14 August 2024

Submission: Draft 2025 Inputs, Assumptions and Scenarios Report scenarios

The Australian Pipelines and Gas Association (APGA) represents the owners, operators, designers, constructors and service providers of Australia's pipeline infrastructure, connecting natural and renewable gas production to demand centres in cities and other locations across Australia. Offering a wide range of services to gas users, retailers and producers, APGA members ensure the safe and reliable delivery of 28 per cent of the end-use energy consumed in Australia and are at the forefront of Australia's renewable gas industry, helping achieve net-zero as quickly and affordably as possible.

APGA welcomes the opportunity to contribute to the Australian Energy Market Operator (AEMO)'s consultation on draft scenarios for the 2025 Inputs, Assumptions and Scenarios Report (IASR). A key input into the Integrated System Plan (ISP), the IASR influences the type and pace of energy investment in Australia. As such, IASR assumption accuracy is critical to achieving least cost energy decarbonisation in Australia.

The 2025 IASR will be the most accurate IASR yet thanks to changes proposed within the consultation paper. In particular, choices which improve accuracy of gas power generation modelling will help to better optimise the ISP and hence the National Transmission Network Development Plan (NTNDP). However, key assumption choices underpinning the IASR risk overinvestment in electricity infrastructure – in opposition to the National Electricity Objective (NEO).

Gas use decarbonisation alternatives

The National Electricity Law (NEL) requires AEMO to act in line with the NEO while delivering the IASR. The NEO which requires AEMO to act in the long-term interests of consumers of electricity with respect to price, safety and decarbonisation. It would be reasonable to consider that overinvestment in electricity infrastructure would act in opposition to the NEO.

APGA has identified two assumption choices in underlying CSIRO Climateworks Multi-sector Modelling, a key input into the IASR, which risk overinvestment in electricity infrastructure[1]. Accuracy of these assumptions tends to be overlooked as the assumptions relate to outcomes for gas customers, not electricity customers. The assumptions in question are:

- Biomethane costs 4x to 6x greater than seen in Australia's Bioenergy Roadmap.
- 100% hydrogen appliances prohibited in all but the Hydrogen Export scenario.

[1] CSIRO, 2022, *Multi-sector Modelling 2022*, https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/2023-inputs-assumptions-and-scenarios-consultation/supporting-materials-for-2023/csiro-climateworks-centre-2022-multisector-modelling-report.pdf

While outcomes of gas customers are not the focus of the NEO, APGA contends that the above assumptions impact CSIRO modelling, and hence AEMO activities relative to the NEO, in the following manner:

a) The chosen assumptions do not reasonably reflect the contemporary fact base relating to gas decarbonisation alternatives and risk underestimation of their use;
b) Therefore risk CSIRO modelling risks overestimating electricity demand from gas decarbonisation;
c) Therefore AEMO risks overestimating electricity generation, transmission and storage demand across the NEM throughout the IASR, ISP and NTNDP; and
d) Therefore AEMO risk recommending higher than necessary investment through the IASR, ISP and NTNDP in opposition to the NEO.

APGA demonstrates these risks within its submission through comparison between CSIRO and ACIL Allen modelling[2] demonstrating:

1. CSIRO modelling can be reasonably seen to be impacted by assumption choices.
2. Contemporary biomethane and hydrogen appliance assumptions are more realistic than assumptions chosen in CSIRO Climateworks Modelling; and
3. Where these assumptions are used in analogous modelling, substantially lower levels of electricity demand arise as a result of gas use decarbonisation.

Analysing CSIRO and ACIL Allen modelling side by side indicates that the **Step Change Scenario could overestimate electricity demand by as much as 50 – 100PJpa** considering residential gas decarbonisation alone as a result of CSIRO assumption choices.

Recommendation

Proceeding with an IASR based on current CSIRO Climateworks Multi-sector Modelling risks AEMO recommending overinvestment in electricity transmission via the NTNDP which is inconsistent with the NEO.

To be consistent with the NEO, APGA recommends AEMO request CSIRO to re-run its Climateworks Multi-sector Modelling with updated biomethane and hydrogen appliance assumptions which better align with the contemporary basis of fact around these topics.

Proposed assumptions include:

- Biomethane cost and availability per datasets behind Australia's Bioenergy Roadmap
- Availability of 100% hydrogen appliances, if not from today, from a reasonable date in the medium term such as 2030.

APGA supports AEMO's efforts to deliver the most accurate IASR possible consistent to its obligations under the NEO and welcomes a continuation of this conversation across the coming weeks and months.

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[2] ACIL Allen, 2024, *Renewable Gas Target: Delivering lower cost decarbonisation for gas customers and the Australian economy*, https://apga.org.au/renewable-gas-target

Dispatchable renewable electricity generation

Dispatchable Renewable Electricity (DRE) generation such as Pumped Hydroelectric Energy Storage (PHES) and Battery Energy Storage Systems (BESS) are critical to the future of the NEM. As such, they account of a substantial proportion of future electricity cost. However, the IASR lacks the necessary data to accurately compare these forms of DRE to a further option – hydrogen gas power generation (HGPG) via hydrogen supply chains.

