Reminder… Working problem statement

Additional comments:
- *Advisory Board (AB) member commented on capturing 'tipping points' and timing for taking action*
- *Another AB member suggested elements of the problem statement are tested with customers to help prioritise the objectives*
- *A further AB member said how we highlight the risk and keep it front of mind is really important*

We want to explore how Jemena can be a partner to achieve consumers' and community objectives for:

1. **Safe services**
2. **Reliable and resilient services**
3. **Stable and affordable prices**
4. **A decarbonised energy supply**
5. **Through a fair return on agreed investments.**

An AB member suggested the addition of 'resilience' be included alongside 'reliable services'

Another AB member suggested 'holistic energy system' to capture the whole of energy system

AB member commented that the 'fair return on investment' should be achieved through 'agreed activities'

Another AB member spoke about 'fair and equitable treatment of risk'

Two AB members asked about who is carrying the risk and whose appetites for risk are we talking about?

A further AB member suggested including 'efficiency' somewhere in the problem statement and Jemena noted this is captured in agreed investments

An AB member commented that 'affordable' will mean something different to different customer segments

An AB member noted that 'environmental impacts and considerations' including the visual impact of decarbonisation should be included here, and Peta discussed environmental biodiversity.

An AB member commented that the 'fair return on investment' should be for both Jemena and customers

Jemena
bringing energy to life

Gas Networks 2050: Future scenarios summary report

What are the plausible scenarios for the NSW 2030 to 2050 energy system and what role does gas play in each?

Final Report

—

January 2023

It will be disruptive, this transition – It's something human civilisation has never seen before.

Dr Alan Finkel, Expert Panel Guest Speaker

Use of the Report

Inherent Limitations Disclaimer

This report has been prepared as outlined with Jemena Gas Networks in the Scope Section of the engagement letter/contract dated 16/09/2022. The services provided in connection with this engagement comprise an advisory engagement, which is not subject to assurance or other standards issued by the Australian Auditing and Assurance Standards Board and, consequently, no opinions or conclusions intended to convey assurance have been expressed.

The findings in this report are based on a qualitative study and the reported results reflect a perception of Jemena Gas Networks but only to the extend of the sample surveyed, being Jemena Gas Networks approved representative sample of stakeholders. Any projection to the wider stakeholder group is subject to the level of bias in the method of sample selection.

No warranty of completeness, accuracy or reliability is given in relation to the statements and representations made by, and the information and documentation provided by Jemena Gas Networks stakeholders consulted as part of the process.

No reliance should be placed by Jemena Gas Networks on additional oral remarks provided during the presentation, unless these are confirmed in writing by KPMG.

KPMG has indicated within this report the sources of the information provided. We have not sought to independently verify those sources unless otherwise noted within the report.

KPMG is under no obligation in any circumstance to update this report, in either oral or written form, for events occurring after the report has been issued in final form.

Notice to Third Parties Disclaimer

This report is solely for the purpose set out in the Scope Section and for Jemena Gas Networks' information and is not to be used for any purpose not contemplated in the engagement letter/contract or to be distributed to any third party without KPMG's prior written consent.

This report has been prepared at the request of Jemena Gas Networks in accordance with the terms of KPMG's engagement letter/contract dated 16/09/2022. Other than our responsibility to Jemena Gas Networks, neither KPMG nor any member or employee of KPMG undertakes responsibility arising in any way from reliance placed by a third party on this report. Any reliance placed is that party's sole responsibility.

Purpose

Development of this *Future Scenarios Summary Report* details the four plausible scenarios created to support and inform Jemena Gas Networks' future Business Plan for 2025 to 2030.

This report captures the methodology and outputs of a co-design process established to develop a series of future plausible scenarios for Jemena Gas Network (Jemena) in New South Wales (NSW). The scenarios were framed over two horizons; a mid-term horizon of 2030 and a long-term horizon of 2050. The scenarios also considered the broader energy system and then specifically outlined implications for gas networks.

This work forms part of a wider program of activities being undertaken by Jemena to inform future regulatory plans for the period of its next Business Plan 2025 to 2030. Other activities include economic modelling based on the drivers identified in these scenarios, working with an Advisory Board to consider the key issues to address in the Business Plan and detailed customer and stakeholder engagement activities in relation to those issues.

This report also includes detailed information about the role of Expert Panel members and Jemena in the development of the scenarios.

Role of KPMG

KPMG guided the Expert Panel through the development of the Gas Networks 2050 scenarios, leveraging deep energy industry and climate transition experience.

KPMG was engaged by Jemena to support and facilitate the co-design scenario planning series. KPMG's role, as an independent facilitator, was to provide material and information for Panellist consideration, and to cultivate a space for the Expert Panel to share their views openly.

KPMG was responsible for the collection, collation and documentation of outputs captured throughout the co-design sessions, to ensure all input was reflected in this *Future Scenarios Summary Report*.

In addition to the four Expert Panel sessions, KPMG facilitated one additional 'catch-up' session with a Panel member, and consulted separately with Jemena's economic modelling team to ensure information captured in the scenario planning sessions would effectively feed into the modelling section of the Gas Networks 2050 program.

KPMG's role did not include:

- Influencing Panellist views.
- Assuming decision-making responsibility in relation to core components of the scenario design (e.g., axes).
- Undertaking economic modelling on behalf of Jemena.
- Expressing an opinion on the relative likelihood of the scenarios.
- Advocating for or acting on behalf of Jemena.
- Providing advice on regulatory matters.
- Developing or presenting workshop materials relating to Jemena's Revenue Proposal.
- Expressing an opinion on or conducting an independent review of Jemena's actions.
- Fulfilling the role of preparing an independent consumer report as defined in *Section 3.4.2 Independent consumer support for the proposal* of the AER's Better Resets Handbook.
- Assuming decision-making responsibility on behalf of Jemena.

Contents

Executive Summary

Over the next 30 years to 2050, the Australian and NSW energy systems will undergo substantial transformation, with the ultimate mix of energy resources, technologies and services being currently unclear.

The energy system is operating in a period of fundamental change and uncertainty, with Australia's commitment to decarbonisation creating the need for a rapid transformation of how energy is produced, distributed and used. Simply put, energy is transitioning from a centralised, fossil-fuel based system to a decentralised, renewables-based system, with the objective of meeting net zero by 2050 and interim targets of 43% reductions in emissions by 2030.

The increasing speed with which this transformation is occurring will have a direct impact on gas networks and their plans. Governments' decarbonisation policies, improvements in energy efficiency, constrained supply, volatile wholesale gas prices, and growing competition from renewable electricity are all placing pressure on gas' role in the energy mix. There is a risk that demand for gas networks may decline through either changing consumer behaviours or as a direct result of government policy, which leads to gas networks becoming stranded with potential implications for customers who remain dependent on gas.

Gas networks have the potential to mitigate some of the risks associated with the transition of the energy system to a distributed, renewables based system, particularly through the provision of safe, affordable, reliable, and cost-effective natural gas or blended renewable gas to residential, commercial and industrial customers. Notably, renewable gas has the potential to provide a pathway to reducing the carbon footprint of gas networks which may support broader decarbonisation objectives.

In response to this uncertainty, Jemena developed this Gas Networks 2050 scenario planning exercise to identify and understand plausible scenarios for the future NSW energy system. These scenarios make a contribution to knowledge in the energy sector by tailoring the scenarios to the role of gas networks in the NSW energy system, including understanding the characteristics and usage patterns of the NSW customer base. Notably, the scenarios highlight foreseeable or plausible scenarios for the gas network in the 2050 time horizon, and also more immediately in 2030.

Jemena selected and engaged an Expert Panel of seven independent, energy industry leaders with technical and commercial expertise to co-design four plausible scenarios outlining the future energy system and the role of gas between the chosen time horizons. The Panellists have backgrounds and experience ranging across industry development, policy, market advocacy, network operations and energy research. The scenario planning of the Gas Networks 2050 program leveraged this extensive industry knowledge across four sessions to create four alternative scenarios for the energy system, and the role that Jemena could play within each scenario.

The scenarios developed by the Expert Panel were distinguished by axes based on the potential uptake and penetration of renewable gases, and alternatively the extent of government-directed or market-led progress to decarbonisation. These axes were selected by the Panellists, as they highlighted for Jemena's NSW gas network key issues of great uncertainty, high impact and low levels of control.

In that context, the scenarios produced plausible futures with high and low levels of renewable gas development and uptake, and high and low levels of government policy intervention. The scenarios are listed below and are summarised on the following page.

1. **Electric Hare,** where decarbonisation is supported by strong government policy driving electrification across industry and residential customers, with limited use of green fuels for hard to abate sectors.
2. **Big Hydrogen,** where government policy support underpins a hydrogen export economy with a renewable gas target and certification, subsidies, and tax-offsets, driving down the cost of hydrogen production.
3. **Electric Tortoise,** where residential customers slowly electrify and industrial users transition to biomethane, as hydrogen remains not commercially viable. Transition is market-led and is less centrally coordinated.
4. **Market Hydrogen,** where a near-term technological breakthrough driven by the market results in renewable gases becoming competitive with electrification, creating a diverse energy mix.

