APGA Code of Practice

Renewable gas connections

August 2024

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This Code builds upon the collective knowledge and experience of the Australian gas industry and draws on relevant international standards and best practices. APGA acknowledges the valuable work done by standards organisations, industry bodies, and researchers in Australia and around the world in advancing the safe and reliable integration of renewable gases into gas networks.

Disclaimer

The content of this document is a guide only.

This Code of Practice for Renewable Gas Connections provides guidance on the technical, safety, and commercial aspects of connecting renewable gas production facilities to gas distribution networks and transmission pipelines in Australia. The Code is intended to

complement and support compliance with relevant federal, state, and territory legislation, regulations, and standards governing gas infrastructure and renewable gas development.

The guidance provided in this Code is not intended to be exhaustive or prescriptive, and individual renewable gas projects may require additional or specific considerations beyond those outlined in the Code. Users of the Code are responsible for ensuring compliance with all applicable laws, regulations, and standards, and for seeking appropriate professional advice where necessary.

APGA and the contributors to this Code make no representations or warranties, express or implied, as to the accuracy, reliability, or completeness of the information contained in the Code. APGA and the contributors shall not be liable for any loss, damage, or injury arising from the use of or reliance on the information contained in the Code.

The Code will be reviewed and updated periodically to reflect changes in legislation, standards, industry practices, and stakeholder feedback. Users should ensure they are referencing the most current version of the Code.

Preface

The Australian Pipelines and Gas Association (APGA) is pleased to present the Code of Practice for Renewable Gas Connections. This Code has been developed to provide guidance to gas distributors, transmission pipeline operators, renewable gas producers, and other stakeholders on the requirements and processes for the safe and reliable injection of renewable gases into Australian gas networks.

As Australia transitions to a low-carbon energy future, renewable gases such as biomethane and hydrogen are expected to play an increasingly important role in decarbonising our gas supply. Injecting renewable gases into existing gas infrastructure leverages the significant investments already made in gas networks and provides a cost-effective pathway for reducing greenhouse gas emissions.

The Code covers all aspects of the renewable gas connection process, from initial enquiry and feasibility assessment through to detailed design, construction, commissioning, and ongoing operation and compliance. It incorporates relevant Australian and international standards, industry best practices, and lessons learned from renewable gas projects around the world.

By promoting a consistent and transparent approach to renewable gas connections, the Code aims to facilitate the growth of the renewable gas industry in Australia while ensuring the ongoing safety, reliability, and integrity of our gas networks. APGA is committed to working with all stakeholders to support the successful integration of renewable gases into Australia's energy mix and to advance the transition to a cleaner energy future.

We encourage all stakeholders involved in the development, assessment, approval, and operation of renewable gas connection projects to adopt and apply the guidance provided in this Code. We also welcome ongoing feedback and suggestions for improvement as the Code evolves to reflect the changing needs and practices of the industry.

This Code has been developed by APGA in consultation with its membership.

APGA Members are encouraged to adopt this Code and to provide feedback on its application. Community members are invited to provide feedback to APGA on this initiative.

Comments may be forwarded to APGA at:

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1 Introduction

The Australian Pipelines and Gas Association (APGA) is the peak body representing the pipeline infrastructure industry in Australia. Our members include owners, operators, designers, constructors, and service providers for Australia's gas transmission and distribution networks. APGA's mission is to promote the safe, reliable, and sustainable operation of Australia's gas infrastructure, and to support the growth and development of the gas industry.

As Australia transitions to a low-carbon energy future, renewable gases such as biomethane and hydrogen are expected to play an increasingly important role in decarbonising our gas networks. Injecting renewable gases into existing gas infrastructure offers a cost-effective and efficient way to reduce greenhouse gas emissions while leveraging the significant investments already made in gas transmission and distribution networks.

To support the safe and reliable integration of renewable gases into Australian gas networks, APGA has developed this Code of Practice for Renewable Gas Connections. The Code provides guidance to renewable gas producers, gas distributors, transmission pipeline operators, and other stakeholders on the technical, safety, and commercial requirements for connecting renewable gas facilities to gas networks in Australia.

The Code covers all aspects of the renewable gas connection process, from initial enquiry and feasibility assessment through to detailed design, construction, commissioning, and ongoing operation and compliance. It incorporates best practices and lessons learned from renewable gas projects in Australia and internationally, as well as relevant Australian and international standards and regulations. International examples that have been adapted include connection guidelines from Northern Gas Networks, Cadent Gas and Gas Networks Ireland.

By promoting a consistent and transparent approach to renewable gas connections, the Code aims to facilitate the growth of the renewable gas industry in Australia while ensuring the ongoing safety, reliability, and integrity of our gas networks. APGA is committed to working with all stakeholders to enable the successful integration of renewable gases into Australia's energy mix and to support the transition to a cleaner energy future.

1.1 Purpose and scope

This Code of Practice has been developed by the Australian Pipelines and Gas Association (APGA) to provide guidance to gas distributors, transmission pipeline operators, renewable gas producers, and other stakeholders on the requirements and processes for connecting renewable gas production facilities to gas distribution networks and transmission pipelines in Australia.

The Code aims to facilitate the safe, reliable, and efficient injection of renewable gases, such as biomethane and hydrogen, into gas networks while maintaining gas quality, interoperability, and compliance with relevant standards and regulations.

The scope of the Code covers the technical, safety, and commercial aspects of renewable gas connections, including:

- Renewable gas quality specifications and monitoring requirements.
- Injection facility design, construction, and operation.
- Network capacity assessment and connection design.
- Pipeline infrastructure requirements and modifications.
- Metering, allocation, and settlement arrangements.
- Commercial arrangements, including connection charges, transportation agreements, and incentives.
- Ongoing compliance, reporting, and incident management.

The Code applies to the connection of renewable gas facilities to gas distribution networks operating at pressures up to 1050 kPa and transmission pipelines operating at pressures above 1050 kPa. It covers both brownfield (existing) and greenfield (new) connections, as well as the injection of renewable gases into gas networks for blending with natural gas or for dedicated renewable gas transportation.

The guidance provided in this Code is intended to complement and support compliance with existing federal, state, and territory legislation, regulations, and standards governing gas infrastructure and renewable gas development in Australia. In the event of any inconsistency between the Code and statutory requirements, the relevant legislation and regulations shall take precedence.

The Code is not intended to provide a prescriptive or exhaustive set of rules for renewable gas connections, but rather to establish a framework of principles, minimum requirements, and best practices to guide project proponents and stakeholders in navigating the connection process. Individual renewable gas projects may require additional or specific considerations beyond those outlined in the Code, depending on their location, scale, technology, and commercial arrangements.

APGA may update or amend the Code from time to time to reflect changes in legislation, standards, industry practices, or stakeholder feedback. Users of the Code should ensure they are referencing the most current version and are encouraged to provide feedback to APGA on the Code's application and effectiveness in supporting the growth of the renewable gas industry in Australia.

1.2 Use of the Code

This Code of Practice is intended to be used by a range of stakeholders involved in the development, assessment, approval, and operation of renewable gas connection projects in Australia, including:

- Renewable gas producers and project proponents.
- Gas distribution and transmission pipeline operators.
- Engineering, procurement, and construction (EPC) contractors.

- Gas equipment and service providers.
- Government agencies and regulators.
- Industry associations and peak bodies.
- Consultants and advisors.

The Code is designed to be a reference document that provides guidance and recommendations on the key aspects of renewable gas connections, from initial feasibility through to ongoing operation and compliance. Users of the Code should refer to the relevant sections and clauses that apply to their specific project stage, scope, and jurisdiction.

By promoting a consistent and transparent approach to renewable gas connections, APGA aims to support the growth of the renewable gas industry in Australia while ensuring the ongoing safety, reliability, and integrity of our gas networks. We encourage all stakeholders to adopt and apply the principles and practices outlined in this Code to facilitate the successful integration of renewable gases into Australia's energy mix.

1.3 Key Roles and Responsibilities

1.3.1 Gas Industry, Operators, Regulators and Associations

For the purposes of this Code, the following key roles are discussed throughout:

Role	Description
Renewable Gas Producers	Produce renewable gas, such as biomethane and hydrogen, for injection into the gas network. Renewable gas producers may include landfill operators, wastewater treatment plants, agricultural enterprises, and dedicated renewable gas production facilities.
Transmission Pipeline Operators	Operate and maintain the high-pressure gas transmission pipelines in Australia, transporting gas from production facilities, storage facilities, and interconnection points to distribution networks and large industrial customers. Key transmission pipeline operators include APA Group, Jemena, EPIC, SEA Gas and Australian Gas Networks (AGN).
Distribution Network Operators	Operate and maintain the gas distribution networks that deliver gas to homes and businesses across Australia. Key distribution network operators include Jemena, ATCO, Australian Gas Networks (AGN), Multinet Gas, Ausnet Services, and Evoenergy.
Australian Energy Market Operator (AEMO)	AEMO is the gas market operator responsible for operating the Declared Wholesale Gas Market (DWGM) in Victoria, the Short Term Trading Market (STTM) hubs in Adelaide, Sydney, and Brisbane, and the Gas Supply Hub (GSH) at Wallumbilla. AEMO also oversees gas system security, market settlements, and gas bulletin board operation.
Shippers	Shippers are responsible for arranging the transportation of gas on behalf of producers and suppliers. They enter into contracts with pipeline and network operators to transport gas from production points to consumption points.

Suppliers (Retailers)	Suppliers, also known as retailers, purchase gas on the wholesale market and sell it to end-use customers, including households and businesses. Key gas suppliers in Australia include AGL, Origin Energy, Energy Australia, and various second-tier retailers.
Regulators	The Australian Energy Regulator (AER) is responsible for economic regulation of gas transmission and distribution networks, as well as monitoring and enforcing compliance with the National Gas Law and National Gas Rules. The Energy Ministers' Meeting, composed of federal, state, and territory energy ministers, is responsible for overall energy policy direction and decision-making. State and territory regulators, such as the Essential Services Commission (ESC) in Victoria, are responsible for licensing gas network operators and retailers within their respective jurisdictions.
Australian Pipelines and Gas Association (APGA)	APGA is the peak body representing the pipeline infrastructure industry in Australia. APGA is responsible for promoting the safe, reliable, and sustainable operation of Australia's gas transmission and distribution infrastructure, including developing and maintaining industry codes and standards.
Energy Networks Australia (ENA)	ENA is the national industry body representing Australia's electricity transmission and distribution and gas distribution networks.
Gas Technical Regulators	Each state and territory has a technical regulator responsible for gas safety, technical standards, and licensing of gasfitters and appliance installers. These include: • Energy Safe Victoria (ESV) • NSW Department of Climate Change, Energy, Environment and Water (DCCEEW) • Resources Safety & Health Queensland (RSHQ) • Office of the Technical Regulator (OTR) in South Australia • Department of Energy, Mines, Industry Regulation and Safety (DEMIRS) in Western Australia, divisions of Building and Energy; and WorkSafe Petroleum Safety and Dangerous Goods • Access Canberra • NT WorkSafe The Gas Technical Regulators Committee (GTRC) facilitates collaboration and consistency between the state and territory technical regulators.

1.3.2 Gas Market

In addition to the above, roles and participants within the gas market range from facility operators to shippers and retailers, participants in AEMO's wholesale and retail gas markets who all fulfil a wide variety of roles and responsibilities.

The roles described above generally align with those defined in the gas market, it is noted that there are different terminologies across DWGM in Victoria and the STTM hubs in Adelaide, Sydney, and Brisbane.

An updated list of market participants is available online at AEMO's website https://aemo.com.au/en/learn/market-participants/gas-market-participants with key market participants relevant to renewable gas production provided below.

2 Legislation, Regulation and Standards

Renewable gas producers and distributors should ensure compliance with all relevant federal, state, and territory legislation, regulations, standards, and industry codes applicable to their specific projects and jurisdictions. Where there is any inconsistency between this Code and the relevant legislation or standards, the legislative and statutory requirements shall take precedence.