HGPG gains its dispatchability through two means – access to hydrogen pipeline storage capacity and access to underground hydrogen storage capacity. While the IASR considers electrolyser and hydrogen generation costs, it does not consider data relating to hydrogen transport and storage.

As such, IASR analysis cannot consider the low-cost energy transport and storage options associated with HGPG – storage which could be lower cost than PHES or BESS. This risks the IASR choosing PHES and BESS where HGPG could be a lower cost alternative.

Recommendation

Proceeding with an IASR which does not consider hydrogen pipeline and underground storage upstream of HGPG risks AEMO recommending overinvestment in electricity transmission via the NTNDP which is inconsistent with the NEO.

To be consistent with the NEO, APGA recommends:

- Introducing hydrogen transport and storage data from the Pipelines vs Powerlines study[3]; and
- Engaging with Future Fuels CRC to source underground hydrogen storage cost data sourced through CRC projects.

APGA supports AEMO's efforts to deliver the most accurate IASR possible consistent to its obligations under the NEO and welcomes a continuation of this conversation across the coming weeks and months.

To discuss any of the above feedback further, please contact me on +61 422 057 856 or jmccollum@apga.org.au.

Yours sincerely,

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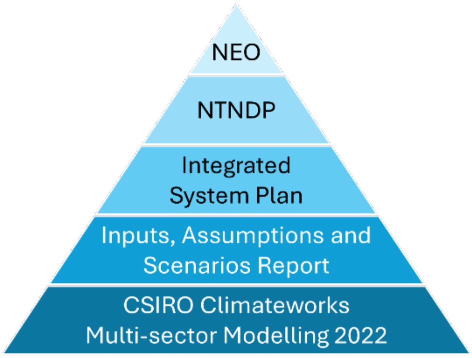
Australian Pipelines and Gas Association

[3] GPA Engineering, 2022, *Pipelines vs Powerlines: a Technoeconomic Analysis in the Australian Context*, https://apga.org.au/research-and-other-reports/pipelines-vs-powerlines-a-technoeconomic-analysis-in-the-australian-context

Gas use decarbonisation alternatives

The IASR and the studies which it references ultimately impact the ability for AEMO to comply with the NEO through its delivery of the NTNDP. Any inaccuracies in studies referenced by the IASR risk over- or under-investment in electricity infrastructure proposed via the NTNDP, and any over- or under-investment in electricity infrastructure would not be consistent with the NEO. Therefore, inaccuracies in studies referenced by the IASR directly impact the ability for AEMO to deliver upon the NEO. This includes CSIRO Climateworks Multi-sector Modelling.



APGA has long raised concerns about the modelling outcomes seen in CSIRO Climateworks Multi-sector Modelling, and this modelling had been broadly dismissed by the industry as unreflective of the future gas market. In the absence of decarbonisation modelling reflective of industry experience, APGA and ENA engaged ACIL Allen to undertake micro- and macro-economic modelling of gas use decarbonisation[4]. The study focused on gas directly consumed in Australia, and priority was placed on using publicly available assumption data.

Upon completing this analysis, ACIL Allen modelling was compared with CSIRO Climateworks Multi-sector Modelling. This comparison led to two observations:

1. Where assumptions were similar, CSIRO and ACIL Allen modelling produced reasonably aligned outcomes **implying similar model functionality across CSIRO and ACIL Allen models.**
2. Where CSIRO and ACIL Allen outcomes differ, differences are reasonably attributable to different input assumption choices by CSIRO and ACIL Allen **implying outcome differences are predominantly due to differences in assumption choices.**

These observations raise two questions with relation to the IASR and AEMO's obligations to which the NEO applies:

1. Are the assumption choices made in CSIRO Climateworks Multi-sector Modelling the most reasonable reflection of gas decarbonisation options?
2. Would retaining or amending these assumptions align with AEMO adherence to the NEO?

APGA explores these questions by detailing below:

- Similarities between CSIRO and ACIL Allen Modelling
- Differences between CSIRO and ACIL Allen modelling
- Consideration of the reasonability of CSIRO assumptions

[4] ACIL Allen, 2024, *Renewable Gas Target: Delivering lower cost decarbonisation for gas customers and the Australian economy*, https://apga.org.au/renewable-gas-target

Similarities between CSIRO and ACIL Allen Modelling

AEMO commissioned the CSIRO Climateworks Centre to complete multi-sector modelling of four decarbonisation scenarios. This involved quantifying the changing influences that will affect electricity demand under various emissions targets across the period 2021-22 to 2053-54. Comparing this analysis with analysis by ACIL Allen, the residential energy supply outcomes of CSIRO's Hydrogen Export scenario align with residential gas decarbonisation outcomes in ACIL Allen's High Hydrogen scenario.