Jemena intends to undertake economic modelling on each plausible scenario to illustrate the variety of possible future outcomes for gas, and the required investment decisions that may be needed of Jemena ahead of the 2025-2030 NSW regulatory period. This modelling will be used to highlight 'no regrets' actions and short-term pathways that may be available as the Australian energy system moves towards net zero by 2050.

This report describes the method for developing the scenarios, biographical details of the Expert Panellists, the scenario outcomes, and the key assumptions and drivers that will be modelled as an outturn of this scenario work.

Executive Summary (cont.)

War-time effort, with ambitious policies for net zero and rapid decarbonisation, supported by customers

Scenario 1: Electric Hare

In strong commitment to achieving net zero, Governments take proactive steps to reduce emissions through highly coordinated measures supporting electrification.

Community concern with the impact of the environmental and health impacts of gas, shapes everyday decisions of many households and small businesses who heavily invest in electrification.

Investments in the development and proliferation of hydrogen and other alternative renewable fuels do not yield significant results and they remain cost prohibitive, while commercial and technology breakthroughs overcome the deliverability challenges of mass electrification. New generation infrastructure and distributed electrification drives electricity prices up until Governments intervene with price caps and direct subsides.

Shareholder pressure leads industrial customers to combine electrification and renewable fuels to decarbonise their high heat and hard to abate processes.

A moratorium on new gas connections prevents expansion and leads to network pruning, and by 2050, networks have a limited role servicing a niche small industrial customer base.

Scenario 2: Big Hydrogen

Strong government policy support, with renewable fuel certifications, subsidies and tax offsets, drives down the cost of hydrogen production and leads to a hydrogen export economy in NSW.

Community and shareholder support for net zero leads to significant decline in gas consumption on non-blended networks. Biomethane bridges the gap until significant technology breakthroughs in electrolysis improve the economic viability of hydrogen production. Hydrogen and other renewable gases are deployed to decarbonise industrial customers for both medium and high heat processes.

Many residential customers electrify, but a subset prefer the amenity provided by gas in residential applications, and are willing to pay a premium for hydrogen and renewable gas blends. Synthetic methane has potential as an alternative hydrogen product, mitigating the need for residential appliance replacement, despite low lifecycle efficiency.

The pace of decarbonisation is rapid. Throughout 2030, networks scale up hydrogen projects, and as 2050 approaches, gas networks see a resurgence in their customer base and are responsible for providing hydrogen and renewable gas blends throughout the market.

Biomethane focus limited to hard to abate / gas-dependent users and Hydrogen is a niche product.

Renewable gas penetration

Biomethane is a stepping stone to the Hydrogen mass market.

Market led vs Government led

Scenario 3: Electric Tortoise

This scenario relies on market-led incentives and pressures to transition the sector. The community prioritises affordability and are generally unwilling to pay for the rewiring or building remediation associated with electrification, nor a price premium for renewable fuels.

The market push to electrify has deliverability challenges, as the resources required to build key infrastructure at scale are in high demand across the globe. In contrast to Electric Hare, with less direct government funding or investment to bridge the gap between the decarbonisation ambition and the deliverability of the infrastructure build required, the transition to net zero is slower. The lack of progress in closing the commercial and technical gaps in hydrogen become a significant barrier to adoption. Industrial customers are unable to electrify and seek to decarbonise with biomethane, with the majority of these renewable fuels produced onsite and remotely for injection into gas networks.

Residential customers gradually electrify, while others remain connected to gas, as they experience affordability or infrastructure barriers to transition, negatively impacting the most vulnerable groups.

The role of gas networks remains significant throughout the 2030s, with the gas networks distributing biomethane to industrial users, however, as 2050 approaches, electrification erodes gas network scale and with rising costs and further disconnections, the network becomes stranded.

Scenario 4: Market Hydrogen

The path to decarbonisation is forged by market incentives and pressures, and while less coordinated, it achieves net zero through a diverse yet fragmented energy mix of electricity, natural gas (with CCUS), biomethane, and hydrogen, each being used in their optimal use cases and supported by investments in new technologies.

CCUS and biomethane initially support decarbonisation while hydrogen becomes scalable and viable through technological breakthroughs. Hydrogen is increasingly used by domestic industrial customers.

Residential customers are cost driven and over time as electrification costs decline (including rewiring and building remediation), electrification is ultimately cheaper for consumers. Those who prefer the amenity of gas for residential applications eventually have their needs met as the market invests in tailored renewable fuel technologies for residential applications (e.g., bottled biomethane for cooking) for those willing to pay the premium.

The pace of decarbonisation is relatively slower than Big Hydrogen; in 2030 gas networks scale up hydrogen projects with expansion into 10% hydrogen blending, so that in 2050 the gas networks have a small but meaningful role in industrial and commercial regions.

Policy is outcomes-based and low intervention, with a focus on economic affordability. Decarbonisation is driven by the market.

Figure 1 Expert Panel scenario summaries

Method and Approach

Scope and Objectives of the Project

The scope of work and objective of the Expert Panel series for the Gas Networks 2050 program was to:

1. Facilitate four sessions to support Panellists to co-design four plausible scenarios centred on the role of gas in the NSW future energy system.
2. Ensure developed scenarios were defined by a qualitative description, including key assumptions, and enablers and preconditions, with consideration given to the likelihood of each.
3. Make sure scenarios are not predictions or preferences for the gas future and instead inform strategy development for the upcoming regulatory proposal and 2025-2030 Business Plan.
4. Synthesise scenarios, insights, and approach and methodology into a final outcome report to be published on Jemena's website.

The purpose of the outputs within this report are to provide Jemena with the detailed scenario narratives and drivers, outline the nuance of the process Panellists took to create the outputs, and an overview of the co-design process across the four sessions.

Engagement Approach and Principles

Jemena leveraged a co-design methodology for this series and allowed the Panellists to share their depth of experience and expertise to ensure all scenarios adequately considered the contextual energy environment across political and regulatory, economic, technological, and environmental drivers.

Jemena has Gas Networks 2050 engagement principles which are tailored towards issues that matter most to their customers, informed by the International Association for Public Participation (IAP2) spectrum – Adaptive, Purposeful, Authentic, Collaborative, Inclusive, Measurable, and Transparent

To complement Jemena's Gas Networks 2050 engagement principles, the following Expert Panel engagement principles (see Figure 2 below) were introduced at the start of this process during the pre-briefings with the Expert Panellists, and underpinned the development of the four plausible scenarios.

Figure 2 Expert Panel engagement principles

Method and Approach (cont.)

Expert Panellists

The Expert Panel was comprised of seven individuals from across the energy industry

Jemena selected and engaged an Expert Panel of seven independent, energy industry leaders with technical and commercial expertise to co-design four plausible scenarios outlining the future energy system and the role of gas between the chosen time horizons. Panellists selected had backgrounds and experience across industry development, policy, market advocacy, network operations and energy research.

Table 1 Expert Panellist profiles

Expert Panellist		Experience and Profile
Andrew Lewis	Executive Director Energy, NSW Treasury - Office of Energy and Climate Change	Andrew Lewis has almost 20 years' experience working in and around energy in a variety of roles, and brings perspectives from his time at government agencies, ministerial offices, an energy peak body and energy market participants. Andrew has held senior executive positions with a strong focus on developing and implementing strategies and programs for energy market reforms, policy and regulatory analysis and development, consumer protection and support, stakeholder engagement and technical regulation.
Brian Spak	Director, Energy System Transition Energy Consumers Australia	Brian Spak is leading the transition to a clean, reliable, safe, abundant, and affordable energy system by advocating for market, regulatory, and policy changes on behalf of Australia's residential customers and small-businesses. Brian formerly led grid and renewable energy integration research at CSIRO, Australia's national science agency, was a utility insider at Portland General Electric (the greenest investor-owned utility in the US), and clean energy lobbyist and corporate sustainability pro at Green Strategies.
Matthew Clemow	Group Manager Gas Markets and System Operations, Australian Energy Market Operator (AEMO)	Matthew Clemow has been at AEMO for over nine years. During this time, he has been responsible for the operation of the Victorian Gas Transmission System, the AEMO wholesale gas markets, including Victorian Declared Wholesale Gas Market and the Short Term Trading Markets, the Gas Supply Guarantee process for monitoring gas supplies for power generation in the National Electricity Market, and the publication of the Victorian Gas Planning Report.
Matthew Warren	Director, Boardroom Energy	Matthew Warren, former Chief Executive of the Australian Energy Council, has a track record of 25 years working inside Australia's energy and environmental policy debates. He is author of the Walkley nominated book, 'Blackout – How is Australia running out of energy?'. A professional journalist and economist, he is a regular contributor on energy policy and climate change for the Australian Financial Review, and was the environment writer for The Australian. He's currently Principal of Boardroom Energy and Director of ENPEC Pty Ltd.

Method and Approach (cont.)

Expert Panellists (cont.)

Table 1 Expert Panellist profiles (cont.)