Legislation, regulations and standards are all being revised and developed to support the implementation of renewable gases. As these developments progress this section may not be kept up to date and producers and operators should stay up-to-date with revised documentation.

2.1 Legislation and regulation

The legal and regulatory framework for renewable gas injection in Australia consists of a combination of federal, state, and territory legislation, as well as industry-specific regulations, standards, and codes of practice.

At the federal level, the key legislation governing the gas industry includes:

- National Gas Law (NGL) and National Gas Rules (NGR).
- National Greenhouse and Energy Reporting Act 2007 (NGER Act).

The NGL and NGR establish the national regulatory framework for gas transmission and distribution networks, including provisions for third-party access, economic regulation, and gas quality specifications. The NGER Act sets out reporting obligations for greenhouse gas emissions and energy production and consumption, while the Renewable Energy (Electricity) Act 2000 creates the Renewable Energy Target (RET) scheme, which incentivises renewable electricity generation.

National energy-related legislation, such as amendments to the National Energy Laws, are enacted through the South Australian Parliament.

At the state and territory level, the key legislation relevant to renewable gas injection includes:

- Gas Supply Acts and Regulations.
- Pipeline Acts and Regulations.
- Petroleum and Gas Acts and Regulations.
- Environmental Protection Acts and Regulations.
- Planning and Development Acts and Regulations.
- Hydrogen Acts.

These state and territory laws govern various aspects of gas infrastructure development, operation, and safety, as well as environmental and planning approvals for renewable gas

projects. Federal laws provide the overarching frameworks, and fill gaps where there are no state or territory law.

Some of the specific state and territory legislation relevant to renewable gas injection include:

- New South Wales: Gas Supply Act 1996, Pipelines Act 1967.
- Victoria: Gas Industry Act 2001, Gas Safety Act 1997.
- Queensland: Petroleum and Gas (Production and Safety) Act 2004.
- Western Australia: Gas Standards Act 1972, Petroleum Pipelines Act 1969.
- South Australia: Gas Act 1997, Petroleum and Geothermal Energy Act 2000.
- Tasmania: Gas Act 2000, Gas Pipelines Act 2000.
- Australian Capital Territory: Utilities Act 2000, Gas Safety Act 2000.
- Northern Territory: Energy Pipelines Act 1981, Petroleum Act 1984.

The above lists are not exhaustive and legislation is amended from time to time.

2.2 Standards (Australian and International)

In addition to the above legislation, there are several key standards and industry codes that may be relevant to renewable gas injection or the production facility, including:

- AS 1375 Industrial fuel-fired appliances.
- AS/NZS 1596 - The storage and handling of liquefied petroleum (LP) Gas.
- AS/NZS 3645 - Essential requirements for gas equipment.
- AS/NZS 3788 – Pressure equipment – In-service inspection.
- AS 3814 - Industrial and commercial gas-fired appliances.
- AS 4041 - Pressure piping.
- AS 4564 Specification for general purpose natural gas.
- AS/NZS 4645 series - Gas distribution networks.
- AS 2885 series - Pipelines - Gas and liquid petroleum.
- AS/NZS 5601.1 Gas installations – General installations.
- AS/NZS 60079 series - Explosive atmospheres.
- SA HB 225:2023 Guideline for blending hydrogen into pipelines and gas distribution networks

In addition to the Australian standards listed above, there are several international and regional standards that may be relevant to renewable gas injection projects in Australia, particularly in relation to gas quality, safety, and equipment design and performance.

Some of the key international and regional standards that may be applicable include:

- NZS 5442 - Specification for reticulated natural gas.
- NZS 5425 - Code of practice for CNG compressor and refuelling stations.
- CEN TR17238 - Proposed limit values for contaminants in biomethane based on health assessment criteria.

- CEN-TR 17797-- Gas infrastructure - consequences of hydrogen in the gas infrastructure and identification of related standardisation need in the scope of CEN/TC 234.
- EN 16723-1 - Natural gas and biomethane for use in transport and biomethane for injection in the natural gas network - Part 1: Specifications for biomethane for injection in the natural gas network.
- EN 16723-27 - Natural gas and biomethane for use in transport and biomethane for injection in the natural gas network - Part 2: Automotive fuels specification.
- EN 16726- Gas infrastructure - Quality of gas - Group H.
- IGEM/TD/16 - Bio methane injection.
- ISO 6974 (all parts) - Natural gas-Determination of composition and associated uncertainty by gas Chromatography.
- ISO 10715 - Natural gas — Sampling guidelines.
- ISO 13686 - Natural Gas - Quality designation.
- ISO 14532 - Natural gas - Vocabulary.
- ISO 15403 - Natural gas - Natural gas as a compressed fuel for vehicles (all parts).
- ISO/TS 16922 - Natural Gas – Guidelines for odorising gases.
- ISO 16923 - Natural gas fuelling stations - CNG stations for fuelling vehicles.
- ISO 16924 - Natural gas fuelling stations - LNG stations for fuelling vehicles.
- ISO 19880-1 - Gaseous hydrogen - Fuelling stations - Part 1: General requirements.
- ISO/TS 19883 - Safety of pressure swing adsorption systems for hydrogen separation and purification.
- ISO 20675 - Biogas - Biogas production, conditioning, upgrading and utilisation - Terms, definitions and classification scheme (ISO 20675).
- ANSI/NACE MR0175/ISO 15156 – Petroleum and natural gas industries – Materials for use in H2S-containing environments in oil and gas production.

These international and regional standards provide guidance on gas quality specifications, safety requirements, fuelling station design (if applicable), and equipment performance that may be relevant to renewable gas injection projects, particularly where harmonisation with global best practices is desired.

It is important to note that while these international standards can provide useful guidance, they do not supersede or replace the applicable Australian standards and regulations. Renewable gas producers and network operators should consult with the relevant regulatory authorities and industry bodies to determine the specific standards and requirements applicable to their projects.

2.3 Guidelines and Codes

There are several industry guidelines and codes of practice that provide further guidance on renewable gas injection in Australia.

Some of the key industry guidelines and codes include:

- APGA Code of Environmental Practice: Onshore Pipelines.
- APGA Code of Practice for Upstream Polyethylene Gathering Networks in the Coal Seam Gas Industry.
- APGA Stakeholder Engagement Guidelines.
- Australian Energy Market Operator (AEMO) Gas Quality Guidelines.
- AEMO Wholesale Market Gas Quality Monitoring Procedures (Victoria).
- AEMO STTM Procedures.
- Resource Safety & Health Queensland (RSHQ) - Petroleum and Gas Inspectorate - Guideline for operating plant - Biogas (June, 2022).
- PR3.2-10 Hydrogen Pipeline Systems - Design-Construction-Operation- FFCRC COP (Code of Practice)

These industry guidelines and codes provide additional guidance on environmental management, pipeline design and operation, stakeholder engagement, gas metering, gas quality specifications, and market operations that are relevant to renewable gas injection projects.

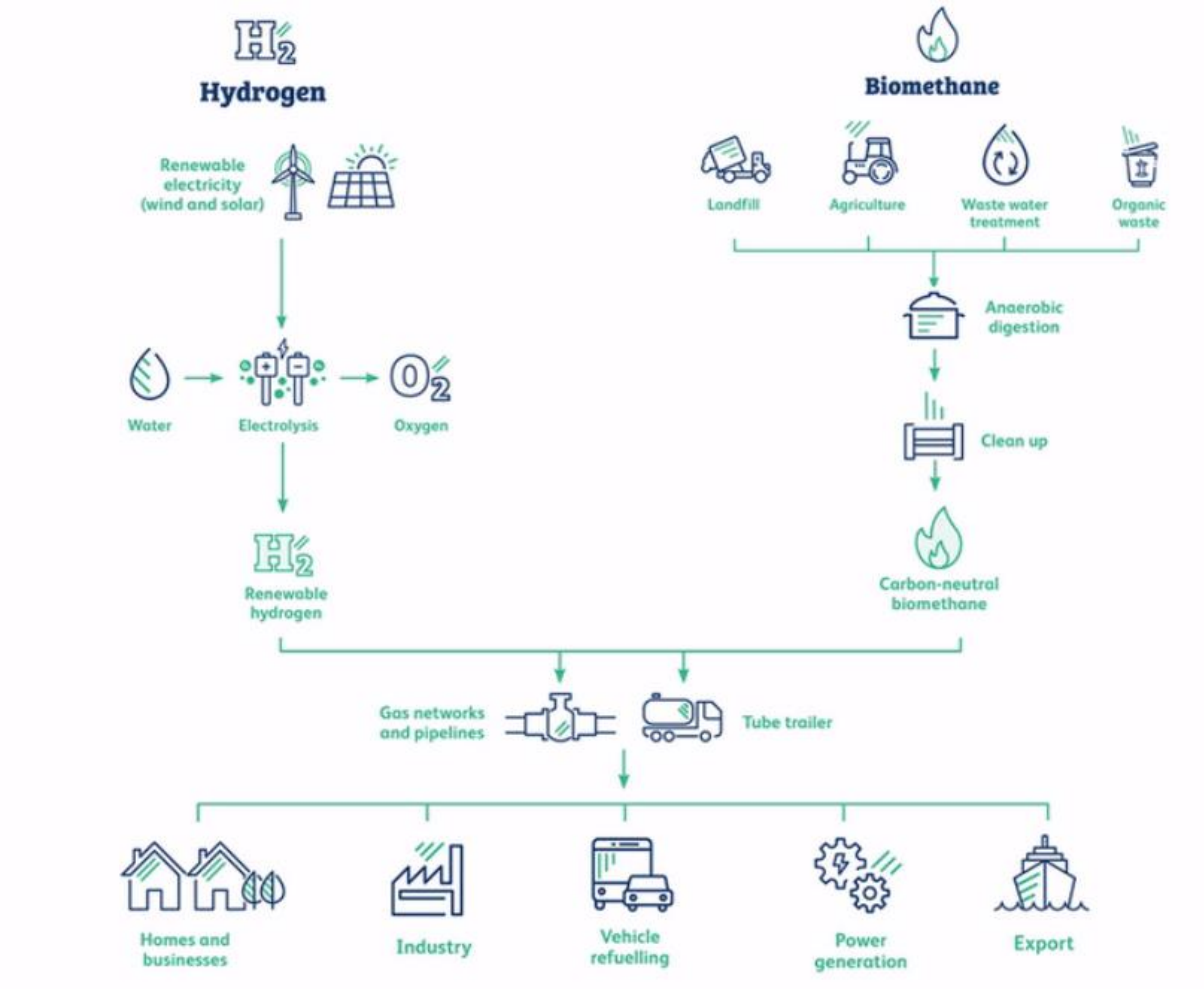
Renewable gas producers and network operators should familiarise themselves with the applicable industry guidelines and codes and incorporate the relevant requirements and best practices into their project planning and execution.

3 Renewable Gas Injection Overview

3.1 What is Renewable Gas

Renewable gas refers to gases which do not produce any additional carbon emissions when used. Common forms of renewable gas include renewable hydrogen and biomethane, shown in Figure 1 below.