Outcomes

Scenario	Decarbonisation Option	
	Electrification	Renewable Gas
Climateworks Hydrogen Export	37%	63%
ACIL Allen High Hydrogen	28%	71%

Notable model similarities and differences

Model aspect	Climateworks Hydrogen Export	ACIL Allen High Hydrogen
Hydrogen cost (Similarity)	Considers exports, associated with lower electrolyser CAPEX.	Scenario considered sensitivity of 20% lower hydrogen costs.
Hydrogen appliances (Similarity)	Scenario allowed for 100% hydrogen appliances.	Scenario allowed for 100% hydrogen appliances.
Biomethane cost (Similarity)	Considers biomethane cost 4x to 6x higher than ARENA study.	Considers biomethane cost 20% higher; -50% availability.
Net vs Absolute Zero (Difference)	Appears to have considered absolute zero, no offsets.	Considered net zero, limited high-cost offsets from 2050.

Similarities in assumptions and outcomes across both scenarios indicates that:

1. Both models function similarly; and
2. The outcomes of both models are relative to the input assumptions considered by each model.

The outcomes of both analyses imply the following in the event that these assumptions are more accurate than the Step Change Scenario:

a) The Step Change Scenario would be influencing overinvestment in electricity infrastructure via the NTNDP, which in turn would be misaligned with the NEO.
b) Over half of residential gas customers would be disadvantaged if forced to electrify gas use, instead of being provided the opportunity to transition to renewable gas.

Whether 63% or 71% of residential gas consumers would transition to renewable gas under these assumptions does not change this conclusion – both outcomes imply that:

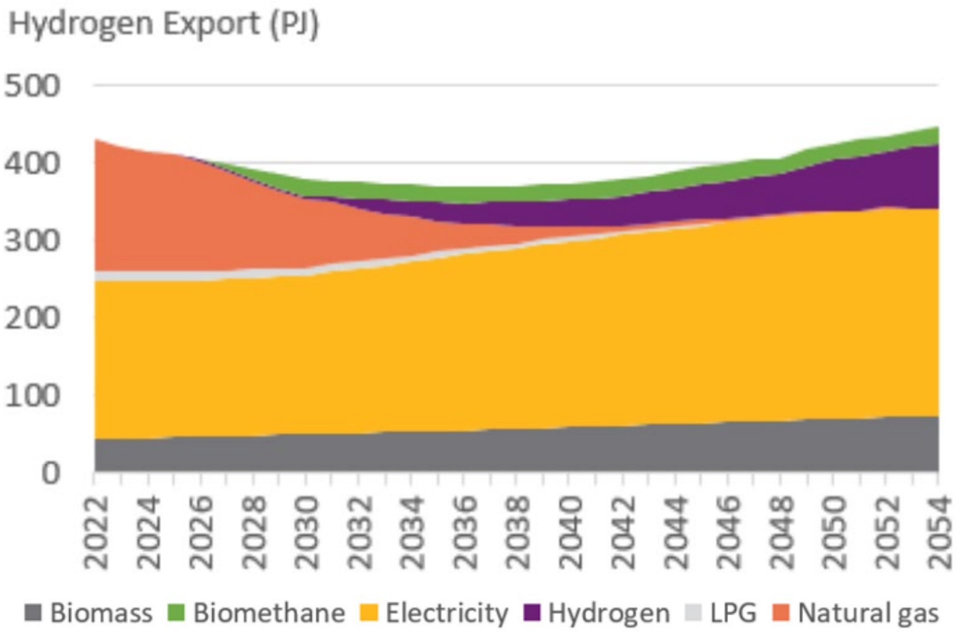
- Energy and decarbonisation policy should support both gas decarbonisation options, rather than pursuing one over the other; and
- An NTNDP supporting sufficient electricity infrastructure to supply 100% gas electrification would be drive overinvestment in opposition to the NEO.

The above observations are explored through the following sections which explore:

- Climateworks Hydrogen Export Scenario analysis
- ACIL Allen High Hydrogen Scenario analysis
- Similarities and differences in outcomes and assumptions between scenarios

Climateworks Hydrogen Export Scenario analysis

The fuel share in residential buildings in the NEM for the Climateworks Hydrogen Export scenario can be found in Figure 4-15 of the Climateworks report – included below. The Climateworks study considers all fuel supply into NEM connected residences. From a gas perspective, this chart indicates a move away from natural gas and a move towards electrification, hydrogen and biomethane.

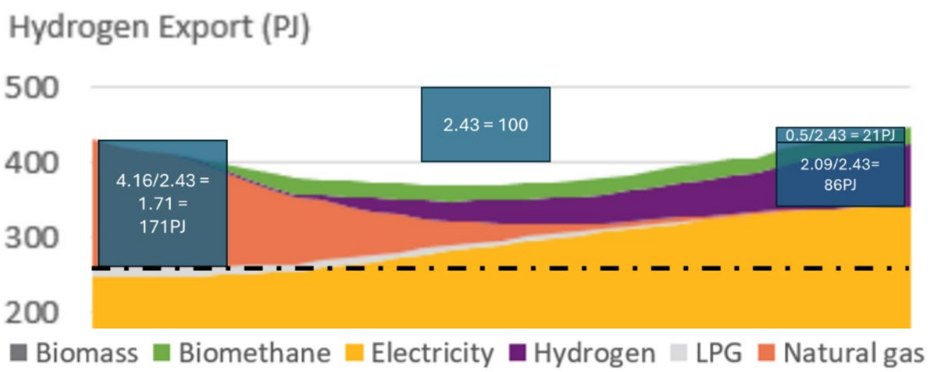


*Please excuse the resolution – the chart is small within the Climateworks report.