Expert Panellist		Experience and Profile
Dr Patrick Hartley	Leader of CSIRO Hydrogen Industry Mission	Dr. Patrick Hartley is responsible for the strategic and operational leadership of a major new national research initiative launched in May 2021, and is focused on delivering research, development and demonstrations, which enable the scaleup of Australia's domestic and export hydrogen industries. In 2018, he established CSIRO's Hydrogen Energy Systems Future Science Platform. This major initiative focuses on addressing research challenges which underpin the development of hydrogen energy value chains in Australia.
Shahana McKenzie	Chief Executive Officer Bioenergy Australia	Shahana McKenzie has a strong track record of driving public, government and consumer campaigns for the non-profit sector over the last 20 years. She is committed to driving growth in the Bioenergy sector and advocating for it as a key renewable energy solution for the future. Since joining, Shahana has led the renewal of the organisation and leading Bioenergy Australia's contribution on matters such as climate science, jobs creation, regional development, and energy supply, to ensure national benefits for the next decade and beyond.
Shaun Reardon	Executive General Manager Jemena Networks	Shaun Reardon is responsible for the oversight of Jemena's Gas and Electricity Distribution Businesses. This includes responsibility for strategy, commercial, regulation, customer services, asset management, and network operations. Shaun has over 25 years' experience in the energy industry, having held management positions in marketing, regulatory, management, strategy and commercial. Shaun holds a Masters of Marketing, a PhD in Mechanical Engineering and is a Graduate member of the Australian Institute of Company Directors.

Method and Approach (cont.)

Workshop Design and Approach

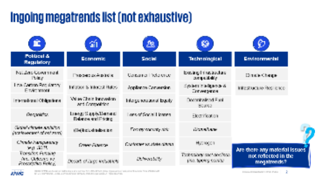
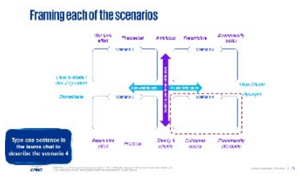
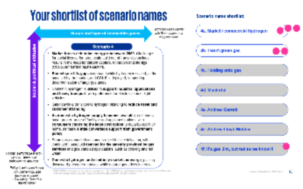
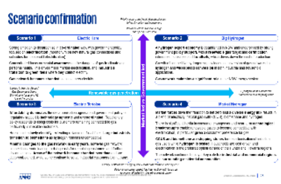
Online sessions implemented a variety of engagement techniques to develop plausible scenarios for the future of gas in NSW.

Four, three-hour sessions were held. Each session was tailored to generate deep discussion between Expert Panellists to iteratively create and define the four scenarios, and highlight similarities and points of divergence of outcomes for the future of gas broadly and for Jemena.

The Expert Panel sessions were conducted using Microsoft Teams, and included the use of online digital tools, including Mentimeter and Mural, to engage the Panellists and foster online collaboration.

Table 2 below summarises the objectives and outputs from each session. Activities throughout each of the sessions were designed to allow all Panellists to have equal input into the co-design process to create the four plausible scenarios.

Table 2 Expert Panel series overview

Session	Objective	Output
Session 1: Introductions, Scenario Purpose & Drivers	• Facilitate stakeholder introductions and align on scope, project objectives, and establish guiding principles • Outline the process and purpose of plausible scenario development • Guest speaker presentation on energy system trends from Dr Alan Finkel • Shortlist of potential scenario drivers	
Session 2: Scenario Framing	• Select final driver combination • Start to develop high-level scenario narratives for scenarios and possible names for each • Discuss fixed and variable assumptions across the scenarios	
Session 3: Scenario Detailing & Enablers	• Shortlist potential scenario names • Relative scaling of each scenario • Generate assumptions and economic rationale relevant to Jemena's model for each scenario • Articulate the trajectory of scenarios across 2030 and 2050 time horizons	
Session 4: Agree Scenarios & Review	• Review and finalise scenario narratives in detail, including internal consistency • Review assumptions and economic rationale • Finalise the name for each scenario • Consider relative likelihood of each scenario	

Method and Approach (cont.)

Workshop Design and Approach (cont.)

These scenarios developed through this process make a contribution to knowledge in the energy sector by tailoring the scenarios to the role of gas networks in the NSW energy system, including understanding the characteristics and usage patterns of the NSW customer base. Notably, the scenarios highlight foreseeable or plausible scenarios for the gas network across two time horizons, being the long-term view to 2050, and also more immediately in 2030.

Plausible Scenario Methodology

Plausible scenarios are realistic, plausible, and consistent bold narrative descriptions of situations in the future, based on a selection of key future factors and their related interdependencies.

Creating plausible scenarios was a fundamental requirement for the Gas Networks 2050 program and Jemena's 2025-2030 Business Plan. Plausible scenarios are defined as outcomes that could plausibly occur based on current knowledge and trends and must be credible, internally logical, challenging and relevant to the issue at hand. Plausible scenarios should also be summarised in a narrative that outlines the divergent pathways and future, as shown in Figure 3 below.

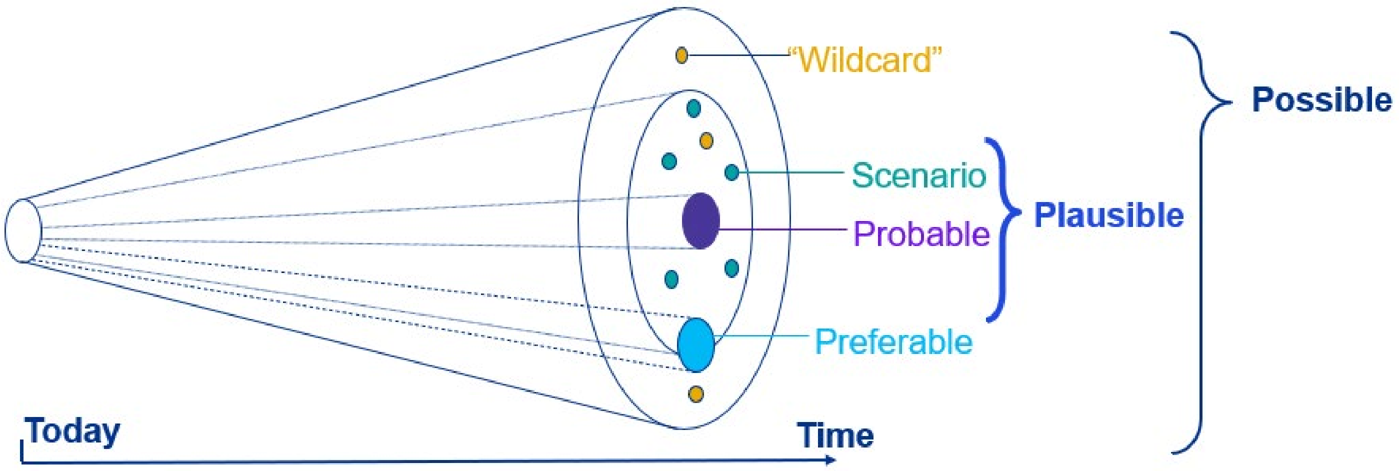


Figure 3 Approach to creating plausible scenarios

- **Possible**, that is, it 'might' happen, basically future knowledge
- **Plausible**, something that 'could' happen, and is based on current knowledge
- **Probable**, something that is 'likely' to happen, that is current trends
- **Preferable**, something that we 'want' to happen, and is the result of value judgements

Scenario Outcomes

Co-Designed Scenarios

The extent that decarbonisation is government led or driven by the market, and the penetration of renewable gas, characterised and framed the four scenarios

The four plausible scenarios were developed to represent a range of potential outcomes for gas and gas distribution networks, and were distinguished by axes based on the potential uptake and penetration of renewable gases, and alternatively the extent of government-directed or market-led progress to decarbonisation. These axes were selected by the Panellists, as they highlighted for Jemena's NSW gas network key issues of great uncertainty, high impact and low levels of control.

The scenarios, which explore high and low levels of renewable gas development and uptake, and high and low levels of government policy intervention, are:

1. **Electric Hare,** where decarbonisation is supported by strong government policy driving electrification across industry and residential customers, with limited use of renewable fuels for hard to abate sectors.
2. **Big Hydrogen,** where government policy support underpins a hydrogen export economy with a renewable gas target and certification, subsidies, and tax-offsets, driving down the cost of hydrogen production.
3. **Electric Tortoise,** where residential customers slowly electrify and industrial users transition to biomethane, as hydrogen remains not commercially viable. Transition is driven by business and community investment.
4. **Market Hydrogen,** where a near-term technological breakthrough driven by the market results in renewable gases becoming competitive with electrification, creating a diverse but fragmented energy mix.