Figure 1 - Renewable Gases example of production and uses[1]



3.1.1 Biomethane[2]

Biomethane is produced from biogas. Biogas is produced through a biological process known as anaerobic digestion, where microorganisms break down raw materials such as

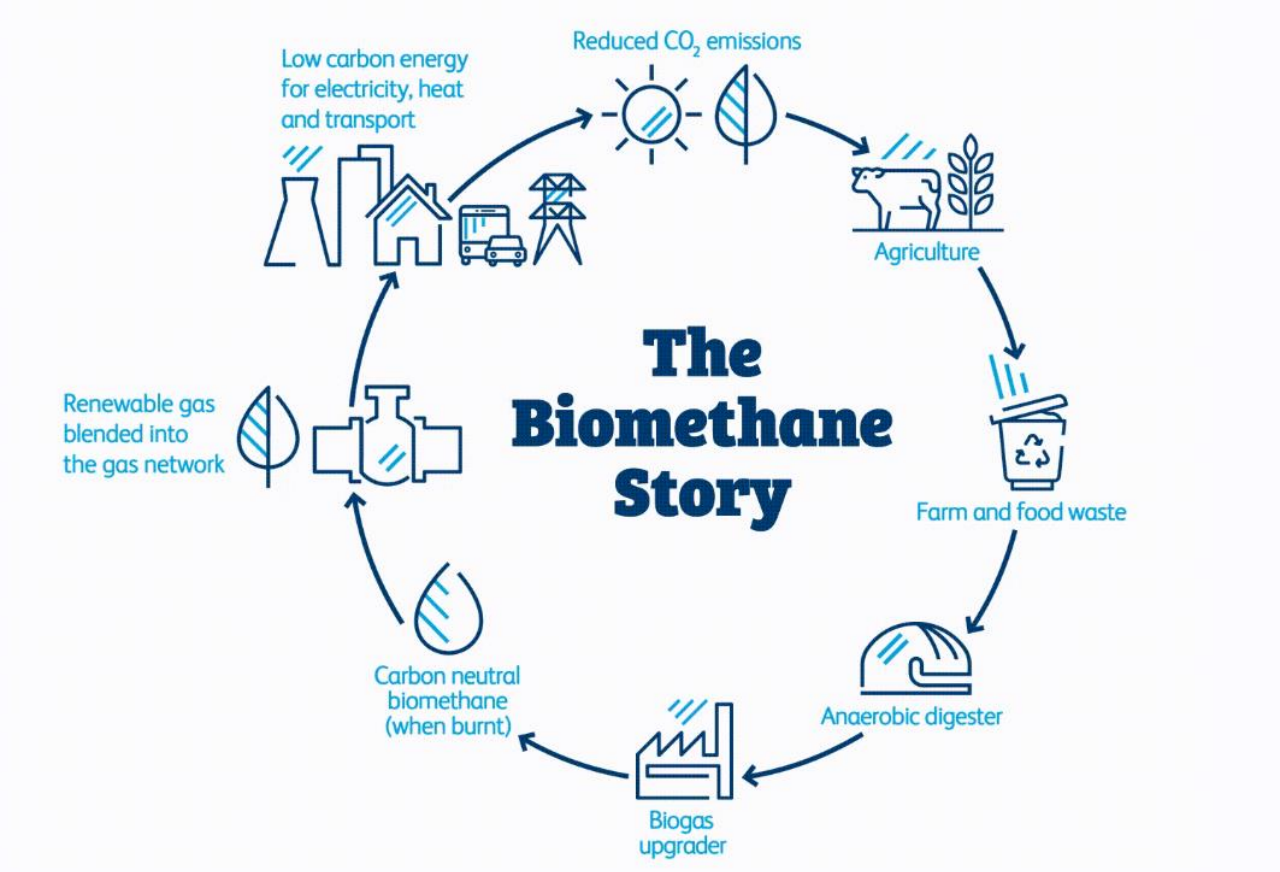
[1] Image provided by Australian Gas Infrastructure Group
[2] Clean Energy Regulator, 2022, *Emissions Reduction Fund: Biomethane Method Package 2022 – Simple Method Package*, https://cer.gov.au/document/biomethane-method-package-simple-method-guide

agricultural waste, manure, landfill and plant material in an oxygen free environment. This produces a mix of methane, carbon dioxide (CO_2) and other remnant gases.

'Upgrading' is the process of refining biogas into biomethane. It involves treating biogas to remove water, CO_2, and other remnant gases, resulting in a near-pure methane product (≥95% methane concentration). A range of upgrading technologies are commercially available, with variation in the treatment technology, capital and operation costs, and scalability.

While biomethane does produce the same emissions as natural gas when combusted, that combustion of biomethane releases the carbon absorbed by the biogenic material from the atmosphere during its life, and on this basis is considered to have net-zero carbon emissions (Figure 2). Biomethane is essentially interchangeable with natural gas. It can be used in existing gas networks and appliances without modification, and can substitute for natural gas in industrial manufacturing processes.

Figure 2 - The biomethane lifecycle[3]



[3] Image provided by Australian Gas Infrastructure Group

3.1.2 Renewable Hydrogen[4]

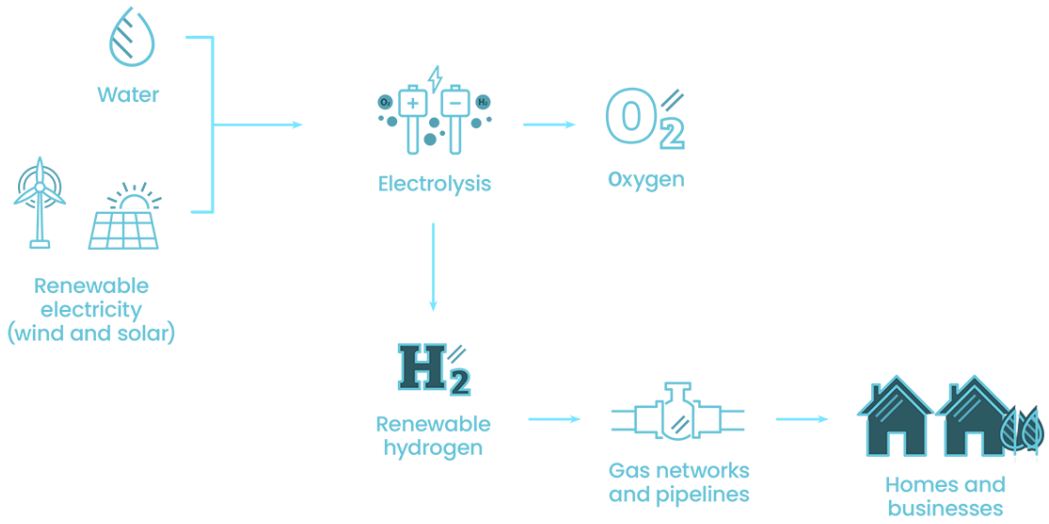
Hydrogen can be used as a carrier of energy. It can be stored as a gas or liquid, or made part of other molecules, and has many uses such as fuel for transport or heating, a way to store electricity, or a feedstock in industrial processes.

Hydrogen energy can be stored as a gas and blended for transport into existing natural gas pipelines. When converted to a liquid or utilised to produce another suitable material such as ammonia or alumina, hydrogen can also be transported on trucks and in ships.

When hydrogen is produced using renewable energy or processes, renewable or 'green' hydrogen is an emissions free fuel and becomes a way of storing renewable energy for use when it is needed.

Renewable hydrogen is typically produced through electrolysis using renewable electricity, generated from wind and solar. Water is pumped into an electrolyser, and separated into hydrogen and oxygen using electricity (Figure 3).

Figure 3 – The renewable hydrogen process[5]



[4] ARENA, 2024, *Hydrogen Energy,* accessed 5 June 2024, available at https://arena.gov.au/renewable-energy/hydrogen/

[5] Image provided by Australian Gas Infrastructure Group

3.2 Benefits of Renewable Gas Injection

Injecting renewable gases, such as biomethane and hydrogen, into Australian gas networks offers several benefits:

- Decarbonisation: Renewable gases can help reduce greenhouse gas emissions associated with natural gas use, contributing to Australia's climate change mitigation efforts and the transition to a low-carbon economy.
- Energy security: Diversifying gas supply sources through renewable gas injection enhances energy security and reduces reliance on imported natural gas.
- Improved waste management: Producing biomethane from organic waste materials, such as agricultural and food waste, provides a sustainable waste management solution and supports the circular economy.
- Economic opportunities: Renewable gas production and injection can create new jobs and economic opportunities in regional and rural areas, particularly in the agricultural and waste management sectors.
- Utilisation of existing infrastructure: Injecting renewable gases into existing gas networks leverages the substantial investment in gas infrastructure and minimises the need for extensive new infrastructure development.

3.3 Process of Injecting Renewable Gas[6]

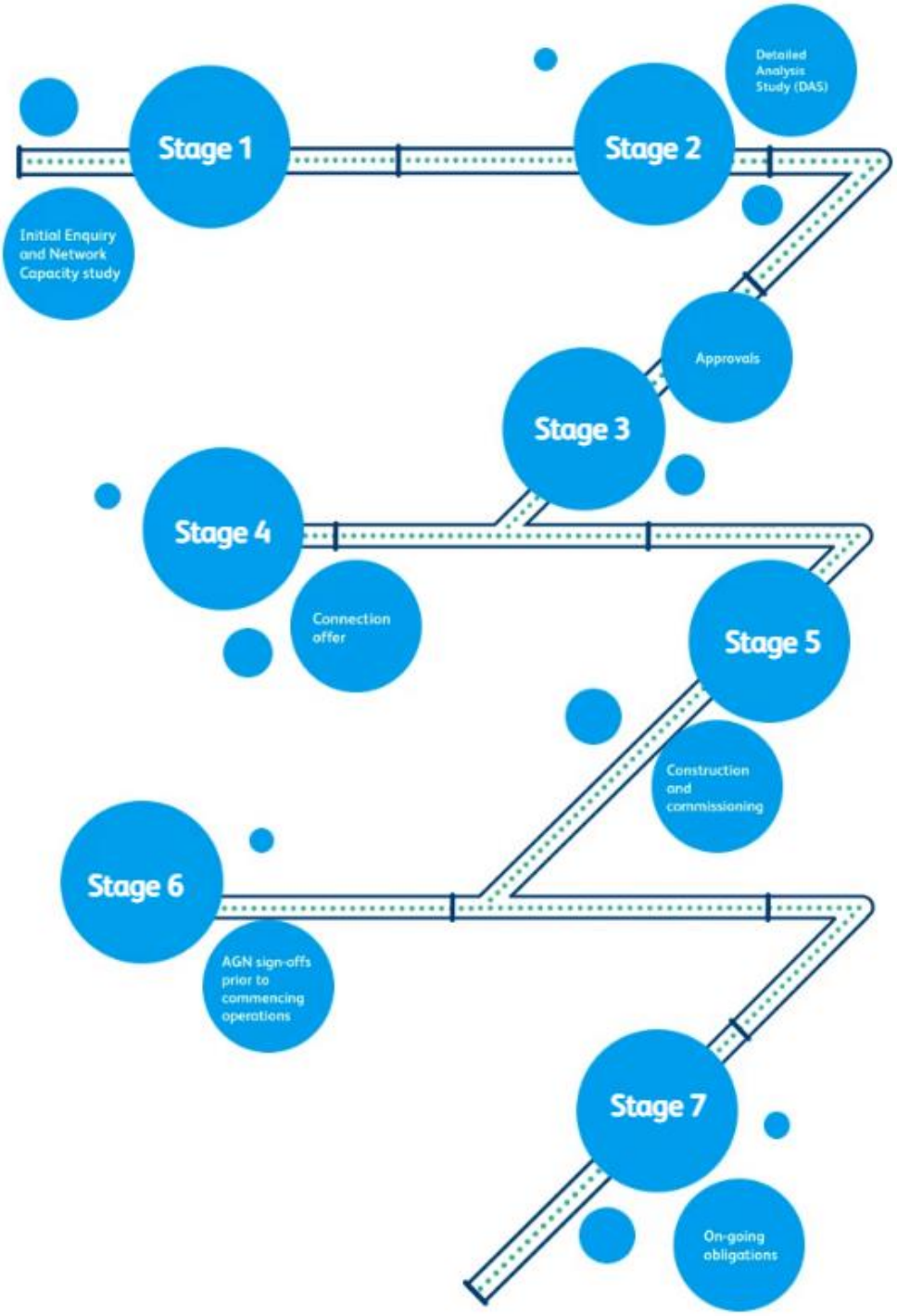
An example summary of the staged process of connecting a renewable gas producer facility to a gas network or pipeline is shown below:

1. Initial enquiry with distribution network or transmission pipeline operator.
2. Detailed Analysis Study.
3. Approvals including market participation registration.
4. Connection Offer – pipeline operator and renewable gas producer agree to connection offer and enter into necessary legal agreements.
5. Construct and commissioning of the injection facility.
6. Complete testing and gain final injection approval from distribution network or transmission pipeline operator.
7. Commence injection and comply with ongoing obligations.