While chart data is not provided alongside the study, this can be estimated using the chart scales, as seen below. This indicates that Climateworks estimated 171PJpa of residential natural gas use in 2022. The Climateworks model transitions 21PJpa of potential natural gas use to biomethane and 86PJpa to hydrogen (or a total of 107PJpa to renewable gas). It is unclear from the Climateworks report how much a potential increase in residential gas demand is considered within its analysis.

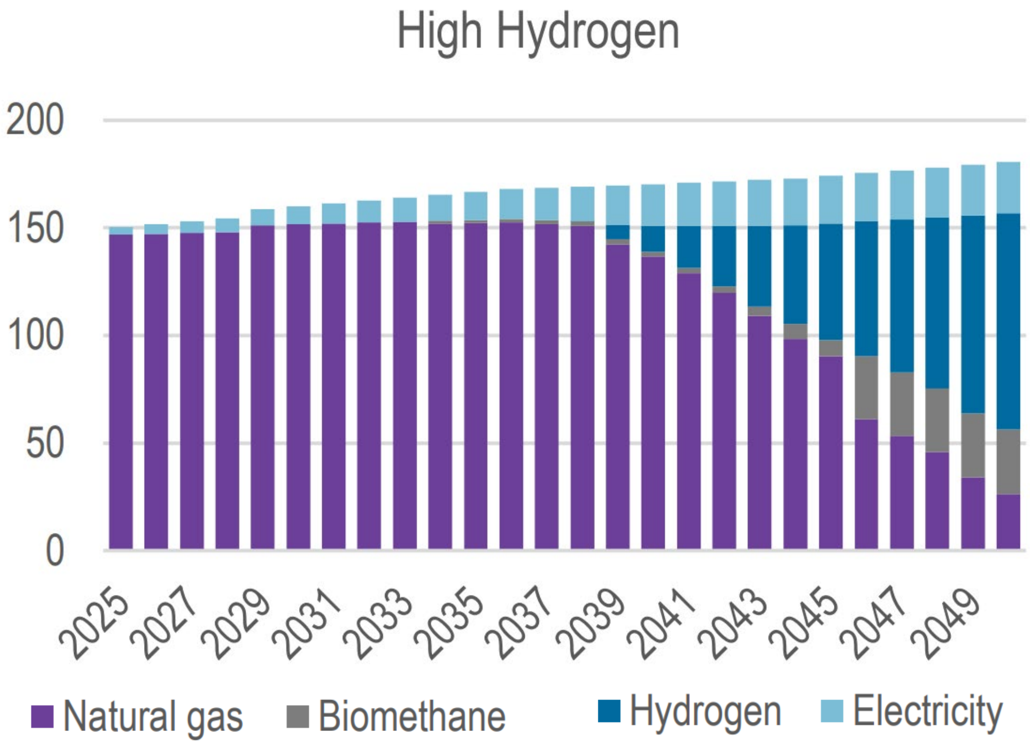
This demonstrates a combination of electrification and renewable gas being used to decarbonise residential natural gas use noting:

- 63% of residential natural gas use is transitioned to renewable gas use;
- 37% of residential natural gas use is electrified (presuming electrification as the alternative to natural gas use i.e. not biomass).



ACIL Allen High Hydrogen scenario analysis

The fuel mix for decarbonising gas using appliances in residential buildings across Australia for the ACIL Allen High Hydrogen scenario can be found in Figure 3.15 of the ACIL Allen report – included below. The ACIL Allen study considers only decarbonising gas supply into residences. This chart indicates a move away from natural gas and a move towards electrification, hydrogen and biomethane.



This chart starts with 148PJpa of residential natural gas use with around 2.4PJpa of existing gas use already electrified in year 1. This indicates that ACIL Allen started with around 152PJpa of potential residential gas use in 2025.

The ACIL Allen study baseline shows an increase in potential gas demand of 32PJpa between 2025 and 2050 as seen in Figure 3.2 of the report. Noting that residential demand was the only sector which considered demand growth, this 32PJpa (21%) increase is attributable to residential demand growth in lieu of emissions policy.

Of this combined 184PJpa of potential natural gas use in 2050, the model transitions 30PJpa to biomethane and 100PJpa to hydrogen (or a total of 130PJpa to renewable gas) by 2050.

This also demonstrates a combination of electrification and renewable gas being used to decarbonise residential natural gas use noting:

- 71% of future potential residential natural gas use transitioning to renewable gas use.
- 29% of future potential residential natural gas use is either electrified or decarbonised via high-cost carbon offsets from 2050.