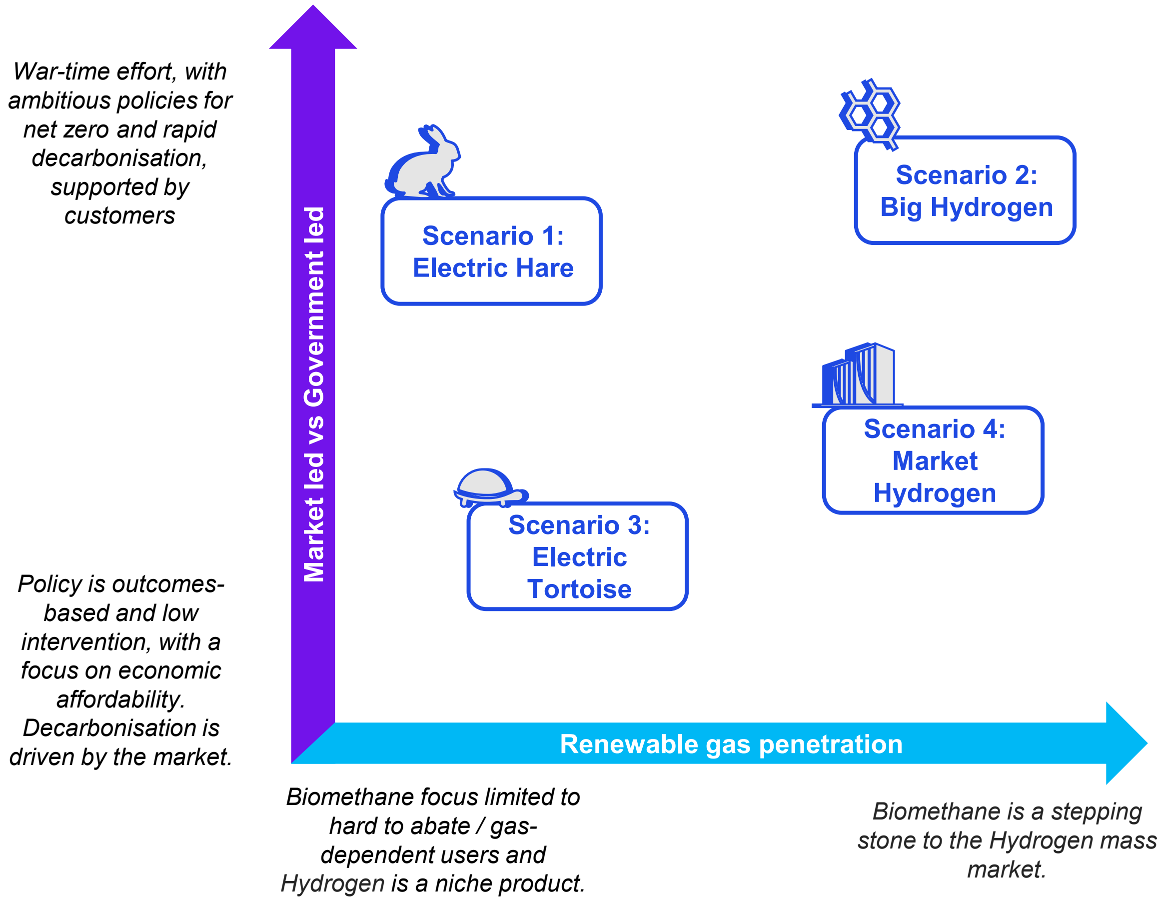


Figure 4 Relative placement of each scenario across Market Led vs Government Led and Renewable Gas Penetration drivers

Scenario Summaries

Scenario 1: Electric Hare

In strong commitment to achieving net zero, Governments take proactive steps to reduce emissions through highly coordinated measures supporting electrification. Community concern with the impact of the environmental and health impacts of gas, shapes everyday decisions of many households and small businesses who heavily invest in electrification. Investments in the development and proliferation of hydrogen and other alternative renewable fuels do not yield significant results and they remain cost prohibitive, while commercial and technology breakthroughs overcome the deliverability challenges of mass electrification. New generation infrastructure and distributed electrification drives electricity prices up until Governments intervene with price caps and direct subsides. Shareholder pressure leads industrial customers to combine electrification and renewable fuels to decarbonise their high heat and hard to abate processes. A moratorium on new gas connections prevents expansion and leads to network pruning, and by 2050, networks have a limited role servicing a niche small industrial customer base.

Scenario 2: Big Hydrogen

Strong government policy support, with renewable fuel certifications, subsidies and tax offsets, drives down the cost of hydrogen production and leads to a hydrogen export economy in NSW. Community and shareholder support for net zero leads to significant decline in gas consumption on non-blended networks. Biomethane bridges the gap until significant technology breakthroughs in electrolysis improve the economic viability of hydrogen production. Hydrogen and other renewable gases are deployed to decarbonise industrial customers for both medium and high heat processes. Many residential customers electrify, but a subset prefer the amenity provided by gas in residential applications, and are willing to pay a premium for hydrogen and renewable gas blends. Synthetic methane has potential as an alternative hydrogen product, mitigating the need for residential appliance replacement, despite low lifecycle efficiency. The pace of decarbonisation is rapid. Throughout 2030, networks scale up hydrogen projects, and as 2050 approaches, gas networks see a resurgence in their customer base and are responsible for providing hydrogen and renewable gas blends throughout the market.

Scenario 3: Electric Tortoise

This scenario relies on market-led incentives and pressures to transition the sector. The community prioritises affordability and are generally unwilling to pay for the rewiring or building remediation associated with electrification, nor a price premium for renewable fuels. The market push to electrify has deliverability challenges, as the resources required to build key infrastructure at scale are in high demand across the globe. In contrast to Electric Hare, with less direct government funding or investment to bridge the gap between the decarbonisation ambition and the deliverability of the infrastructure build required, the transition to net zero is slower. The lack of progress in closing the commercial and technical gaps in hydrogen become a significant barrier to adoption. Industrial customers are unable to electrify and seek to decarbonise with biomethane, with the majority of these renewable fuels produced onsite and remotely for injection into gas networks. Residential customers gradually electrify, while others remain connected to gas, as they experience affordability or infrastructure barriers to transition, negatively impacting the most vulnerable groups. The role of gas networks remains significant throughout the 2030s, with the gas networks distributing biomethane to industrial users, however, as 2050 approaches, electrification erodes gas network scale and with rising costs and further disconnections, the network becomes stranded.

Scenario 4: Market Hydrogen

The path to decarbonisation is forged by market incentives and pressures, and while less coordinated, it achieves net zero through a diverse yet fragmented energy mix of electricity, natural gas (with CCUS), biomethane, and hydrogen, each being used in their optimal use cases and supported by investments in new technologies. CCUS and biomethane initially support decarbonisation while hydrogen becomes scalable and viable through technological breakthroughs. Hydrogen is increasingly used by domestic industrial customers. Residential customers are cost driven and over time as electrification costs decline (including rewiring and building remediation), electrification is ultimately cheaper for consumers. Those who prefer the amenity of gas for residential applications eventually have their needs met as the market invests in tailored renewable fuel technologies for residential applications (e.g., bottled biomethane for cooking) for those willing to pay the premium. The pace of decarbonisation is relatively slower than Big Hydrogen; in 2030 gas networks scale up hydrogen projects with expansion into 10% hydrogen blending, so that in 2050 the gas networks have a small but meaningful role in industrial and commercial regions.

Scenario Narratives

Scenario 1: Electric Hare

Axes	Market led vs Government led:	Renewable gas penetration:
	War-time effort, with ambitious policies for net zero and rapid decarbonisation, supported by customers	*Biomethane focus limited to hard to abate / gas-dependent users and Hydrogen is a niche product.*

The *Electric Hare* scenario is characterised by a strong commitment to achieving net zero by governments and communities. Governments take proactive steps to ensure emissions reductions across the economy through **highly coordinated measures supporting electrification.** Interventions include moratoriums on new gas connections and usage, while both households and industrial users are subsidised for the switch to electrification. To achieve these outcomes the government shifts from the traditional market-led approach to a central planning approach actively coordinating investors and participants to ensure emissions targets are met.

Political capital driving this change originates from growing community support and commitment to decarbonisation and sustained higher prices for gas due to international market pressures. The community is particularly concerned with environmental and health impacts of gas. These concerns shape the everyday decisions of individuals in their choice for home appliances as well as their choices on where they invest their personal savings. **Residential and small business customers heavily invest in electrification**, including the installation of distributed solar and battery systems. Barriers around solar and storage on communal buildings such as apartment blocks are solved. Electric Vehicles (EVs) are commonplace with most public spaces supporting charging infrastructure; and efforts are placed into optimising the charging and discharging of batteries and EVs to support greater grid flexibility.

Investments in the development and proliferation of hydrogen and other alternative renewable fuels do not result in breakthroughs that sufficiently improve the technical or cost-competitiveness of hydrogen. The fuels remain largely cost prohibitive and as such adoption across industry is limited to hard-to-abate commercial processes. The high cost means there is a lack of justification to upgrade the elements of the gas network required to enable hydrogen use in households. In contrast, commercial and technology breakthroughs overcome the 'deliverability' challenges of mass electrification, including resourcing challenges of building out infrastructure and flow on impacts to evening peak electricity demand.