The above is a generalised staged approach and some distribution network or transmission pipeline operators may have additional requirements above those stages listed above and shown in Figure 4 below. Please refer to the User Access and/or Interconnection Policies for the operator where relevant.

[6] Content adapted from AGIG, 2024, *Australian Gas Infrastructure Group Non-Scheme Pipeline User Access Guide*, https://www.agig.com.au/-/media/files/agig/agig-non-scheme-asset---user-access-guide.pdf; APA, 2023, *Allgas user access guide*, https://www.apa.com.au/globalassets/our-services/gas-transmission/allgas-user-access-guide.pdf; Jemena, 2023, *Jemena Gas Networks User Access Guide*, https://www.jemena.com.au/siteassets/gas/jgn-user-access-guide.pdf

Figure 4 - Example stages of renewable gas connection process[7]



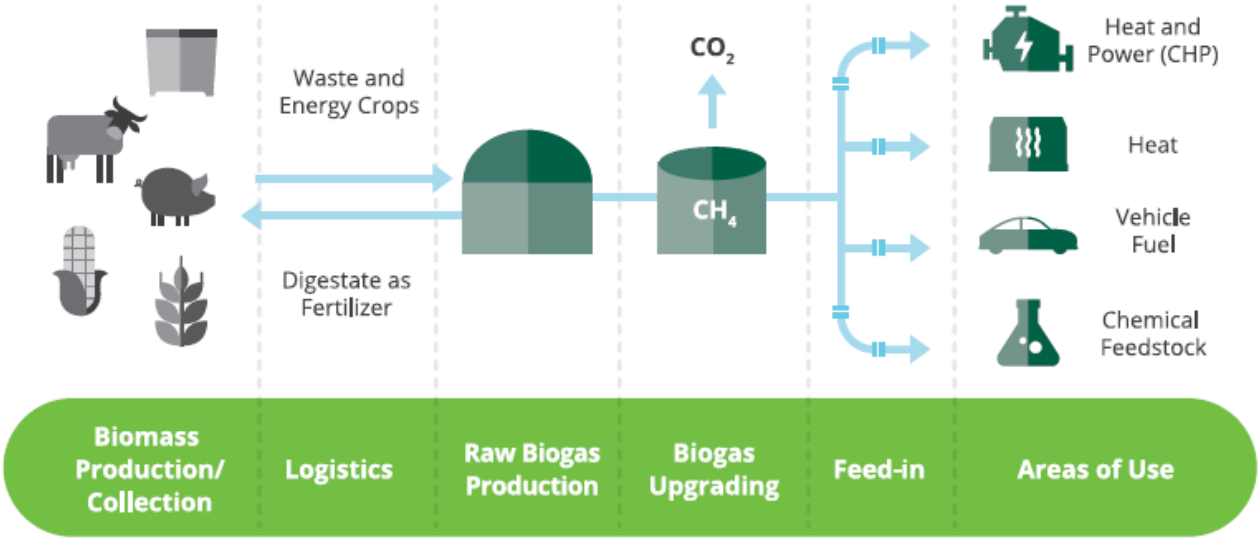
[7] Image provided by Australian Gas Infrastructure Group

3.4 Renewable Gas Injection Overview

The process of injecting renewable gases into Australian gas networks typically involves the following steps:

- Renewable gas production: Biomethane is produced through the upgrading of biogas generated from the anaerobic digestion of organic waste materials (Figure 5). Hydrogen can be produced through various methods, such as steam methane reforming with carbon capture and storage, or electrolysis using renewable electricity.
  - Biogas upgrading can be achieved through a biogas upgrading facility, which utilises water scrubbing and membrane separation to separate methane, CO_2 and other gases, or thermal gasification of solid biomass followed by methanation.[8]
  - CO_2 separated from biogas is usually vented, as it is considered carbon neutral. This CO_2 may instead be recovered as a sustainable source of CO_2 for industry.[9]

Figure 5 - Supply chain for biogas production to biomethane and application[10]



- Gas quality assessment: The renewable gas is analysed to ensure it meets the gas quality specifications required for injection into the network, as outlined in AS 4564 and any additional requirements specified by the gas distributor, transmission pipeline operator or relevant technical regulator.
- Injection facility design and construction: A renewable gas injection facility is designed and constructed to meet the specific requirements of the injection point and the gas network. The facility typically includes gas quality monitoring and measurement

[8] International Energy Agency, 2024, *Introduction to biogas and biomethane*, https://www.iea.org/reports/outlook-for-biogas-and-biomethane-prospects-for-organic-growth/an-introduction-to-biogas-and-biomethane

[9] Cordova S, 2023, *Utilizing CO_2 from biomethane production – Sustainability and climate performance*, https://www.diva-portal.org/smash/get/diva2:1756586/FULLTEXT01.pdf

[10] Image sourced from Sino-German Energy Partnership, 2020, *Biomethane production and grid injection: German experiences, policies, business models and standards*, https://www.energypartnership.cn/fileadmin/user_upload/china/media_elements/publications/Biomethane_German_Experience_Study_EN_Final.pdf

equipment, injection flow control and safety shut-off systems, odorisation systems (if required), and telemetry and communications equipment.

- Connection application and approval: The renewable gas producer submits a connection application to the relevant gas distributor or transmission pipeline operator, which assesses the application and approves the connection subject to meeting all technical, safety, and commercial requirements.
- Commissioning and start-up: The injection facility is commissioned, and the renewable gas is injected into the network, with ongoing monitoring and reporting to ensure compliance with gas quality, safety and regulatory requirements.

It is important for all parties to understand the process of injection, including the gas quality, approvals and in particular the ability to transport (and sell) the gas within the distribution network or transmission pipeline (see **Section 9** for further details).

3.5 Biomethane Injection Facility Ownership

This section of the Code has utilised and adapted successful international examples from Northern Gas Networks, Cadent Gas and Gas Networks Ireland.

When connecting a biomethane production facility to a gas distribution network or transmission pipeline, the Code has provided three general examples of ownership and delineation models:

- Infrastructure Operator Based Injection Facility model (owned by the gas network or pipeline operator);
- Producer Based Injection Facility model (owned by the renewable gas producer); and
- Blended Based Injection Facility (blending to compliance owned by the renewable gas producer).

The choice between the models will depend on factors such as the technical capabilities and preferences of the renewable gas producer, the specific requirements of the distribution network or transmission pipeline operator, and the commercial arrangements agreed upon by both parties. These are example models that have been used successfully internationally.

In all arrangements, it is recommended that standardised designs be utilised to ensure consistency across networks and pipeline operators, with the exception of specific requirements for certain operators.

3.5.1 Infrastructure Operator Based Injection Facility

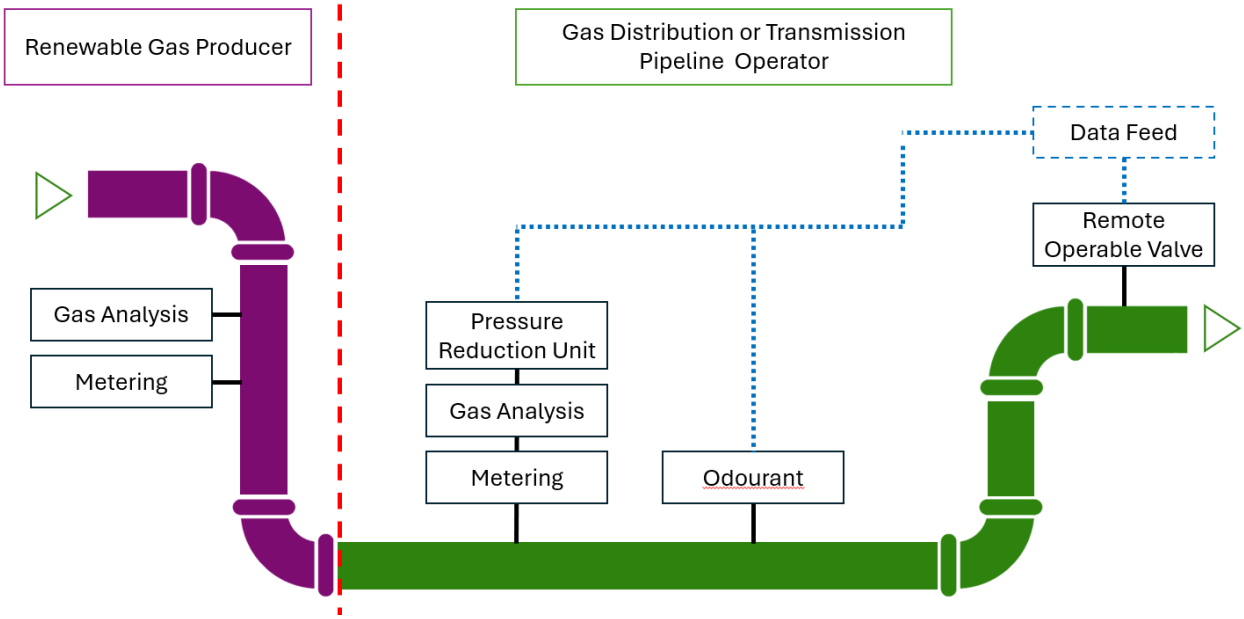
In the Infrastructure Operator Based Injection Facility model, the distribution network or transmission pipeline operator assumes full ownership and responsibility for all equipment within the injection facility. This includes:

- Gas quality monitoring and measurement equipment.
- Injection flow control and safety shut-off systems.

- Odorisation system (if required).
- Telemetry and communications equipment.
- Pressure regulation and overpressure protection devices.

Under the model demonstrated in Figure 6, the distribution network or transmission pipeline operator is responsible for the design, procurement, installation, commissioning, operation, and maintenance of the injection facility. The renewable gas producer is responsible for delivering compliant (on-specification gas - with the exception of odorant) renewable gas to the injection point, which is typically located at the boundary of the injection facility.

Figure 6 - Infrastructure Operator Based Injection Facility - Biomethane[11]



It is noted that while this arrangement may streamline the connection process, it may increase challenges associated with the management and flaring of off-specification gas. It is recommended that in this model, suitable flaring arrangements are made and that the commercial agreement between the injection facility owner and the renewable gas producer is well-defined for off-specification and other failure events.

3.5.2 Producer Based Injection Facility

In the Producer Based Injection Facility model, the renewable gas producer retains ownership and responsibility for most of the equipment required for the injection facility, which is likely to be included within the renewable gas facility itself and may include:

- Gas quality monitoring and measurement equipment.
- Odorisation system (if required).
- Telemetry and communications equipment.

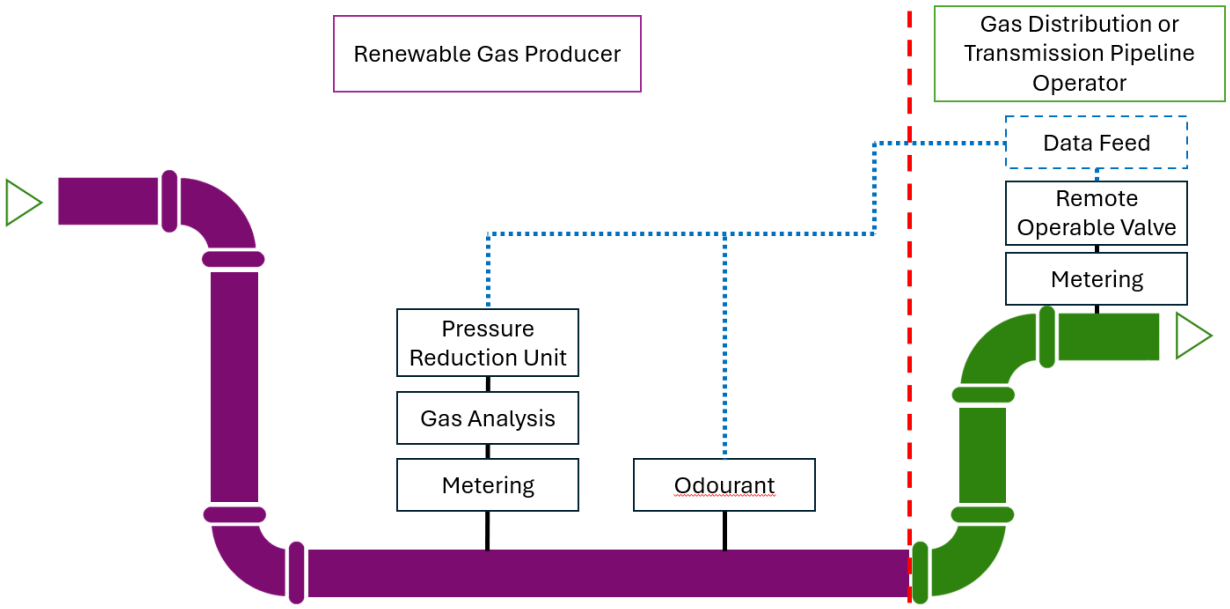
[11] Adapted from Cadent Gas, 2020, *Biomethane gas to grid - Customer connection guide*, https://cadentgas.com/nggdwsdev/media/Downloads/Bio-guide-to-connect-FINAL-280220.pdf

- Pressure regulation and overpressure protection devices (if required or located at the network/transmission injection point).