Similarities and differences in outcomes and assumptions between models

There are notable similarities and differences in assumptions between the Climateworks and ACIL Allen models, as well as between the Hydrogen Export and High Hydrogen scenarios specifically. Understanding these can help explain variations between model outcomes, demonstrating that it is the differences in assumptions chosen by modellers that are driving differences in outcomes. From here, these choices can then be examined. The top 5 assumption similarities and differences identified by APGA are summarised below and detailed further in this section.

Model aspect	Climateworks Hydrogen Export	ACIL Allen High Hydrogen
Residential option allowance (Similarity)	Residential gas customers allowed to decarbonise via electrification, hydrogen and biomethane in all scenarios.	Residential gas customers allowed to decarbonise via electrification, hydrogen and biomethane in all scenarios exc electrify everything possible.
Net Zero vs Absolute Zero (Difference)	Appears to target absolute zero noting no fossil fuel use remains in any scenario.	Allows limited, high cost (>$300/tCO2e) offsets from 2050 onward to allow a net zero outcome if cheaper.
Hydrogen cost (Similarity)	Exports associated with lower electrolyser CAPEX in High Export scenario, higher in remaining model scenarios.	High Hydrogen Scenario considered 20% lower hydrogen costs, higher in remaining model scenarios.
Hydrogen appliances (Similarity/Difference)	Only the Hydrogen Export scenario allowed for 100% hydrogen appliances, other modelled scenarios did not.	All scenarios allowed for 100% hydrogen appliances including the High Hydrogen scenario.
Biomethane cost (Difference)	Appears to only consider biomethane from high-cost Gasification process.	Considered biomethane from lower cost Anerobic Digestion.

Similarity – Allowance for electrification, hydrogen and biomethane

Both model reports demonstrate that all three decarbonisation options are made available to residential gas customers in some way. Neither inherently force customers to use renewable gas or to electrify. This means that choices between each decarbonisation solution are made on economic bases aka the least cost choice for customers.

Similarity – both models allow residential customers to choose electrification, hydrogen or biomethane if the right economic choice for the customer.

Difference – Net Zero vs Absolute Zero

The Climateworks model appears to seek to achieve absolute zero for residential energy customers in its scenarios (Figure 4-15). The ACIL Allen model sought to achieve net zero by 2050 defined via a carbon budget and an allowance for a small volume of high-cost carbon offsets from 2050 onwards (*Carbon budgets* section on page 15-16). This resulted in the ACIL Allen model choosing 25PJpa (30% of available offsets) worth of high-cost carbon offsets from 2050 onwards in place of additional electrification or renewable gas uptake. Residential customers were not provided this option in the Climateworks model.

Difference – targeting net zero by allowing limited carbon offsets from 2050 onward allowed the ACIL Allen model to choose to keep residents on natural gas while applying high-cost offsets instead of introducing more electrification, hydrogen or biomethane.

Similarity – Hydrogen cost
Relative to other scenarios in the study, the Climateworks Hydrogen Export scenario assumes lower hydrogen costs driven by greater technology uptake by the export sector (Figure 2-1). Similarly, ACIL Allen's High Hydrogen scenario simply assumed that hydrogen was 20% cheaper than in the study's core scenarios (Table 3.1).

Similarity – both models similarly introduce substantial volumes of hydrogen in decarbonising residential gas supply due to cost-reducing assumptions. This demonstrates overall alignment between model functionality when assumptions are more aligned.

Similarity – Hydrogen appliances
Both the Climateworks Hydrogen Export and all ACIL Allen High Hydrogen scenarios assume availability of 100% hydrogen appliances. This aligns with work undertaken by Standards Australia to integrate international 100% hydrogen appliance standards into their suite of Australian standards.

Similarity – both scenarios find that a substantial volume of residential gas demand is decarbonised through 100% hydrogen uptake at a lower cost than electrification due to the allowance for residential gas customers to access 100% hydrogen appliances.

Difference – Hydrogen appliances
Climateworks scenarios aside from the Hydrogen Export scenario only consider hydrogen blending up to 10% by volume. All ACIL Allen scenarios consider availability of 100% hydrogen appliances where there is reasonable evidence of these being available, including for residential customers. Alongside this, ACIL Allen also considers hydrogen blending up to 10% by volume in its *natural gas and blends* energy supply option.

Difference – remaining Climateworks models exclude 100% hydrogen appliances, hence do not introduce as much hydrogen in decarbonising residential gas supply across scenarios other than the Hydrogen Export scenario.

Difference – Biomethane cost
There are two technical biomethane production pathways – gasification and anerobic digestion. The Climateworks study only introduces biomethane costs from the higher-cost gasification production pathway (Table 2-11). The Climateworks study does not appear to include the lower cost anerobic digestion production pathway. The ACIL Allen study on the other hand only considers anerobic digestion costs, and only considers feedstock volumes associated with anerobic digestion. ACIL Allen based its assumptions on data from Australia's Bioenergy Roadmap (ACIL Allen study Figure 2.4 and 2.5).

Difference – artificially high biomethane costs reduce the likelihood of biomethane selection by the Climateworks model compared to ACIL Allen model, explaining higher prevalence of biomethane in the full set of ACIL Allen scenarios.