The transition and rapid acceleration of electrification is not costless as net zero is prioritised over affordability and energy security. The cost of delivering new generation infrastructure and distributed electrification results in significant increases in residential electricity prices during the late 2020s, as Australia must compete in the global market for the required skilled resources, funding and materials. The deliverability gap results in a significant costs and by 2030, governments are pressured into intervening to minimise the impact through tougher price caps and direct subsides to electricity consumers. These costly subsidies eventually result in reduce electricity prices in the medium term. In the longer term, low marginal cost renewable electricity replaces the need for subsidies and price caps.

Despite the initial high cost of electricity, shareholder pressure to decarbonise means that **industrial customers** seek a combination of electrification coupled with renewable fuels for high heat and hard to abate processes, which are produced on-site or in local hubs, potentially creating closed circular economies. Some **commercial customers** may no longer be financially viable, as the capital intensity of facility upgrades for decarbonisation proves costly.

In this scenario, the rapid pace of decarbonisation results in a varied role for networks over time. In the period through to 2030, gas networks still maintain a central role across the economy as electrification is scaled. However, the impact of a government moratorium on new connections prevents expansion of the distribution network, leading to proactive network pruning, with eventual proactive plans for closure. By 2050, **gas networks have a very limited role** servicing a niche small industrial customer base, which increasingly becomes economically unviable.

Key attributes of Electric Hare

Government	Social	Technology	Economics	Customers	Decarbonisation
Strong electrification policies	Community committed to decarbonisation	Slow technology development for H2 & biomethane	High energy prices leads to intervention	Rapid adoption of electrification	Rapid decarbonisation

Scenario Narratives (cont.)

Scenario 2: Big Hydrogen

Axes		
Axes	**Market led vs Government led:** *War-time effort, with ambitious policies for net zero and rapid decarbonisation, supported by customers*	**Renewable gas penetration:** *Biomethane is a stepping stone to the Hydrogen mass market.*

The *Big Hydrogen* scenario is characterised by **strong government policy supporting decarbonisation**, with a particular emphasis on renewable gas targets and the introduction of renewable fuel certifications. In combination with a broad set of subsidies and tax offsets, these policies meaningfully drive down the cost of hydrogen and biomethane production. The policy environment sets the conditions for the hydrogen industry to thrive. Rapid shifts in both global and domestic demand for renewable fuels compound this growth, leading to a highly competitive domestic industry and a new export economy in NSW. Hydrogen blending across gas networks becomes increasingly common in the 2030s and, in the longer term, certain distribution networks shift to full hydrogen or renewable fuels. To support the significant increase in demand for fuels like hydrogen, the Government also supports the construction and connection of large quantities of renewables required to produce renewable hydrogen.

Strong community and shareholder support for achieving net zero targets provide the context for **changes in consumer preferences**. Concerns about the environmental impact of natural gas leads to significant decline in gas consumption on non-blended networks. While there is a subset of households that continue to use natural gas to support their preferences for gas-powered cooking and hot water, significant groups of customers are willing to pay a premium for renewable hydrogen in homes.

In the period through to 2030, electrification is the key driver of decarbonisation across the economy. While electrification continues to play a role beyond 2030, this role is lessened relative to Electric Hare as significant technology break throughs in electrolysis improve the economic viability of hydrogen production. These break throughs take the form of reduction in electrolyser production costs, process efficiencies and access to lower cost electricity. These cost reductions improve Australia’s export competitiveness for renewable hydrogen, including ammonia, compared to other international players.

Over the same time period, supply chain improvements for biomethane and renewable gas production improve the uptake of renewable gas across the economy. New **certification for biomethane** supports growing corporate demand for biomethane in the medium term, while specific niche customers continue to use biomethane in the longer term where hydrogen is not a viable option. While synthetic methane has potential as an alternative hydrogen product, mitigating the need for residential appliance replacement, it has low lifecycle efficiency.

Industrial customers use hydrogen and other renewable gases to decarbonise both medium and high heat processes**,** providing relief to those who could not decarbonise through electrification or found the capital intensity of facility upgrades for renewable fuels costly.

The **pace of decarbonisation is rapid** in this scenario and **gas networks maintain a significant role** beyond 2050. Throughout 2030, networks continue on their current trajectory, impacted slightly by electrification, but scaling up their hydrogen capabilities with expansion into 10% hydrogen blending. As 2050 approaches, gas networks see a resurgence in their customer base and are responsible for providing hydrogen and renewable gas blends throughout the market.

Key attributes of Big Hydrogen

Government	Social	Technology	Economics	Customers	Decarbonisation
Strong renewable fuel policies	Community committed to decarbonisation	Rapid technology development for H2 & biomethane	High costs initially, but rapidly fall	Some pay premium for renewable gas amenity	Rapid decarbonisation

Scenario Narratives (cont.)

Scenario 3: Electric Tortoise

Axes	Market led vs Government led:	Renewable gas penetration:
	Policy is outcomes-based and low intervention, with a focus on economic affordability. Decarbonisation is driven by the market.	*Biomethane focus limited to hard to abate / gas-dependent users and Hydrogen is a niche product.*

The *Electric Tortoise* scenario is characterised by lower levels of direct intervention from governments, relying instead on policy that prioritises **market-led incentives and pressures** to transition the sector. This results in a more fragmented decarbonisation approach, with a focus on businesses and communities each making investment decisions that collectively move the energy system to net zero.

In this scenario, the **community prioritises affordability** alongside or ahead of decarbonisation and are unwilling to pay a premium for renewable gases. Renewable gas blends are limited to trials and standalone systems supported by corporate efforts to decarbonise. The limited demand for these fuels results in lower levels of investment directed into research, development and commercialisation of these technologies. In turn, the **lack of technology investment** and capability uplift in hydrogen results in significant cost barriers further limiting its adoption. As such, the market naturally gravitates towards electrification and increasing renewable electricity penetration, which has an established trajectory to commercial adoption. However, the market push to electrify also has deliverability challenges, as the resources required to build key infrastructure at scale are in high demand across the globe. The impact of the mass move to electrify the energy volumes of both gas and transport is technically complex, substantial and expensive. In contrast to Electric Hare, with less direct government funding or investment to bridge the gap between the decarbonisation ambition and the deliverability of the infrastructure build required, the transition to net zero is comparatively slower.

For large, **industrial customers** and hard to abate sectors, electrification cannot supply the amount of energy needed for both medium and high heat processes. Where these customers seek to decarbonise, they choose biomethane as a natural gas substitute. The majority of these renewable fuels are produced onsite and remotely for injection into gas networks. In the long term, certain industrial users deploy CCUS to reduce their onsite scope 1 emissions (E.g., emissions produced from manufacturing processes). Internationally, some governments have invested deeply in hydrogen technology, establishing their competitive advantage in export markets. While there are some transfers of knowledge and technology in the medium term, the domestic hydrogen production remains largely cost prohibitive, and demand is limited to industrial users with decarbonisation commitments and where biomethane is not an option.

Where possible, **residential customers** select the cheapest option to decarbonise and electrify gradually, typically only when required as appliances reach end-of-life, rather than proactively. For example, EV uptake is driven by consumer preference and manufacturer decisions to phase out internal combustion engines internationally. Some residential customers are unable to transition due to affordability barriers of converting appliances or a lack of infrastructure and storage (e.g. communal buildings such as apartment blocks). This ultimately extends reliance on fossil fuels, despite societal environmental concerns as energy costs continues to increase. **Inequity grows** between customer cohorts, with gas network costs spread among a smaller remaining customer base, disproportionately affecting the most vulnerable groups who remain connected to gas. **Government policy** is driven to a reactionary response to rising energy prices in the 2030s, but falls short of providing regulatory intervention on high conversion costs.

In this scenario, the **pace of decarbonisation is comparatively slower,** with the role of gas networks remaining significant throughout 2030, as residential customers extend their reliance on natural gas for the life of existing gas appliances. As the role of the gas network narrows over time to primarily distributing biomethane to industrial users, the increasing customer attrition and lack of network expansion means that biomethane becomes unprofitable. By 2050, the trajectory for electrification has eroded network scale, and with eroding assets, rising costs and further disconnections, **the network and remaining customers become stranded over time.**

Key attributes of Electric Tortoise

Government	Social	Technology	Economics	Customers	Decarbonisation
Policies reactive to price shocks	Community focus on affordability	Slow technology development for H2 & biomethane	High energy prices leads to intervention	Slow to convert	Slow decarbonisation

Scenario Narratives (cont.)

Scenario 4: Market Hydrogen

Axes		
	Market led vs Government led: *Policy is outcomes-based and low intervention, with a focus on economic affordability. Decarbonisation is driven by the market.*	**Renewable gas penetration:** *Biomethane is a stepping stone to the Hydrogen mass market.*

In the *Market Hydrogen* scenario, the path to decarbonisation is forged by **market forces**, underpinned by outcome based policies based largely on incentives and price signals, rather than direct government interventions. While the resulting transition is less coordinated and more likely to be disorderly, net zero is achieved through a **diverse energy mix** of electricity, natural gas (with CCUS), biomethane, and hydrogen being deployed in their optimal use cases. The market drives investment into and uptake of these new technologies, as organisations seek to build their social licenses to operate in an environment where shareholders prioritise ESG commitments.