Under the model demonstrated in Figure 7, the renewable gas producer is responsible for the design, procurement, installation, commissioning, operation, and maintenance of the injection facility.

The distribution network or transmission pipeline operator's ownership and responsibility are limited to a standard metering connection, including a data connection, Remote Operable Valve (ROV), Remote Telemetry Unit (RTU), and the pipeline connecting the ROV to the gas network or transmission pipeline.

Figure 7 - Producer Based Injection Facility - Biomethane[12]



This simplified injection facility arrangement could protect the network and reduce the potential impact of receiving off-specification gas at the injection point. Additionally, it would result in a smaller footprint for the distribution network or transmission pipeline operator.

Note that metering may not need to be performed by both producer and operator for every facility, and different levels of metering may apply to different jurisdictions.

3.5.3 Blended Based Injection Facility

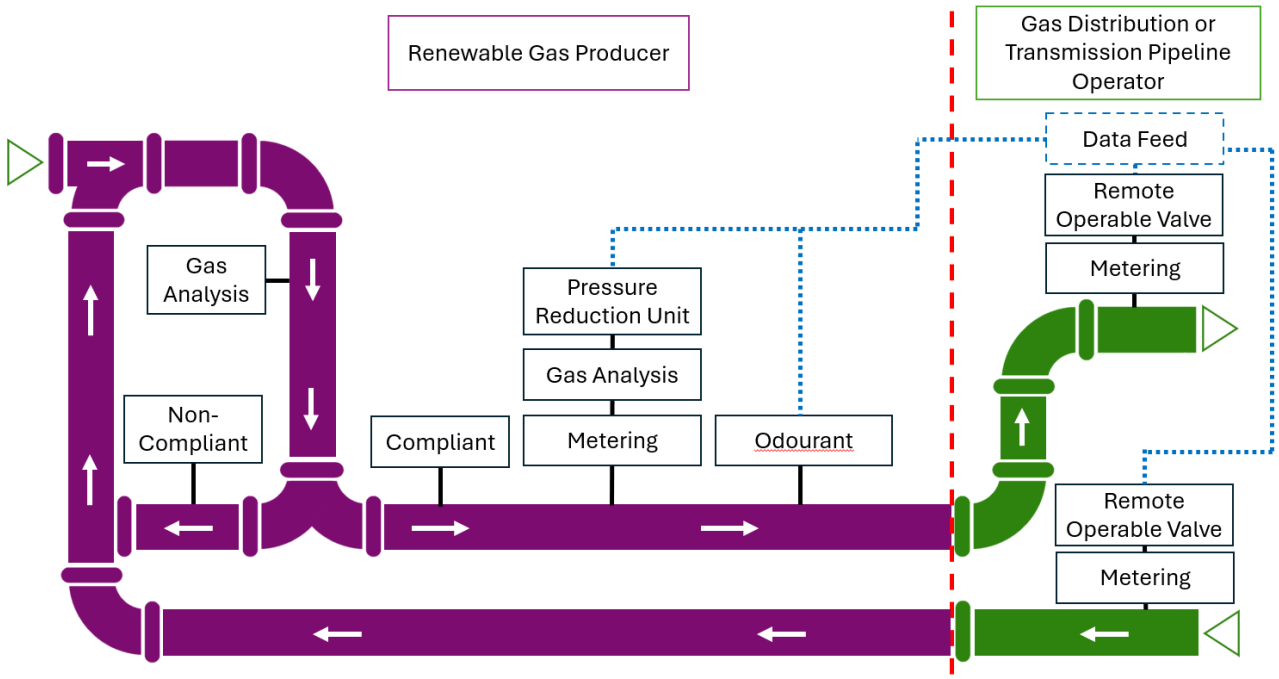
In the Blended Based Injection Facility model, gas is taken from the network and blended with off-specification renewable gas until it meets the required specifications. The blending process is managed by the renewable gas producer to ensure that the final blended gas delivered to the network complies with the relevant gas quality standards.

The renewable gas producer is responsible for the design, installation, operation, and maintenance of the blending equipment, as well as the gas quality monitoring and control

[12] Adapted from Cadent Gas, 2020, *Biomethane gas to grid - Customer connection guide,* https://cadentgas.com/nggdwsdev/media/Downloads/Bio-guide-to-connect-2023.pdf

systems required to ensure the blended gas meets the specifications. The distribution network or transmission pipeline operator's responsibility extends to the standard metering connection, similar to the Producer Based Injection Facility model (Figure 8).

Figure 8 - Blended Based Injection Facility - Biomethane



The Blended Based Injection Facility model allows for the injection of renewable gas that may not initially meet the required specifications, providing an opportunity for the renewable gas producer to gradually increase the biomethane content in the blended gas as the production process is optimised.

However, this model requires careful management of the blending process and close coordination between the renewable gas producer and the distribution network or transmission pipeline operator to ensure that the blended gas consistently meets the required quality standards and does not adversely impact the network or end-users.

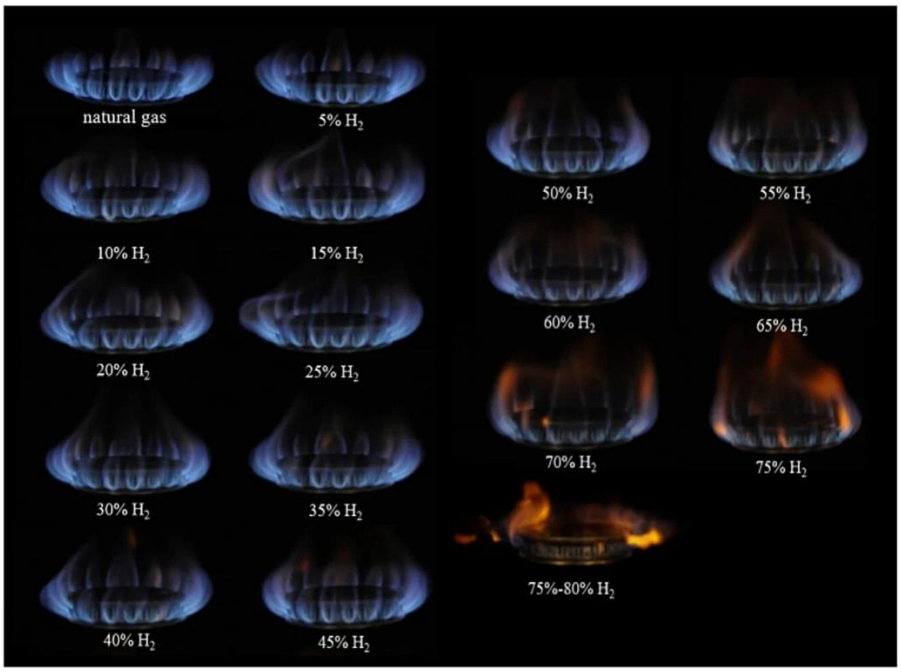
3.6 Hydrogen Injection Facility

When connecting a hydrogen production facility to a gas distribution network or transmission pipeline, additional considerations and requirements may apply due to the specific properties and characteristics of hydrogen. The design and operation of a hydrogen injection facility should address the following key aspects:

- Material compatibility: Hydrogen can cause embrittlement in certain materials, such as high-strength steels and some polymers.
- Pressure and flow control: Hydrogen has a lower volumetric energy density compared to natural gas, which may require higher injection pressures and flow rates to achieve the same energy delivery.

- Leak detection and safety systems: Hydrogen has a higher propensity to leak compared to natural gas due to its smaller molecular size.
- Blending and compatibility: When injecting hydrogen into a natural gas network, the blending ratio should be carefully controlled to ensure compatibility with downstream infrastructure, appliances, and end-use equipment.
- Odorant and flame visibility: Hydrogen is odorless and burns with an invisible flame, although this may appear orange in some appliances and in high hydrogen blends of natural gas (Figure 9). This poses additional safety challenges. The injection facility may require additional odorant injection systems to ensure that the blended gas remains detectable.

Figure 9. Flame colour of combusted natural gas and hydrogen blends[13]



- Compression and storage: Depending on the hydrogen production process and injection requirements, the facility may require compression and storage systems to optimise operations.
- Monitoring and control systems: The injection facility should be equipped with monitoring and control systems similar to that of biomethane injection facilities to ensure the safe and reliable injection of hydrogen into the gas network.
- Hydrogen Pipeline Systems Code of Practice (PR3.2-10 - FFCRC COP); This CoP provides guidance for the design, construction and operation of transmission pipeline systems transporting gaseous hydrogen or blends of hydrogen. Although it is mainly applicable for high pressure pipelines, the majority of technical requirements can also be used for distribution / network piping system.

[13] https://www.xylem.com/en-uk/brands/sensus/blog/hydrogens-impact-on-end-use-appliances--part-1/

4 Renewable Gas Quality and Specifications

4.1 Gas quality requirements

Renewable gases injected into Australian gas networks must meet the gas quality requirements specified in AS 4564 - Specification for general purpose natural gas. This standard defines the acceptable ranges for key gas quality parameters, such as heating value, Wobbe Index, relative density, and contaminant levels.

In addition to AS 4564, renewable gas producers must comply with any specific gas quality requirements set by the relevant gas distributor or transmission pipeline operator, which may be more stringent than the national standard.

Any deviation from relevant gas quality specification including AS4564 would require approval from the gas network and transmission pipeline operator as well as the appropriate State and Federal regulatory authorities.

4.1.1 Deviation

In the instance of non-compliant renewable gas (i.e. specifications outside of AS4564) gas distributors and transmission pipeline operators should (if deemed required) conduct detailed network modelling and impact studies to assess the potential effects of renewable gas injection on network performance, safety, and gas quality. These studies may include:

- Injection risk assessment.
- Formal Safety Assessment.
- Blending and compatibility analyses - i.e. Computational Flow Dynamics (CFD) analysis to determine downstream gas quality.

The results of these studies will inform the connection design process and help identify any required network modifications or upgrades to accommodate renewable gas injections.

It is noted that approval may be required by the distribution and transmission pipeline operator, state-based regulator and AEMO (if applicable to the STTM or the Declared Wholesale Gas Market (DWGM)).

4.1.2 Biomethane Specific Requirements

The current version of AS 4564 does not specify limits or provide any guidance on possible biomethane contaminants. Until the standard is revised to incorporate renewable gases, it is recommended that site-specific gas quality parameter limits be developed for biomethane injections, taking into account the specific gas compositions associated with the upstream biogas source (e.g., landfill, wastewater, agricultural residues, or commercial wastes).