Differences between CSIRO and ACIL Allen modelling

The CSIRO Step Change scenario delivers a clear outcome in favour of residential electrification over transitioning to renewable gas. However, the above assumption analysis alongside results of the full set of CSIRO and ACIL Allen model scenarios indicates that the Step Change result may stem from assumptions that unfairly disadvantage renewable gas options in the model. **This raises questions around whether or not it is reasonable for CSIRO to have chosen the assumptions it has for the majority of its scenarios.**

Comparison of chosen assumptions and outcomes

A comparison of key chosen assumptions can be seen in the table below. Three key differences in assumptions between CSIRO Step Change scenario (and others) and ACIL Allen's Theoretically Efficient Policy (TEP) scenario (and sensitivities) relate to:

- 100% hydrogen appliance availability
- Biomethane Price
- Offset availability

These differences indicate that the 100% residential electrification outcome for CSIRO's Step Change Scenario may simply be a result of assumptions which prohibited or priced out electrification alternatives.

Where 100% hydrogen appliances are made available, where biomethane is priced in line with ARENA analysis, and where high-cost offsets are made available from 2050 onward, models such as those used by Climateworks and ACIL Allen tend to choose these options over electrification for a not-insignificant portion of residential gas customers.

CSIRO H2 Export	ACIL Allen High H2	CSIRO Step Change and others	ACIL Allen TEP and Sensitivities
Assumption: 100% H2 appliances allowed; Result: ~50% residential H2 use	Assumption: 100% H2 appliances allowed; Result: >50% residential H2 use	Assumption: No 100% H2 appliances; Result: No disenable residential H2 use	Assumption: 100% H2 appliances allowed; Result: >50% residential H2 or biomethane use
Assumption: Biomethane Cost 4x to 6x ARENA Report Result: 10% residential Biomethane use	Assumption: Biomethane Cost +20% on ARENA, Report, -50% volume Result: 10% residential Biomethane use	Assumption: Biomethane Cost 4x to 6x ARENA Report Result: little residential Biomethane use	Assumption: Biomethane Cost in line with ARENA Report Result: up to 80% residential Biomethane
Assumption: No offsets available Result: No residential use of offset natural gas	Assumption: Limited, high-cost offsets available Result: Limited residential use of offset natural gas	Assumption: No offsets available Result: No residential use of offset natural gas	Assumption: Limited, high-cost offsets available Result: Some limited residential use of offset natural gas

Reasonability of CSIRO assumptions

The reasonability of the assumptions that led to the CSIRO outcomes needs to be considered. APGA does not consider these assumptions to be reasonable and in the interest of finding the least cost decarbonisation pathway for residential gas customers.

Biomethane cost

As CSIRO chooses a high-cost method for the production of biomethane, the cost assumptions for biomethane are 4-6 times greater than they should be for the Australian market[5]. This obscures the possibility that a transition to biomethane may be cheaper than electrification.

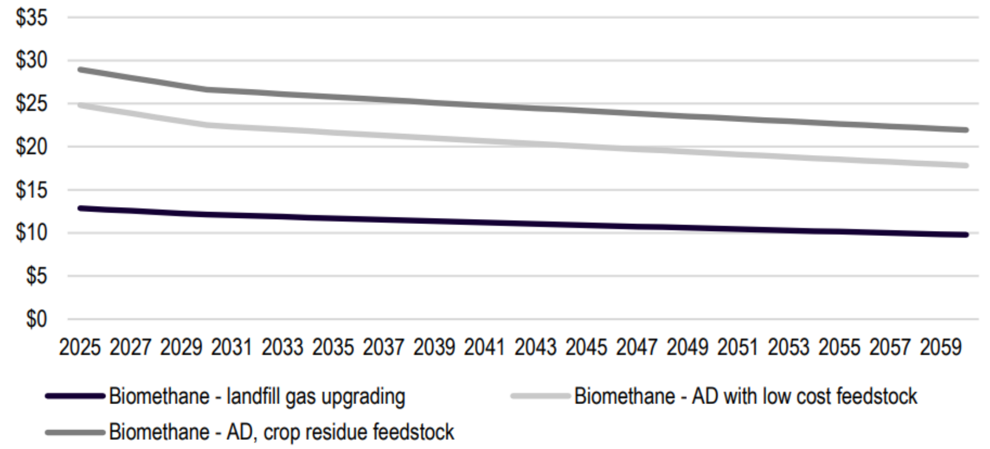
The ACIL Allen Theoretically Efficient Policy Scenario chooses biomethane for the majority of residential gas decarbonisation. Similarities between CSIRO and ACIL Allen models indicates that the CSIRO Step Change Scenario would choose more biomethane if priced accurately.

Notably the CSIRO Climateworks Centre's most recent analysis identifies that electrification costs for space conditioning and cooking range from $35 to $74 per GJ of incumbent fuel displaced[6]. This is to be compared with a biomethane cost of around $25 per gigajoule.