CCUS and biomethane are relied on initially to support industrial decarbonisation. Waste management and water utility businesses are the first to invest in biomethane technologies due to their access to feedstock. The growing demand for decarbonisation across the community pushes biomethane producers to reach further scale across different locations. While biomethane and CCUS plays an important role as transition fuel, there are also simultaneous breakthroughs in hydrogen technology.

For large, **industrial customers**, the proximity to supply chains drives the decisions to adopt respective technologies. Those near to hydrogen hubs opt to switch fuels to hydrogen, while those located close to biomethane supply chains tend to adopt that technology.

The majority of **residential customers** are cost driven and so appliance cutover from gas to electricity typically occurs when the changeover costs are equitable factoring for any rewiring, ventilation or building remediation works required. In this scenario, there is less likely to be direct government funding of these changeover costs. This results in **the role of gas networks declining slowly,** as users replace appliances at end of life when total cutover costs for electrification are comparable with direct gas appliance replacement.

A small number of gas-connected residential customers reject full electrification, however, as they prefer the comfort and convenience of natural gas. This trend will extend the demand for residential gas applications, particularly stovetop cooking and instant water heating. As electrification increases, the market responds to the ongoing demand for instantaneous, high heat through the introduction of new products such as bottled biomethane for cooking, which may be converted to propane and/or butane. These technologies bring **new competitors into the gas market**, but not at a level of penetration that lowers the cost for customers. Over time, bottled biomethane is likely to become increasingly cost competitive, as the customers disconnect from gas networks and the price of gas networks necessarily increase.

In this scenario, the pace of decarbonisation is slower and as part of a more fragmented energy system, in 2030 gas networks continue to service residential and commercial customers. There is a gradual scale up of hydrogen projects and some expansion into 10% hydrogen blending. Looking out to 2050, the gas network will continue to have a **small but meaningful role in supporting heavy industrials**. This role will likely be focused around industrial and commercial regions (e.g. Hunter and Illawarra regions) and surrounding residential communities.

Key attributes of Market Hydrogen

Government	Social	Technology	Economics	Customers	Decarbonisation
Policies based on incentives & price signals	Community focus on affordability	Rapid technology development for H2 & biomethane	Commercially competitive H2 market	Some pay premium for renewable gas amenity	Slow decarbonisation

Scenario Assumptions

Throughout the process of developing the scenario narratives, the Expert Panellists identified a number of fixed universal assumptions.

The following assumptions are consistent through each scenario:

- The Panellists assumed there would be no material change to the government policy of net-zero by 2050
- These plausible scenarios do not explore any change in economic growth, population growth, and household size, type and demographic structure.

Modelling and framing drivers were selected to inform Jemena's economic modelling and outline the distinction between the four scenarios.

To support the economic modelling Jemena will conduct, and ensure each scenario narrative was sufficiently different, modelling and framing drivers were captured across the four plausible scenarios, including a comparison across the two time horizons of 2030 and 2050.

Modelling drivers (page 20-21) were co-designed by KPMG and the modelling team from Jemena, and were further refined during session 4 by the Panellists. These drivers are the basis for the determination of quantitative economic assumptions that will be assigned by the Jemena modelling team as part of the Gas Networks 2050 program.

The following five categories were utilised to aggregate the modelling drivers into appropriate groups for internal and external consistency across the scenarios:

1. Economic
2. End-Use Technology (Demand)
3. Role of the Networks
4. Production Technology (Supply)
5. Policy & Regulation

The consistent use of these five categories ensured that the outputs captured were sufficiently emblematic of political, economic, and technological aspects to demonstrate the nuance across each plausible scenario.

Framing drivers (page 22) were also co-designed by KPMG and the modelling team from Jemena. These drivers are inherently qualitative in nature, and were used to highlight key characteristics and differentiate between each plausible scenario.

The following four categories were utilised to highlight qualitative aspects of the scenarios developed:

1. End-Use Technology (Demand)
2. Energy Market Competition
3. Policy and Regulation
4. Social

Scenario Assumptions – Modelling

Comparison of 2030 and 2050 scenario modelling drivers

The modelling drivers will inform the quantitative assumptions determined through the modelling part of the Gas Networks 2050 program and focuses on assumptions relating to economics, technology, and the role of the network in each scenario.

Table 3 provides the detailed list of 'Economic' and 'End-Use Technology (Demand)' modelling drivers with a comparison between 2030 and 2050. Where there is a shift in a driver between the 2030 and 2050 time horizon within a scenario, this is indicated by an underline in the 2050 assumption.

Table 3 Detailed comparison of modelling drivers - Economic and End-Use Technology (Demand)

Modelling Driver	**1. Electric Hare**		**2. Big Hydrogen**		**3. Electric Tortoise**		**4. Market Hydrogen**	
Economic	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
Wholesale domestic electricity price	Low	Low	Medium	Low	Low	Low	Medium	High
Wholesale domestic natural gas price compared to electricity price	Medium	High	Medium	High	Medium	Low	Medium	Medium
Wholesale domestic hydrogen price compared to electricity price	High	High	Medium	Medium	High	High	High	Medium
Wholesale domestic biomethane price compared to electricity price	High	High	High	Medium	Medium	Medium	High	Low
Delivered electricity price	Low	Medium	High	High	Low	Medium	Medium	High
Delivered gas price	Medium	High	Medium	Medium	High	High	Medium	Medium
End-Use Technology (Demand)	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
Natural gas demand - residential and commercial	Low	Low	Medium	Low	High	Low	Medium	Low
Natural gas demand - industrial	Low	Low	Medium	Low	High	Low	Medium	Medium
Biomethane industrial demand	Low	Low	Low	Low	Medium	High	Medium	High
Biomethane residential & commercial demand	Low	Low	Low	Low	Low	Low	Medium	High
Hydrogen export demand	Low	Low	High	High	Low	Low	Low	Medium
Hydrogen industrial demand	Low	Low	Medium	High	Low	Low	Low	Medium
Hydrogen residential & commercial demand	Low	Low	Medium	Medium	Low	Low	Low	Medium
Electricity network peak demand	High	High	High	Medium	Medium	Medium	Low	Low

Scenario Assumptions – Modelling (cont.)

Comparison of 2030 and 2050 scenario modelling drivers (cont.)

Table 4 provides the detailed list of Role of the Network and Production Technology (Supply) assumptions with a comparison between 2030 and 2050 for each driver under all scenarios. Where there is a shift in a driver between the 2030 and 2050 time horizon within a scenario, this is indicated by an underline in the 2050 assumption.

Table 4 Detailed comparison of modelling drivers - Role of the Network and Production Technology (Supply)

Modelling Driver	1. Electric Hare		2. Big Hydrogen		3. Electric Tortoise		4. Market Hydrogen	
Role of the Networks	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
Gas distribution network utilisation by NSW region - coastal	Medium	Low	High	High	High	Low	High	Medium
Gas distribution network utilisation by NSW region - country/regional	Medium	Low	High	High	High	Medium	High	Medium
Gas transmission network utilisation	Medium	Low	High	High	High	Medium	High	Medium
Production Technology (Supply)	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
Extent of renewable electricity supply (including renewables for H2 export production)	Medium	Medium	Medium	High	Low	Medium	Medium	High
Role of hydrogen in dispatchable energy supply (e.g. VPP, Peakers, Pumped Storage)	Low	Low	Medium	High	Low	Low	Low	Medium
East coast domestic natural gas production (relative to demand)	Sign. Decline	Sign. Decline	Sign. Decline	Sign. Decline	Sign. Decline	Sign. Decline	Sign. Decline	Sign. Decline
Volume of distribution connected hydrogen production	Low	Low	Low	Low	Low	Low	Low	Medium
Feedstock competition (against use in distribution networks)	Low	Low	Low	Low	Low	Low	Medium	Medium
Policy & Regulation	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
Extent of decarbonisation policy (inc. carbon price level)	High	High	High	High	Low	Low	Medium	Medium

KPMG

Scenario Assumptions – Framing

Comparison of 2030 and 2050 scenario framing drivers

Table 5 provides the detailed list of all framing drivers, with a comparison between 2030 and 2050 for each driver under all scenarios. Where there is a shift in a driver between the 2030 and 2050 time horizon within a scenario, this is indicated by an underline in the 2050 assumption.