In the absence of Australian standards for biomethane injection, the European standard EN 16723-1 Natural gas and biomethane for use in transport and biomethane for injection in the

natural gas network - Part 1: Specifications for biomethane for injection in the natural gas network can serve as a reference for best practices. This standard outlines additional parameters that could be considered when assessing the suitability of biomethane for injection into the gas network:

- Carbon monoxide
- Total volatile silicium or silicon (as Si)
- Heavy metals and its compounds
- Fluorine and its compounds
- Chlorine and its compounds
- Fluorinated compounds
- Mono aromatics (BTEX)
- Poly aromatics (PAHs)
- Hydrocarbons
- Mercaptans
- Terpene
- Biological agents
- Dust impurities
- Ammonia (NH3)
- Amine

It is important to note that the specific biomethane connection requirements and gas quality specifications may vary depending on the state and location of the injection point. As the injection of biomethane into Australian gas networks is still a relatively new practice, it is expected that initial projects will be assessed on a case-by-case basis.

Approval for biomethane injection projects will likely involve consultation with key stakeholders, including:

- The Australian Energy Market Operator (AEMO)
- The relevant gas distribution network or transmission pipeline operator
- State-based energy regulators

4.1.3 Hydrogen Specific Requirements

For hydrogen blending, the following parameters should be considered:

- Hydrogen blend percentage and its impact on Wobbe Index and Heating Value.
- Potential hydrogen embrittlement on existing pipeline infrastructure.
- Hydrogen compatibility with downstream Commercial Type A and Type B appliances.
- Impact of hydrogen blend on natural gas feedstock facilities.
- Hydrogen blending rate of change to mitigate drastic fluctuations in injection rates and heating values.
- Safety considerations for hydrogen connections, such as remote isolation and fail-safe design.
- Additional odorisation requirements for hydrogen blended gas injections.

- Principles of Hydrogen Pipeline Systems Code of Practice (PR3.2-10 - FFCRC COP) may be used as a technical guideline.

4.2 Gas composition limits

Gas composition limits apply to natural gas, where applicable renewable gases shall comply (if required) with the following:

- AS 4564
- AEMO - Gas Quality Guidelines
- State-based energy regulator requirements.

4.3 Heating value and Wobbe Index

AS 4564 specifies the following requirements for the heating value (HV) and Wobbe Index (WI) of natural gas, which also apply to renewable gases:

	Maximum	Minimum
Wobbe Index	46.0 MJ/m^3	52.0 MJ/m^3
Higher Heating Value	42.3 MJ/m^3	

Gas distributors and transmission pipeline operators may specify narrower ranges for HV and WI to ensure compatibility with their networks and end-use equipment.

4.4 Odorant requirements

Renewable gases injected into distribution networks must be odorised to ensure detectability in accordance with AS 4564 which require gas odorisation to have an odour intensity that is detectable at a level not exceeding 20% LEL.

It is noted that AEMO specifies the following requirements:

> *AEMO has determined that the gas odorant specification requirement for the DTS is a blend of 70% THT and 30% TBM injected into the gas stream at a rate of at least 7 mg/m3 in the gas. AEMO has determined this gas odorisation regime meets the standard gas quality specifications (AS 4564) and the Regulation requirements.*[14]

[14] AEMO, 2024, *Wholesale Market Gas Quality Monitoring Procedures (Victoria)*, https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/gas_consultations/2023/amendments-to-victorian-declared-wholesale-gas-market-and-retail-market/ppc/wholesale-market-gas-quality-monitoring-procedures.pdf

In Western Australia the requirement for the minimum and maximum levels of odorant is defined within the *Gas Standards (Gas Supply and System Safety) Regulations 2000*. The requirement is that the level of odorant within the gas is to be

> *distinctive, unpleasant and non-persistent, when the gas is discharged, throughout that discharge indicates to a person with a normal sense of smell the presence of gas down to 20% the lower explosive limit. Where the selected and preferred odorant is a blend of 70% THT and 30% TBM the minimum limit as specified in Schedule 1 is 8 mg/m3 in the gas.*[15]

Transmission pipelines may have different odorisation requirements, and renewable gas producers should consult with the relevant transmission pipeline operator to determine any specific odorant requirements.

4.5 Monitoring and testing

Renewable gas producers must implement a monitoring and testing program to ensure ongoing compliance with gas quality requirements. This program should include:

- Continuous monitoring of key gas quality parameters using online analysers.
- Periodic sampling and laboratory analysis to verify the accuracy of online analysers and to test for additional parameters not measured continuously.
- Maintenance and calibration of gas quality monitoring equipment in accordance with manufacturer recommendations and industry best practices.
- Reporting of gas quality data to the relevant gas distributor or transmission pipeline operator at the required frequency and format.

Gas distributors and transmission pipeline operators may also conduct their own monitoring and testing of renewable gas quality to ensure compliance with their specific requirements.

[15] *Gas Standards (Gas Supply and System Safety) Regulations 2000* available at https://www.legislation.wa.gov.au/legislation/statutes.nsf/law_s1136.html

5 Renewable Gas Injection Facility Requirements

5.1 Injection facility overview

A renewable gas injection facility is a critical component of the renewable gas injection process, responsible for ensuring that the gas meets the required quality specifications and is safely and efficiently injected into the gas network. The design and construction of the injection facility must comply with relevant Australian standards, including:

- AS/NZS 4645 series - Gas distribution networks.
- AS 2885 series - Pipelines - Gas and liquid petroleum.
- AS/NZS 60079 series - Explosive atmospheres.
- AS 3814 - Industrial and commercial gas-fired appliances.

5.2 Gas quality monitoring and measurement equipment

The production or injection facility must include gas quality monitoring and measurement equipment to ensure that the renewable gas meets the required specifications before injection into the network. This equipment may include:

- Gas chromatograph for measuring gas composition.
- Wobbe Index analyser.
- Moisture analyser.
- Where specified by state law, specified contaminants.
- Flow measurement devices / market meters (e.g., ultrasonic, or Coriolis flow meters) – See Section 8

The selection, installation, and maintenance of gas quality monitoring and measurement equipment should comply with relevant Australian standards, such as:

- AS/NZS 4645.1 - Gas distribution networks - Network management
- AS/NZS 2885.1 - Pipelines - Gas and liquid petroleum - Design and construction.

The renewable gas quality data can be provided by the biogas or hydrogen producers facility, if sufficient assessments have been completed to determine the appropriate controls and risk mitigation measures to the network or pipeline is acceptable. This may include post upgrading gas quality data provided to the network operator in real-time to allow appropriate shut-in controls.

5.3 Injection flow control and safety shut-off systems

The injection facility must incorporate flow control and safety shut-off systems to ensure safe and controlled injection of renewable gas into the network. These systems may include:

- Flow control valves to regulate the injection rate.

- Slam-shut valves to automatically shut off the gas flow in the event of a pressure, flow, or gas quality deviation.
- Pressure monitoring and overpressure protection devices.
- Emergency shut-down (ESD) systems.

The design and operation of these systems should comply with relevant Australian standards, such as

- AS/NZS 4645.1 - Gas distribution networks - Network management
- AS/NZS 2885.1 - Pipelines - Gas and liquid petroleum - Design and construction.

5.4 Telemetry and communications

The injection facility must include telemetry and communications equipment to enable remote monitoring and control of the facility, as well as data exchange with the gas distributor or transmission pipeline operator. The telemetry and communications system should comply with the relevant Australian standards and the specific requirements of the gas distributor or transmission pipeline operator.

If the injection facility is owned and operated by the gas distributor or transmission pipeline operator as a flow measurement and shut-off then the renewable gas producers must provide remote monitoring as well as data exchange for relevant gas quality data to ensure in any event of non-compliance of gas quality the slam-shut valves would operate.

5.5 Facility layout and hazardous area classification

The layout of the injection facility should be designed to ensure safe and efficient operation, maintenance, and access. Hazardous areas within the facility should be classified in accordance with AS/NZS 60079.10.1, and all electrical equipment installed in these areas must comply with the requirements of the AS/NZS 60079 series of standards.

6 Connection Process

6.1 Injection facility ownership

As highlighted in Section 3.5 when connecting a renewable gas production facility to a gas distribution network or transmission pipeline, there are three primary ownership models that can be considered (see Section 3.5).

The choice of ownership model will depend on the specific requirements and preferences of the renewable gas producer and the distribution network or transmission pipeline operator.

6.2 Enquiry and feasibility assessment

Renewable gas producers interested in connecting to a gas distribution network or transmission pipeline should initiate the connection process by submitting an enquiry to the relevant gas distributor or transmission pipeline operator. If a form is not available on the operators website, the enquiry should generally include:

- Details of the proposed renewable gas production facility and injection facility.
- Expected gas composition, minimum and maximum flow rates, and pressures
- Proposed location of the injection point.
- Timeframe for the project.

The distribution network or transmission pipeline operator will assess the feasibility of the proposed connection based on factors such as:

- Available network capacity.
- Compatibility of the renewable gas within the network or pipeline.
- Proximity to the existing network infrastructure.
- Compliance with relevant regulations, standards, and industry codes relevant to the network or transmission pipeline operator.

Following the feasibility assessment, the gas distributor or transmission pipeline operator will provide feedback to the renewable gas producer on the viability of the project and any specific initial requirements or constraints.

Note that these enquiry and assessment criteria are not exhaustive and different operators may have different requirements.

6.3 Capacity assessment and connection design

If the proposed connection is deemed feasible, the gas distributor or transmission pipeline operator will conduct a detailed capacity assessment to determine the available network capacity at the proposed injection point and any potential impacts on the network and end-users.

Based on the capacity assessment, the gas distributor or transmission pipeline operator will develop a preliminary connection/injection design as per Section 5. The connection design will be developed in consultation with the renewable gas producer and will comply with relevant Australian standards, regulations, and industry codes.

6.4 Connection application and approval

Once the connection design has been finalised, the renewable gas producer will submit a formal connection application to the gas distributor or transmission pipeline operator. The application should include:

- Detailed information on the renewable gas production facility and injection facility.
- Proposed connection design.
- Gas quality monitoring and management plan.
- Health and safety management plan.
- Environment and heritage management plan.
- Evidence of compliance with relevant regulations, standards, and industry codes.

The gas distributor or transmission pipeline operator will assess the connection application and may request additional information or modifications to the proposed design. If the application is approved, the gas distributor or transmission pipeline operator will issue a connection approval, which may include specific conditions or requirements that must be met before the connection can proceed.

6.5 Connection agreement and commercial arrangements

Following connection approval, the renewable gas producer and the gas distributor or transmission pipeline operator will enter into a connection agreement, which will outline the terms and conditions of the connection, including:

- Technical and operational requirements.
- Gas quality specifications and monitoring requirements.
- Metering and allocation arrangements.
- Liabilities and indemnities.
- Termination and dispute resolution provisions.

The connection agreement will also specify the commercial arrangements for the injection of renewable gas, including any tariffs, fees, or charges applicable to the connection and ongoing operation of the injection facility.

6.6 Injection facility construction, testing and commissioning

Following the execution of the connection agreement, the renewable gas producer or network/pipeline operator can proceed with the construction of the injection facility in

accordance with the approved connection design and relevant Australian standards and regulations.

Throughout the construction process, the gas distributor or transmission pipeline operator may conduct inspections to ensure compliance with the approved design and any conditions specified in the connection approval.

Upon completion of construction, the injection facility will undergo a comprehensive testing and commissioning process to verify its performance and compliance with gas quality, safety, and operational requirements. The testing and commissioning process will be conducted in accordance with relevant Australian standards and industry best practices. The gas distributor or transmission pipeline operator will review the testing and commissioning results and, if satisfied, will provide final approval for the injection facility to commence operation.

6.7 Injection facility operation, maintenance, and decommissioning

Following commencement of operations, the renewable gas producer or the network/pipeline operator is responsible for the ongoing operation and maintenance of the injection facility in accordance with the connection agreement, relevant Australian standards, and industry best practices. This includes:

- Continuous monitoring and management of gas quality (if applicable).
- Regular maintenance and calibration of gas quality monitoring (if applicable) and measurement equipment.
- Reporting of gas quality and operational data to the gas distributor or transmission pipeline operator.