Table 2-11 Investment cost for gasification and methanation ($/GJ/year)

	2020	2030	2040	2050
Progressive Change, Step Change, Hydrogen Export	151.38	119.29	94.38	93.66
Exploring Alternatives	151.38	64.03	31.91	31.91

Figure 2.4 Biomethane cost series ($/GJ)



Source: ACIL Allen analysis of Enea and Deloitte 2021, Australia's Bioenergy Roadmap, https://arena.gov.au/knowledge-bank/australias-bioenergy-roadmap-report/, adjusted for inflation using ABS CPI data

[5] ARENA, 2021, *Australia's Bioenergy Roadmap* and associated appendices and datasets, https://arena.gov.au/knowledge-bank/australias-bioenergy-roadmap-report/

[6] CSIRO Climateworks Centre, 2023, Climateworks Centre decarbonisation scenarios 2023, https://www.climateworkscentre.org/wp-content/uploads/2023/10/Climateworks-Centre-decarbonisation-scenarios-2023-Assumptions-and-Methodology-Report-November-2023.pdf

100% hydrogen appliance availability
100% hydrogen appliances are available globally, with a small number available in Australia[7]. These are being demonstrated in HyHome today[8]. Not including this technically viable option obscures a potentially lower cost decarbonisation pathway for residential gas customers.

That the CSIRO Hydrogen Export scenario and ACIL Allen model chooses 100% hydrogen appliances for residential customers indicates that the Step Change scenario would choose 100% hydrogen appliances for some customers – if assumptions allowed. This would have substantially different implications for energy policy in the best interests of residential gas customers, including a multi-vector approach to decarbonisation including support for electrification and hydrogen.

If there is discomfort about 100% hydrogen appliances being commercially available in Europe but not yet in Australia, the impacts of the above analysis indicates that a consideration of 100% hydrogen appliances being available by the end of the decade would be more in line with IASR assumptions than a complete disregard for these appliances.

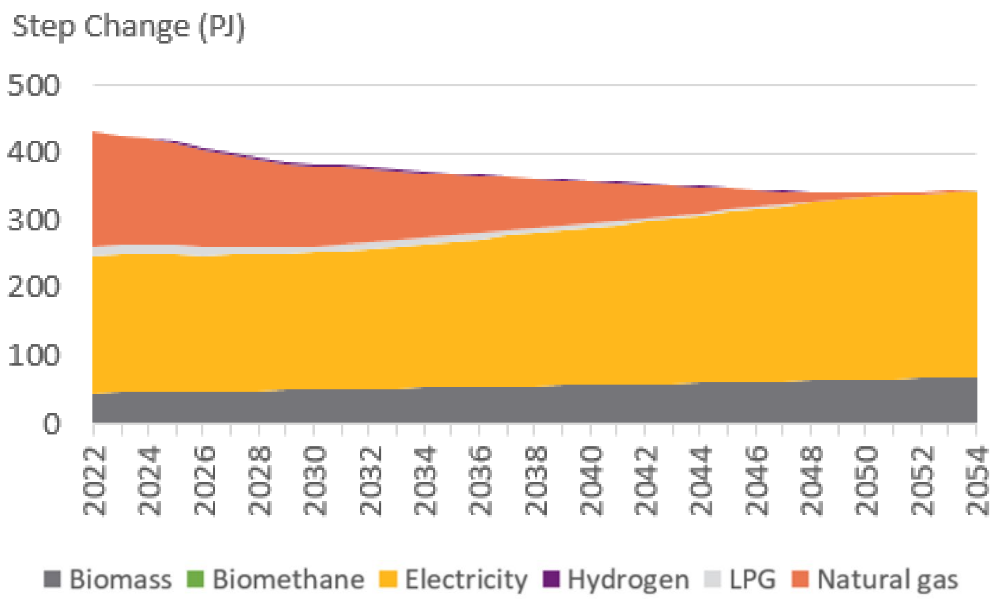
Impact of assumption differences

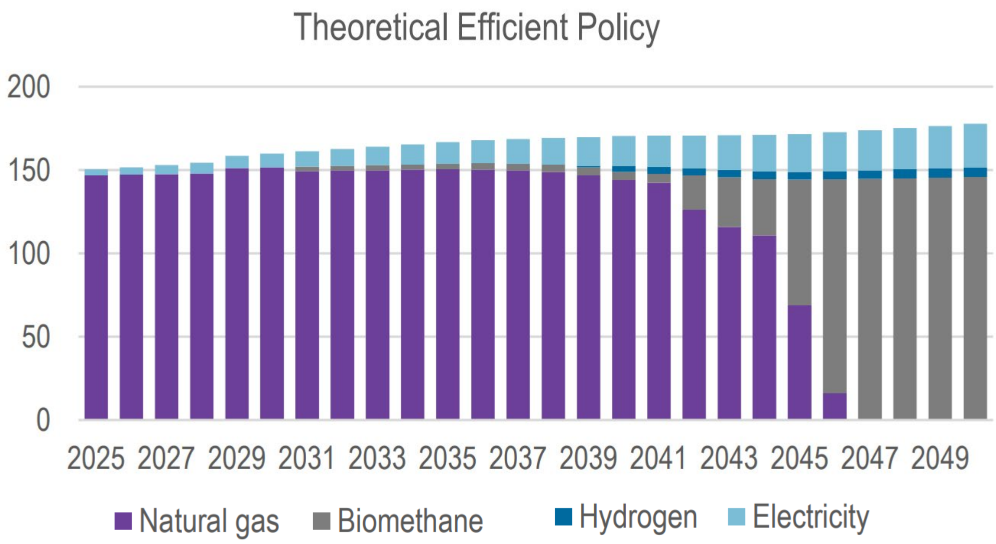
The above comparison implies that, had CSIRO chosen to use the same biomethane and hydrogen appliance assumptions as ACIL Allen, it would have derived a similar result. To demonstrate the impact of these differences in assumptions, charts depicting residential fuel mix outcomes from core scenarios in CSIRO and ACIL Allen studies are included below. The difference in electricity demand between these two studies is around 50 – 100PJpa depending on average electric appliance efficiency.