Table 5 Detailed comparison of all framing drivers

Driver	1. Electric Hare		2. Big Hydrogen		3. Electric Tortoise		4. Market Hydrogen	
Energy Market Competition	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
Convergence of electricity and hydrogen markets / systems (prices become linked)	Low	Low	High	High	Low	Low	Medium	High
New forms of competition (e.g. micro-grids, meso competition, aggregators, retail tariffs, residential H2 production)	Medium	Medium	High	High	Low	Low	Medium	Medium
Business & consumer demand side response participation	High	High	Medium	Medium	Medium	Medium	Low	Low
End-Use Technology (Demand)	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
Fuel Cell Uptake (hydrogen)	Low	Low	High	High	Low	Low	Medium	Medium
Policy and Regulation	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
Technology specific vs agnostic policy & regulatory support (inc. subsidies for appliance conversion, renewable gas targets, reg barriers to renewable gas)	Specific	Specific	Specific	Specific	Agnostic	Agnostic	Agnostic	Agnostic
Extent of moratorium on new natural gas connections	High	High	Low	Low	Low	Low	Low	Low
Pace of decarbonisation policy & regulatory change (fast vs slow)	Fast	Fast	Fast	Fast	Slow	Slow	Slow	Slow
Social	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
Consumer preference for natural gas	Low	Low	Low	Low	Medium	Medium	Medium	Medium
Consumer preference for renewable gas blends - Hydrogen (requires appliance change)	Low	Low	High	High	Low	Low	Medium	High
Consumer preference for renewable gas blends - Biomethane (no appliance change required)	Low	Low	Low	Low	Low	Low	Medium	High
Extent of consumer technology choice (e.g. fuel, appliances)	Low	Low	Medium	Medium	Low	Low	High	High
Consumer willingness to pay a renewable premium (extent of pressure on fossil fuel social licence)	High	High	High	High	Low	Low	Medium	Medium

Scenario Relative Likelihood

A requirement of scenarios, as set out by the Australian Energy Regulator (AER), is that a view is provided in relation to the relative likelihood of a given scenario.

To meet this requirement, each Expert Panellist was invited to cast a vote on the relative likelihood of each scenario by allocating 100% across the four scenarios, based on their own qualitative assessment. *It is noted that Dr Patrick Hartley, who participated in the Expert Panel in his role at CSIRO, requested to abstain from voting.*

Based on the Panellist votes, the relative likelihood of each of the four scenarios is shown in Figure 5 below.

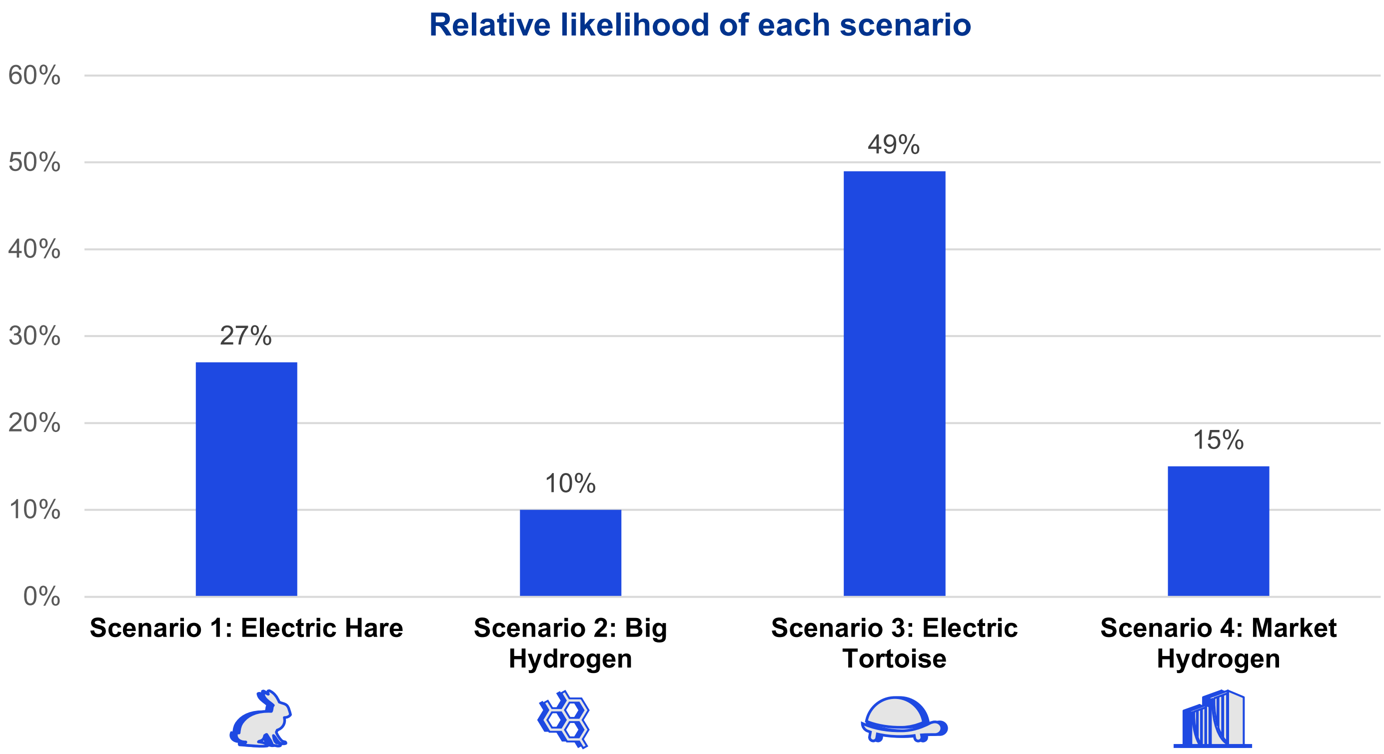


Figure 5 Relative likelihood of each scenario

Next Steps

Next Steps for the Expert Panel scenarios

Economic Modelling

Jemena intends to undertake economic modelling on each plausible scenario to illustrate the variety of possible future outcomes for gas, and the required investment decisions that may be needed of Jemena ahead of the 2025-2030 NSW regulatory period. This modelling will be used to highlight 'no regrets' actions and short-term pathways that may be available as the Australian energy system moves towards net zero by 2050.

The modelling produced will also be used as an input into the Jemena Gas Networks 2050 Advisory Board series, as a method of testing a range of potential response options to select those best suited to address both customers' and Jemena's interests.

Appendix A: Attendance Record

Expert Panellist Attendance

Table 6 Expert Panellist attendance

		Session 1	Session 2	Session 3	Session 4
Andrew Lewis	Executive Director Energy, NSW Treasury - Office of Energy and Climate Change	Attended	Attended	Attended	Attended *(partial)*
Brian Spak	Director, Energy System Transition Energy Consumers Australia	Attended	Attended	Attended	Attended
Matt Clemow	Group Manager, Gas Operations Australian Energy Market Operator (AEMO)	Attended	Attended	Attended	Attended
Matthew Warren	Director, Boardroom Energy	Attended	Attended	Attended	Attended
Dr Patrick Hartley	Leader of CSIRO Hydrogen Industry Mission	Apology	Apology	Attended	Attended
Shahana McKenzie	Chief Executive Officer, Bioenergy Australia	Attended	Attended	Apology	Attended
Shaun Reardon	Executive General Manager, Jemena Networks	Attended	Attended	Attended	Apology

Appendix A: Attendance Record (cont.)

Guest Attendance

Table 7 Expert Panel guest attendance

		Session 1	Session 2	Session 3	Session 4
Frank Tudor	Managing Director, Jemena Gas Networks	Attended	Attended	Attended	Apology
Dr Alan Finkel	Guest Speaker	Attended	N/A	N/A	N/A

Observer Attendance

Table 8 Expert Panel observer attendance

		Session 1	Session 2	Session 3	Session 4
Rob Gannon	Associate Director, Australian Energy Regulator (AER)	N/A	Attended	Attended	Attended
Mark Henley	Member, Consumer Challenge Panel (CCP)	N/A	N/A	Attended	N/A
Rosemary Sinclair	Advisory Board Chair and Member, Jemena Gas Networks 2050 Advisory Board	N/A	N/A	Attended	Attended
Natalie Thacker	Customer Advisory Board Member, Jemena Gas Networks 2050 Advisory Board	N/A	Attended	N/A	N/A

Non-Participant Attendees

In addition to the above, non-participant regular attendees were:

- Jemena engagement team and modelling team attendees
- Facilitator team, KPMG

Contacts:

Dr Matt Pearce

KPMG Partner – National Sector Lead, Power & Utilities

T: + 61 61 403 999 494
E: mpearce1@kpmg.com.au

Ben Twartz

KPMG Director –Energy & Climate Transition

T: + 61 439 313 458
E: btwartz@kpmg.com.au

KPMG.com.au

Fact Sheet

Introduction to modelling

About the Jemena Gas Networks Modelling tool

About the model

While we don't have a crystal-ball, modelling enables us to understand how actions we take today could impact our customers and our business tomorrow.

A key ingredient in modelling is scenarios. Scenarios consider different versions of the future, for example:

- one scenario may test a situation where there is wide-spread use of hydrogen in residential settings,
- while another may test a situation where hydrogen is primarily used in commercial settings.

Our model considers the impact each scenario will have on our customers and business, looking at things like customer bills, our return on investment, and other factors.

By modelling a range of scenarios we are able to understand what may or may not happen and can better prepare for the future by incorporating this into our future pricing and services model.

At the 21 February 2023 Advisory Board session we'll give panel members the opportunity to test a range of scenarios as part of a modelling exercise.

About the scenarios

What is it?

