the decompression of the mixture needs to be predicted with high accuracy.

RP3.2-03: The AS2885 online community - Completed
The Australian Standard “AS2885” is widely seen as a go-to document for pipeline engineers to design, construct, and operate a safe pipeline. This project developed an online AS2885 handbook / community: https://as2885.info/ It provides a series of documents, discussions and references to help users resolve the technical and application uncertainties that accompany a Standard like AS 2885. The platform can be used throughout the life of the CRC for future discussion around the design and operation of, for example, hydrogen pipelines.

RP3.2-04: Cohesive gas impurities – In Progress
Electrically conductive deposits are observed in some pipelines carrying coal seam gas that are impacting cathodic protection (CP) operation and fouling equipment. This project will confirm that nature of the deposits and develop potential solutions to reduce their extent and/or impact. The results of this work are relevant to both existing and future gaseous fuels.

RP3.2-05: Tensile strain capacity (projects A, B and C) – In Progress
This project provides a better understanding on tensile strain capacity, and specifically tensile strain capacity under various weld strength matching conditions (over and under matching). This will enable designers and project proponents to optimise designs for new pipelines. It will also allow for assessment of existing pipelines in the vicinity of girth welds under weld strength (under / over) matching conditions.

RP3.2-06: Development of a new fracture propagation model based on advanced damage models accounting for the effects of stress-state on failure – In Progress
This project focusses on the development of a new model capturing accurately the physics at play during a running ductile fracture event. This fracture control model is based on an alternative representation of the material’s resistance to fracture.

RP3.2-07: Metering and gas quality monitoring of future fuel blends in transmission pipelines – In Progress
This project defines the measurement uncertainty levels of commonly used measurement instrumentation when deployed on future fuel gas blends and assess the performance of flow computing and other gas measurement software systems when future fuel blends are introduced.

RP3.2-08 Development of efficient and effective methodologies for the abandonment of pipelines – In Progress
This project delivers technical guidelines for end-of-life pipeline decommissioning and abandonment, based on international practices translated for Australian situations. This research supports decision making around abandonment vs repurposing of existing infrastructure for future fuels.

3.3 Smart monitoring, data management and asset condition prediction

RP3.3-01: Gap analysis of smart monitoring and data analytics for fuel infrastructure networks – Completed
This project involved a literature review and industry survey in order to clearly identify needs, gaps and opportunities in smart monitoring, data analytics and asset condition prediction for fuel infrastructure networks. This project provided a roadmap for future projects to be undertaken under this theme.

RP3.3-02: Performance review of inspection techniques for un-piggable pipelines - Completed
This project aims to clarify current status and performance of techniques used for inspection and monitoring of non-piggable pipelines. The project develops guidance material for industry in terms of which tools are best used in specific applications and identifies potential knowledge gaps that require further research and development.

RP3.3-04 - Smart Sign technology for continuous easement interference monitoring – In Progress
This project aims to design a smart visual sensor able to process locally (i.e. at the edge of the network) the live video feed of a CCTV to establish the level of threat associated with a pipeline encroachment and alert the operator of the pipeline in real-time. The video will be analysed by a cutting-edge AI specially adapted and optimised to this application.

3.4 Advanced infrastructure repair and protection systems

RP3.4-01: Retrofitting pipelines by in situ coating – In Progress
This project aims to develop internal coatings for existing steel pipelines that can be applied in situ, cost effectively, without exposure or removal of the buried pipe. The coatings are being evaluated for protection against hydrogen permeation, to reduce the risk and incidence of hydrogen embrittlement. There is also scope for these coatings to manage fugitive emissions from steel pipelines.

RP3.4-02: Closed-loop CP control system for fuel networks - Completed
This project studied the development of a closed control loop for real-time adjustment of cathodic protection systems for pipelines that experience coating damage. The closed loop system considers the dynamic nature of the environment to which assets are exposed. This new closed control system would be based on corrosion monitoring data from electrochemical probes that are unaffected by IR-drops across the soil.

RP3.4-03: External Interference / Pipeline Damage Assessment – Phase 1 – In Progress
The project is the first stage in the development of a Centre of Excellence for External Interference and Pipeline Damage Assessment. The project involves an upgrade of an existing test rig to assess the risk of external interference by large scale Horizontal Directional Drilling equipment to pipelines and networks.

RP3.4-04: Keyhole coating damage treatment – In Progress
This project develops streamlined methods for local coating repair and treatment that do not require uncovering the pipe. The research focus is on the development of corrosion mitigation fluids and a delivery method to inject them near coating defects along the pipe without the need to excavate, thereby allowing for potential cost savings of coating defect repairs.

RP3.4-05 Validation of quality assurance tests for two-part epoxy coatings – In Progress
This project uses a combination of standard and non-standard coating testing methods to evaluate, in a short period of time, the likelihood of premature failure of two-part epoxy coatings.

RP3.4-07 Supplementary tests on the effect of bi-directional potential excursions on cathodic protection – In Progress

This project conducts a short supplementary test program in order to better confirm and quantify the degree of the effect of cathodic transients under different conditions.