If the injection facility is operated by the renewable gas producer, the gas distributor or transmission pipeline operator will periodically audit the injection facility to ensure ongoing compliance with the connection agreement and relevant standards.

If the renewable gas producer decides to cease operation of the injection facility, they must notify the gas distributor or transmission pipeline operator in accordance with the terms of the connection agreement. The decommissioning process must be carried out in compliance with relevant Australian standards, regulations, and industry best practices to ensure the safety and integrity of the gas network or transmission pipeline.

7 Network Considerations

7.1 Network capacity and constraints

Gas distributors and transmission pipeline operators must assess the available capacity in their networks to accommodate renewable gas injections while maintaining the safety, reliability, and quality of gas supply to end-users. Factors that may influence network capacity include:

- Pipeline diameter and operating pressure.
- Existing gas flows and demand profiles – in particular between winter and summer, and day and night.
- Proximity to major gas users or demand centres.
- Presence of network constraints, such as pressure reduction stations or flow control valves.
- Planned network maintenance and unplanned interruptions.
- Reliability and affordability.

Gas distributors and transmission pipeline operators should use network modelling and simulation tools to assess the impact of renewable gas injections on network capacity and identify any potential constraints or required network upgrades.

7.2 Network pressure requirements

Renewable gas injection facilities must be designed to operate within the pressure parameters specified by the gas distributor or transmission pipeline operator to ensure compatibility with the existing network. Key considerations include:

- Minimum and maximum injection pressures.
- Allowable pressure fluctuations.
- Ramp-up and ramp-down rates.

These requirements will be specified in the connection agreement and must be adhered to by the renewable gas producer to maintain the safety and integrity of the gas network.

7.3 Pipeline infrastructure requirements

The injection of renewable gas may require modifications or upgrades to the existing pipeline infrastructure to accommodate the increased flows or to address potential gas quality issues. This may include:

- Installation of additional pressure regulation or flow control devices.
- Upgrade of pipeline materials or components to handle higher gas volumes or different gas compositions.

- Installation of gas conditioning or treatment equipment to ensure compatibility with downstream end-use equipment.

Any required pipeline infrastructure modifications or upgrades will be identified during the connection design phase and will be carried out by the gas distributor or transmission pipeline operator in accordance with relevant Australian standards and industry best practices, such as:

- AS/NZS 4645 series - Gas distribution networks.
- AS 2885 series - Pipelines - Gas and liquid petroleum.

7.4 Network Modelling and Impact Studies

Gas distribution and transmission pipeline operators may conduct detailed network modelling and impact studies to assess the potential effects of the injection on network performance, safety, and gas quality. These studies may required to ensure the safe and reliable operation of the gas network and to identify any necessary modifications or upgrades to accommodate the renewable gas injection.

Network modelling studies typically involve the use of computational fluid dynamics (CFD) simulations and other advanced modelling techniques to predict the behaviour of the renewable gas within the network. These studies help to determine:

1. The optimal location and configuration of the injection point to minimise impacts on network pressure, flow, and gas quality.
2. The maximum allowable injection rates and volumes based on network capacity and demand profiles and delivery pressure.
3. The potential for gas quality variations and their impact on end-use equipment and appliances.
4. The need for any network reinforcements, such as pipeline upgrades, pressure regulating stations, or gas conditioning equipment.

In addition to network modelling, gas distributors and transmission pipeline operators may also conduct risk assessments and safety studies to evaluate the potential hazards associated with renewable gas injection.

The scope and complexity of the network modelling and impact studies will depend on factors such as the size and location of the injection project, the characteristics of the renewable gas, and the specific requirements of the gas distributor or transmission pipeline operator. In some cases, additional studies may be required to address specific concerns or to comply with regulatory requirements.

The results of the network modelling and impact studies will inform the design and operating parameters of the injection facility, as well as any necessary modifications to the gas network. Gas distributors and transmission pipeline operators will work closely with renewable gas producers to ensure that the injection project meets all safety, reliability, and performance requirements and is compatible with the existing gas infrastructure.

7.5 Downstream customer requirements

The injection of renewable gas into the network must not adversely affect the safety, reliability, or performance of downstream customer equipment and appliances. Gas distribution and transmission pipeline operators must ensure that the blended or entirely renewable gas delivered to end-users complies with the gas quality specifications outlined in AS 4564 and any additional requirements specified by state law and in customer contracts or agreements.

Gas distributors and transmission pipeline operators should engage with major downstream customers, such as power generators or industrial users, to assess the potential impact of renewable gas injections on their operations and to identify any specific gas quality or supply requirements that must be met.

8 Gas Measurement and Allocation

Accurate measurement and allocation of renewable gas injections are critical for ensuring proper billing, settlement, and reconciliation in the gas market. The specific requirements and processes for gas measurement and allocation will depend on the location of the injection point and the applicable market arrangements, such as the Short Term Trading Market (STTM), the Declared Wholesale Gas Market (DWGM), or Heating Value Management Plan.[16]

8.1 Metering requirements and standards

Accurate measurement of the volume and energy content of renewable gas injected into the network is critical for billing, allocation, and reconciliation purposes. Metering equipment installed at the injection facility must comply with the relevant Australian standards and industry best practices, including:

- AS/NZS 4645 series - Gas distribution networks.
- AS 2885 series - Pipelines - Gas and liquid petroleum.
- AS 4944 - Gas measurement systems - In-service compliance testing.
- AEMO Wholesale Market Metering Procedures (Victoria).
- AEMO STTM Procedures.

The metering equipment must be selected, installed, commissioned, and maintained in accordance with the requirements specified in the connection agreement and the relevant standards to ensure accuracy and reliability of the measured data.

Some states have a measurement standard specified in regulations, for example Queensland under the *Petroleum and Gas Act* and *Petroleum and Gas Regulations*. Proponents should be aware of any suitable measurement standard that applies in their jurisdiction.

8.2 Gas Nomination and Allocation

Renewable gas producers or their retailers must nominate the expected daily quantities of gas to be injected at each injection point in accordance with the relevant market procedures. The process for nomination and allocation varies depending on the market in which the injection point is located.

8.2.1 DWGM (Victoria)

In the Victorian DWGM, market participants submit injection nominations to AEMO in accordance with the Wholesale Market Procedures (Victoria). AEMO uses the metering data

[16] As defined in the Western Australian *Gas Standards (Gas Supply and System Safety) Regulations 2002*

from the injection point to allocate injections to each market participant for settlement purposes.

8.2.2 STTM

In the STTM hubs (Adelaide, Sydney, and Brisbane), shippers submit offers to supply gas at the hub, which are used by AEMO to determine the market schedule and allocate gas deliveries in accordance with the STTM Procedures. Allocation agents at each hub determine the actual quantities of gas supplied by each shipper based on metering data and the allocation methodology specified in the STTM Procedures.

8.2.3 Non-STTM and Non-DWGM

For injection points located outside of the STTM and DWGM, the allocation of renewable gas injections will be determined by the metering data from the injection point and any applicable contractual arrangements between the renewable gas producer, retailers, and the distribution network or transmission pipeline operator.

8.3 Gas Day Calculation

The total energy quantity of renewable gas injected into the network during each gas day must be calculated in accordance with the methodology specified in the National Gas Rules (NGR) and the relevant AEMO market procedures.

The gas day energy quantity calculation involves the aggregation of the metered volume and energy content data over the 24-hour gas day period, taking into account any adjustments for gas quality variations or metering errors. The gas day energy quantity data is used for settlement and allocation purposes and must be reported to the relevant gas distributor or transmission pipeline operator in accordance with the requirements specified in the connection agreement.

8.4 Measurement Verification and Auditing

To ensure the accuracy and reliability of the metering data, the renewable gas producer must implement a measurement verification and auditing program in accordance with the requirements specified in the connection agreement and the relevant Australian standards. The verification and auditing program should include:

- Regular calibration and maintenance of metering equipment.
- Periodic testing and validation of metering accuracy.
- Investigation and resolution of any metering discrepancies or anomalies.
- Reporting of verification and auditing results to the relevant gas distributor or transmission pipeline operator.

The gas distributor or transmission pipeline operator may also conduct their own independent audits of the metering installation and data to ensure compliance with the connection agreement and the relevant standards and industry best practices.

9 Commercial Arrangements

9.1 Connection charges and ongoing fees

Renewable gas producers seeking to connect to a gas distribution network or transmission pipeline will be required to pay connection charges and ongoing fees as specified in the connection agreement. These charges and fees may include:

- Application and feasibility study fees.
- Design and construction costs for the injection facility and any required network upgrades
- Metering and gas quality monitoring equipment costs.
- Ongoing operation and maintenance fees.
- Network access and usage charges.

The specific charges and fees applicable to a renewable gas injection project will be determined by the gas distributor or transmission pipeline operator, based on the characteristics of the project, the required network modifications, and the applicable regulatory framework.

9.2 Gas Transportation Arrangements

Renewable gas transportation arrangements can be managed by the Renewable Gas Producer or could be supported by a Retailer or a Shipper which has the capacity and capability to manage gas transportation in the region of the renewable gas production.

It is noted that irrespective of the gas transportation arrangements, whether managed by Renewable Gas Producer or Retailer, the following market situations may apply.

It is recommended that **renewable gas producers** ensure that gas transportation is available at the renewable gas injection location as a priority.

In all cases, the gas transportation arrangements must comply with the relevant provisions of the National Gas Law, the National Gas Rules, and any other applicable state or territory legislation and regulations governing the operation of gas networks and pipelines.

9.2.1 STTM

The STTM operates at defined gas hubs in Sydney, Adelaide, and Brisbane. In the STTM, shippers (which may include renewable gas producers or their nominated retailers) submit offers to supply gas at the hub. AEMO uses these offers to determine the market schedule and the allocation of gas deliveries to each shipper. The market sets a daily market price for gas at each hub and facilitates the allocation of pipeline capacity to shippers.

The STTM Procedures outline the responsibilities of Trading Participants, STTM facility operators, STTM distributors, and AEMO in relation to the operation of the STTM, including:

- Registration of trading participants, facility operators, and distributors.
- Submission of offers and bids by shippers.
- Scheduling and pricing of gas at the hubs.
- Allocation of pipeline capacity to shippers.
- Settlement and prudential requirements.
- Market monitoring and reporting.

Renewable gas producers injecting into distribution networks or transmission pipelines connected to STTM hubs must ensure compliance with the relevant provisions of the STTM Procedures, which may include registration as a trading participant, submission of injection offers, and management of settlement and prudential obligations.

9.2.2 DWGM (Victoria)

The DWGM operates in Victoria and is a market-based gas balancing mechanism. In the DWGM, market participants (which may include renewable gas producers or their nominated retailers) submit injection and withdrawal bids to AEMO. AEMO uses these bids to determine the market schedule and the allocation of gas deliveries and withdrawals for each market participant.

The Wholesale Market Procedures (Victoria) outline the responsibilities of market participants, distributors, and AEMO in relation to the operation of the DWGM, including:

- Registration of market participants and distributors.
- Submission of injection and withdrawal bids by market participants.
- Scheduling and pricing of gas in the DWGM.
- Allocation of gas deliveries and withdrawals to market participants.
- Settlement and prudential requirements.
- Market monitoring and reporting.

Renewable gas producers injecting into the Victorian gas distribution network or the Declared Transmission System (DTS) must ensure compliance with the relevant provisions of the Wholesale Market Procedures (Victoria), which may include registration as a market participant, submission of injection bids, and management of settlement and prudential obligations.

9.2.3 Transportation outside the STTM and DWGM

For renewable gas injections into distribution networks or transmission pipelines outside of the STTM and DWGM, gas transportation arrangements will be governed by contractual agreements between the renewable gas producer (or their nominated retailer) and the relevant distribution network or transmission pipeline operator.

These transportation agreements will specify the terms and conditions for the injection, transportation, and delivery of the renewable gas, including:

- Nomination and scheduling of gas injections and withdrawals.
- Gas quality and pressure specifications.
- Metering and allocation procedures.
- Transportation tariffs and charges.
- Balancing and imbalance management.
- Curtailment and interruption provisions.