Scenarios were developed in consultation with the Expert Panel and are consistent and plausible narrative descriptions of situations in the future. They're based on a selection of key future factors and interdependencies.

What it isn't

The scenarios are not intended as predictions or projections, but are rather a guide to help us understand what may happen if a given set of circumstances were to eventuate.

About the model

What does our model consider?

It models outcomes for our customers and our business from 2025 to 2050 under each of the scenarios. Specifically, it allows comparison of customer impacts by:

- customer segment including:
  - residential – high-rise
  - residential – detached, semi-detached, medium and low density
  - commercial, and
  - industrial.
- how Jemena's response options impact different customer groups over time.
- how our response options affect the value of our asset base.
- bill scenario: the model outputs how customer bills are different for each scenario.

It can be used to assess (for a given scenario):

- whether a response action improves the desired outcome
- the time horizon for this action, and
- the impact of adopting a combination of response actions.

What can't it do?

The model doesn't look at energy security, nor demand responses. It is also a static model focusing on high-level outcomes and assumptions about infrastructure under each scenario.

What are the principles of the model?

Our principles for building the model are:

- Transparency
- Simplicity
- Robustness.

Because the Expert Panel scenarios are big-picture, we did some work to build out the detail, and the team's specific thinking is included below.

What assumptions drive the model?

The model is driven by:

- forecasts of future demand by an independent expert according to the narratives set by the Expert Panel
- our research on suitable asset management plans to facilitate the forecasted demand
- the revenue recovery mechanism and regulatory assumptions set by the Australian Energy Regulator
- research about the maximum price customers are willing to pay for gas.

We illustrate this in figure one (below).

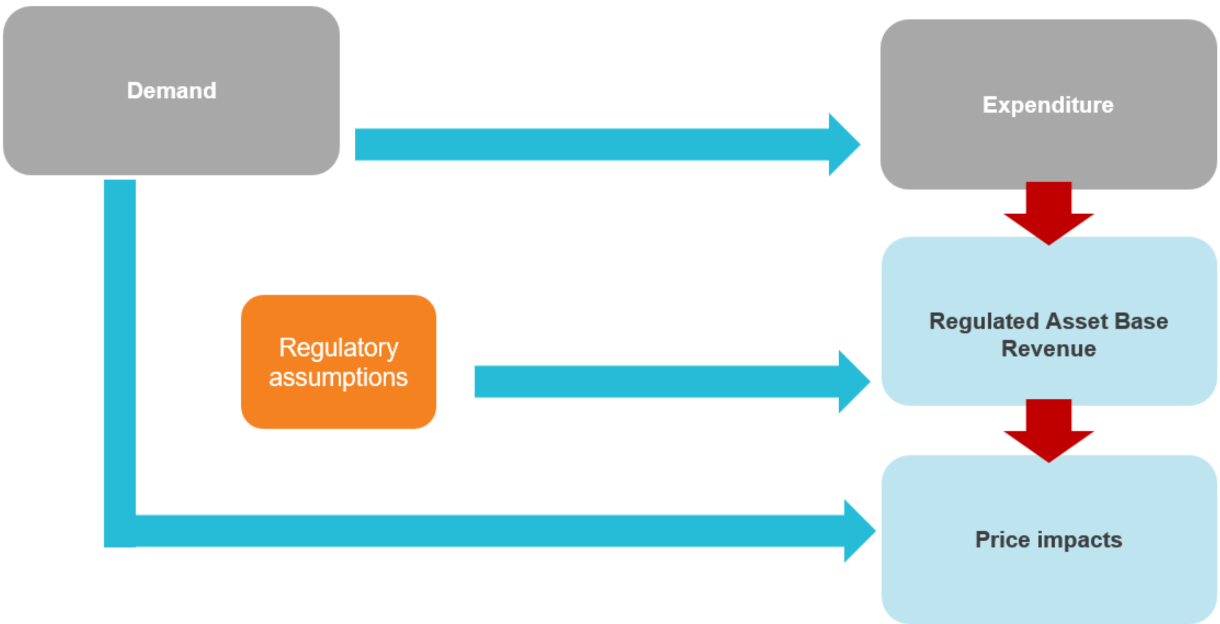


Figure 1: Assumptions driving the model

How have we sourced these assumptions?

We sourced the assumptions from different areas across our business, our asset management practice, expected expenditure to maintain our assets, the regulatory environment, an external independent expert's view on Jemena's future gas demand and our research on the infrastructure required to facilitate renewable gas.

Join us for the optional deep dive on the **Gas Networks 2050 Model in March 2023.** We're open to your feedback. Some things we can do in relation to your feedback is:

- update the model reflect your feedback
- seek more clarification
- agree on assumptions until we get more information.

Contact Us:

For more information about the modelling tool or to ask a question, seek feedback or receive regular updates, please contact us:

Ph: 0401 021560 (Merryn)

Session 7 Draft agenda

Advisory Board

Wednesday, 22 March 2023, 6.5 hours

Date:	Wednesday, 22 March 2023	**Duration:**	6.5 hours
Location:	In person: KPMG Offices Level 38 Tower 3/300 Barangaroo Ave, Sydney	**Security:**	Internal
Meeting Purpose:	1. Consider each Expert Panel scenario to examine what customer demand and gas service conditions arise in it, and how the available response options perform 2. Deliberate on what responses perform best across the range of scenarios and would be suitable to put forward to Jemena's Customer Forum for customer testing 3. Agree if there should be any packaging of options and any narratives to introduce what these packages have been shortlisted for customer testing		

Time	Duration	Item
9.30am	10 min	Advisory Board arrives.
9.40am	10 min	**1. Welcome** • Acknowledgement of country • The purpose of the session • Our objectives for the day
9.50am	30 min	**2. Feedback** Reflections: • from session 6 • opt ins • pre-reading
10.20am	10 min	**3. The agenda for today** Build understanding of scenarios and the approach we'll take today.
10.30am	20 min	**4. Recap** Orientation and setting the scene, response options and parameters for the deliberative discussions
10.50am	10 min	**5. Morning tea**
11.00am	45 min	**6. Exploration: Electric Tortoise** Consider which of the deep dive options are viable in 'Electric Tortoise' and how do these perform, including: • About the scenario • Response options group discussion • Regroup and present back.
11.45am	45 min	**7. Exploration: Electric Hare** Consider which of the deep dive options are viable in 'Electric Hare' and how do these perform, including:

Time	Duration	Item
		• About the scenario • Response options group discussion • Regroup and present back.
12.30pm	30 min	**8. Lunch**
1.00pm	45 min	**9. Exploration: Market Hydrogen** Consider which of the deep dive options are viable in 'Market Hydrogen' and how do these perform, including: • About the scenario • Response options group discussion • Regroup and present back.
1.45pm	45 min	**10. Exploration: Big Hydrogen** Consider which of the deep dive options are viable in 'Big Hydrogen' and how do these perform, including: • About the scenario • Response options group discussion • Regroup and present back.
2.30pm	75 min	**11. Consolidation: Deliberations – what to engage on** Build shared view of best performing responses (across all scenarios – 'preferred actions') and potential packaging for customer testing.
3.45pm	10 min	**12. Session wrap-up** Opportunity to share reflections from the day
3.55pm	5 min	**13. Close and next steps** Agree next steps with timelines.
4.00pm		**Finish**

Session 6 Agenda

Advisory Board

Tuesday, 21 February 2023, 3 hours

Date:	Tuesday, 21 February 2023	**Duration:**	3 hours
Location:	Microsoft Teams (videoconference)	**Security:**	Internal
Dial In Details:	Included within Outlook calendar invite		
Meeting Purpose:	• **Problem statement:** Recap and iterate the problem statement • **Plausible future scenarios:** Orientation of the four plausible future scenarios followed by Q&A • **Gas Networks 2050 Model:** Develop a common understanding of the Gas Networks 2050 analysis approach and inputs • **Session 7:** Review agenda for Session 7 and identify additional information required to maximise engagement		

Duration	Item	Background reading
5 min	**1. Welcome** a. Acknowledgement of Country b. Agenda for today	
15 min	**2. Reflections from session 5** a. Feedback and responses	To get answers to your detailed questions, Q&A summary will be circulated next week.
20 min	**3. Problem statement recap** a. Recap and iterate the problem statement	Attachment: 1.1 - Annotated working problem statement.pdf Link here
40 min	**4. Plausible future scenarios:** a. Orientation of the four plausible future scenarios b. Q&A	Attachment: 1.2 Gas Networks 2050 Future Scenarios Expert Panel report.pdf Link here. Note this report is classified confidential.
70 min	**5. Gas Networks 2050 Model** a. Develop a common understanding of the Gas Networks 2050 analysis approach and inputs b. Q&A	Attachment: 1.3 Gas Networks 2050 Model fact sheet.pdf Link here
20 min	**6. Session 7** a. Review draft agenda for Session 7 and identify additional information required to maximise engagement, agree what order we will consider the scenarios in.	Attachment: 1.4 Draft agenda Advisory Board session 7 Link here
10 min	**7. Session wrap-up and close**	