The specific terms of the transportation agreement will depend on the individual circumstances of the renewable gas project and the requirements of the distribution network or transmission pipeline operator. Renewable gas producers should engage with the relevant operator early in the project development process to discuss and negotiate the necessary transportation arrangements.

9.3 Gas billing and settlement

The billing and settlement processes for renewable gas injections will vary depending on the location of the injection point and the applicable market arrangements.

The renewable gas producer will be required to provide all necessary information and data to support the billing and settlement process, including metering data, gas quality data, and any other relevant operational or commercial information.

9.3.1 STTM

In the Short Term Trading Market (STTM), AEMO is responsible for the billing and settlement of gas transactions in accordance with the STTM Procedures. The settlement process involves:

1. Determination of the market schedule and price for each gas day.
2. Allocation of gas quantities to each trading participant based on metering data and the market schedule.
3. Calculation of settlement amounts for each trading participant based on the allocated quantities and market price.
4. Issuance of preliminary and final settlement statements to each trading participant.
5. Payment of settlement amounts by trading participants with negative net positions (i.e., those who withdrew more gas than they injected or purchased).
6. Payment of settlement amounts to trading participants with positive net positions (i.e., those who injected or sold more gas than they withdrew).

Renewable gas producers injecting into the STTM must ensure that they (or their nominated retailer) are registered as trading participants and comply with the settlement and prudential requirements outlined in the STTM Procedures.

9.3.2 DWGM (Victoria)

In the Declared Wholesale Gas Market (DWGM), AEMO is responsible for the billing and settlement of gas transactions in accordance with the Wholesale Market Procedures (Victoria). The settlement process involves:

1. Determination of the market schedule and price for each gas day.
2. Allocation of gas quantities to each market participant based on metering data and the market schedule.
3. Calculation of settlement amounts for each market participant based on the allocated quantities and market price.
4. Issuance of preliminary and final settlement statements to each market participant.
5. Payment of settlement amounts by market participants with negative net positions (i.e., those who withdrew more gas than they injected or purchased).
6. Payment of settlement amounts to market participants with positive net positions (i.e., those who injected or sold more gas than they withdrew).

Renewable gas producers injecting into the DWGM must ensure that they (or their nominated retailer) are registered as market participants and comply with the settlement and prudential requirements outlined in the Wholesale Market Procedures (Victoria).

9.3.3 Non-STTM and Non-DWGM

For renewable gas injections outside of the STTM and DWGM, billing and settlement will be governed by the contractual arrangements between the renewable gas producer (or their nominated retailer), the distribution network or transmission pipeline operator, and any other relevant parties (such as gas shippers or end-users).

These contractual arrangements will specify the terms and conditions for the measurement, allocation, and billing of the renewable gas injections, including:

- Metering and allocation procedures.
- Calculation of energy quantities and any applicable adjustments.
- Billing frequency and payment terms.
- Dispute resolution procedures.

The renewable gas producer (or their nominated retailer) will be responsible for providing all necessary data and information to support the billing and settlement process, as specified in the relevant contractual arrangements.

In all cases, the gas billing and settlement arrangements must comply with the relevant provisions of the National Gas Law, the National Gas Rules, and any other applicable state or territory legislation and regulations governing the operation of gas markets and networks.

9.4 Renewable Gas Certificates, Incentives and Credits

Renewable gas producers may be eligible for various incentives and credits designed to support the development and deployment of renewable gas projects in Australia. These incentives, certificates and credits may include:

- GreenPower Renewable Gas Guarantee of Origin.
- Australian Carbon Credit Units (ACCUs) under the Emissions Reduction Fund (ERF) scheme.
- Hydrogen Guarantee of Origin Scheme.
- State or territory-based renewable gas incentives or grant programs.

The availability and eligibility criteria for these incentives and credits may vary depending on the specific characteristics of the project.

Renewable gas producers should seek guidance from relevant government agencies, industry associations, and legal and financial advisors to understand the incentives and credits available for their projects and to ensure compliance with the applicable rules and regulations.

10 Ongoing Compliance and Reporting

10.1 Gas quality compliance monitoring

Renewable gas producers must implement a comprehensive gas quality compliance monitoring program to ensure that the gas injected into the network continuously meets the specifications outlined in AS 4564 and any additional requirements specified in the connection agreement.

The compliance monitoring program should include:

- Continuous online monitoring of key gas quality parameters, such as heating value, Wobbe Index, and composition.
- Periodic sampling and laboratory analysis to verify the accuracy of online measurements and to test for additional parameters not measured continuously.
- Alarm and notification systems to alert the renewable gas producer and the gas distributor or transmission pipeline operator of any gas quality excursions or non-compliances.
- Procedures for investigating and rectifying any gas quality non-compliances, including root cause analysis and corrective action implementation.

The renewable gas producer must maintain accurate records of all gas quality monitoring data and make this data available to the gas distributor or transmission pipeline operator upon request.

10.2 Incidents and emergency response

Renewable gas producers must develop and implement an emergency response plan to effectively manage any incidents or emergencies that may occur at the injection facility or in relation to the renewable gas supply. The emergency response plan should be developed in consultation with the gas distributor or transmission pipeline operator and should be consistent with the requirements of:

- AS/NZS 4645.1 - Gas distribution networks - Network management.
- AS 1596 - The storage and handling of LP Gas.
- AS/NZS 3000 - Electrical installations (known as the Australian/New Zealand Wiring Rules).

The emergency response plan should include:

- Identification of potential emergency scenarios and risks.
- Roles and responsibilities of personnel in emergency situations.
- Communication protocols and contact details for relevant stakeholders.
- Procedures for safe shutdown, isolation, and restart of the injection facility.
- Coordination with the gas distributor or transmission pipeline operator's emergency response procedures.

- Regular training and drills to test the effectiveness of the emergency response plan.

The renewable gas producer must report any incidents or emergencies to the gas distributor or transmission pipeline operator in accordance with the requirements specified in the connection agreement and the relevant industry codes and standards.

10.3 General maintenance and testing requirements

Renewable gas producers must implement a comprehensive maintenance and testing program to ensure the safe, reliable, and efficient operation of the injection facility and associated equipment. The maintenance and testing program should be developed in accordance with the manufacturer's recommendations and the relevant Australian standards and industry best practices, including:

- AS/NZS 4645.1 - Gas distribution networks - Network management.
- AS 2885.3 - Pipelines - Gas and liquid petroleum - Operation and maintenance.
- AS 3814 - Industrial and commercial gas-fired appliances.

The maintenance and testing program should include:

- Regular inspections and performance checks of critical components, such as meters, gas quality analysers, and safety shutoff valves.
- Calibration and validation of metering and gas quality monitoring equipment.
- Preventive maintenance tasks, such as lubrication, cleaning, and replacement of consumables.
- Corrective maintenance and repair of any faulty or degraded components.
- Record-keeping and reporting of all maintenance and testing activities.

The renewable gas producer must provide the gas distributor or transmission pipeline operator with a copy of the maintenance and testing program and any updates to the program as they occur.

10.4 General reporting and record keeping requirements

Renewable gas producers must maintain accurate and up-to-date records of all relevant information pertaining to the operation of the injection facility and the supply of renewable gas into the network. These records should be kept in accordance with the requirements specified in the connection agreement and the relevant Australian standards and industry best practices, such as:

- AS/NZS 4645.1 - Gas distribution networks - Network management.
- AS 2885.3 - Pipelines - Gas and liquid petroleum - Operation and maintenance.

The records that must be maintained and made available to the gas distributor or transmission pipeline operator upon request may include:

- Gas quality monitoring data and reports.

- Metering data and validation reports.
- Maintenance and testing records.
- Incident and emergency response reports.
- Calibration and verification certificates for critical equipment.
- Training and competency records for personnel involved in the operation and maintenance of the injection facility.

The renewable gas producer must also comply with any additional reporting requirements specified in the connection agreement, such as regular performance reports, gas quality excursion reports, or annual compliance statements.

11 Supporting Information

11.1 Acronyms

Acronym	
AEMO	Australian Energy Market Operator
APGA	Australian Pipelines and Gas Association
AS	Australian Standard
CER	Clean Energy Regulator
CFD	Computational Fluid Dynamics
DWGM	Declared Wholesale Gas Market
ESV	Energy Safe Victoria
FMEA	Failure Modes and Effects Analysis
GJ	Gigajoule
GG	Green Gas Certification Scheme
HIRA	Hazard Identification and Risk Assessment
HV	Heating Value
I&C	Industrial and Commercial
LEL	Lower Explosive Limit
LGC	Large-scale Generation Certificate
MAOP	Maximum Allowable Operating Pressure
MJ	Megajoule
MJ/m^3	Megajoules per cubic meter
NGL	National Gas Law
NGR	National Gas Rules
ppm	Parts per million
ROV	Remote Operable Valve
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
STTM	Short Term Trading Market
WI	Wobbe Index

11.2 Key stakeholders

Government and Regulatory Bodies

- Australian Energy Market Operator (AEMO)
- Australian Energy Regulator (AER)
- Clean Energy Regulator (CER)
- Department of Industry, Science, Energy and Resources (DISER)
- Energy Ministers' Meeting
- Energy Safe Victoria (ESV)
- NSW Department of Climate Change, Energy, Environment and Water (DCCEEW)
- Resources Safety & Health Queensland (RSHQ)
- Office of the Technical Regulator (OTR) in South Australia
- Department of Energy, Mines, Industry Regulation and Safety (DEMIRS) in Western Australia, divisions of Building and Energy; and WorkSafe Petroleum Safety and Dangerous Goods
- Access Canberra
- NT WorkSafe
- Gas Technical Regulators Committee (GTRC)

Industry Associations

- Australian Pipelines and Gas Association (APGA)
- Australian Hydrogen Council
- Bioenergy Australia
- Energy Networks Australia
- Gas Appliance Manufacturers Association of Australia (GAMAA)
- Gas Energy Australia (GEA)

Research and Innovation

- Future Fuels Cooperative Research Centre (FFCRC)
- CSIRO Energy
- Australian Renewable Energy Agency (ARENA)

11.3 Reference materials and industry resources

Australian Standards

- AS/NZS 4645 series - Gas distribution networks
- AS 2885 series - Pipelines - Gas and liquid petroleum
- AS 4564 - Specification for general purpose natural gas
- AS/NZS 60079 series - Explosive atmospheres
- AS/NZS 1596 - The storage and handling of LP Gas
- AS 3814 - Industrial and commercial gas-fired appliances
- AS/NZS 5601 - Gas installations

APGA Guidelines and Publications

- APGA Code of Environmental Practice
- APGA Pipeline Engineer Competency Standards
- APGA Stakeholder Engagement Guidelines
- Hydrogen Pipeline Systems Code of Practice (PR3.2-10 - FFCRC COP)

AEMO Procedures and Guidelines

- AEMO Wholesale Market Gas Scheduling Procedures
- AEMO STTM Procedures
- AEMO Market Procedures

International Standards and Guidelines

- ISO 13686 - Natural gas - Quality designation
- EN 16723 - Natural gas and biomethane for use in transport and biomethane for injection in the natural gas network
- EASEE-gas CBP - European Association for the Streamlining of Energy Exchange - gas Common Business Practice

Industry Resources

- Gas Networks Ireland - A Guide to Biomethane Connections to the Northern Ireland Gas Network (March, 2023)
- Northern Gas Networks - Biomethane: a producer's handbook (July, 2020)
- Northern Gas Networks - Green Gas Guide (August, 2023)
- Cadent Gas - Biomethane gas to grid, Customer connection guide

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Australian Standards:

- AS 2885 Series, Pipelines - Gas and liquid petroleum, Standards Australia.
- AS/NZS 3788 – Pressure equipment – In-service inspection
- AS 3814 - Industrial and commercial gas-fired appliances
- AS 4564:2020, Specification for general purpose natural gas, Standards Australia.
- AS 4645 Series, Gas distribution networks, Standards Australia.
- AS/NZS 5601 - Gas installations
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