In the context of the IASR and its impact on AEMO's adherence to the NEO, a 50 – 100PJpa of electricity demand difference is significant. Overestimating electricity demand by 50 – 100PJpa not only risks unnecessary electricity transmission investment, but also risks signalling unnecessarily high levels of investment in energy storage. This is because residential gas demand peaks in the morning and evening.

This difference demonstrates the risk of not taking contemporary biomethane and hydrogen appliance data into account. Alignment demonstrated between both modelling indicates the possibility that CSIRO analysis could show similar outcomes once this data is considered. This in turn indicates that failing to rerun CSIRO analysis without this data would be a failure to adhere to the NEO.

[7] Energy Networks Australia, 2023, *Hydrogen Appliances for Homes*, https://www.energynetworks.com.au/resources/reports/hydrogen-appliances-for-homes/
[8] AGIG, 2024, *HyHome website*, https://www.australiangasnetworks.com.au/hyhome





Conclusion and Recommendation

The past sections identified that the assumptions made by CSIRO are no longer a reasonable reflection of gas decarbonisation choices. Further, analogous modelling using more contemporary data leads to substantial differences in electricity demand in the order of 50 – 100PJpa. Observations made throughout these sections demonstrate:

- Basing the IASR upon the existing CSIRO Climateworks Multi-sector Modelling risks substantial overestimation of electricity demand in the order of 50 – 100PJpa.
- Which risks substantial overestimation of electricity transmission and storage requirements identified in the ISP.
- Which risks substantial overestimation of electricity transmission and storage investment identified in the NTNDP.
- Which risks misalignment of the NTNDP with the NEO.

On this basis, APGA recommends that AEMO engage CSIRO Climateworks Centre to rerun its Step Change Scenario with updated biomethane cost and availability data as well as updated hydrogen appliance availability data which considers availability from 2030.

Dispatchable renewable electricity generation

DRE generation such as PHES and BESS are critical to the future of the NEM and account of a substantial proportion of future electricity cost. However, the IASR lacks the necessary data to accurately compare these forms of DRE to a further option – HGPG supplied fuel via hydrogen supply chains.

While electrolyser and generator CAPEX is included in the GenCost report, more information is required to fully understand hydrogen storage and supply. Beyond the ability to fast-start alone, HGPG gains its dispatchability through two means – access to hydrogen pipeline storage capacity and access to underground hydrogen storage capacity. These represent forms of energy storage behind DRE which is not currently considered in the IASR alongside BESS and PHES.

The value of considering hydrogen transport and storage by pipeline is explained through the value of existing gas infrastructure, as well as being demonstrated through technoeconomic analysis of gas and hydrogen pipelines. On these bases the Future Fuels CRC is undertaking analysis comparing PHES and HGPG forms of DRE supply chains, and APGA encourages AEMO to engage with the Future Fuels CRC to access this analysis.

Existing gas infrastructure

Direct comparison of like-for-like gas and electricity infrastructure demonstrates that gas infrastructure consistently costs less when providing equal or higher supply capacity. This is why gas infrastructure draws lower revenues from customers.

The two tables below demonstrate comparisons of the regulated asset bases (RABs) of comparable gas and electricity infrastructure in Victoria and the ACT.

Costs and deliveries of Victoria's energy infrastructure[9]

Transmission and Distribution Infrastructure	Regulated Asset Base ($m)	Actual Annual Revenues ($m)	Actual Energy Delivered (GWh)	Max Demand Capacity (MW)
Electricity	17,329	2,825	41,480	8,684
Gas	5,631	774	64,722	23,250

Relative cost of energy delivery for gas and electricity distribution in the ACT[10]

Energy distribution networks	Regulated asset base ($m)	Actual annual revenues ($m)	Actual energy delivered (GWh)	Average cost to deliver a GWh ($)
Electricity	981	140	2,851	49,106
Gas	377	67	2,201	30,436

[9] APGA, 2021, *Submission: Victorian Gas Substitution Roadmap Consultation Paper*, https://www.apga.org.au/sites/default/files/uploaded-content/field_f_content_file/210816_apga_submission_to_the_victorian_gas_substitution_roadmap_consultation_paper.pdf

[10] APGA, 2023, *Submission: Regulating for the prevention of new fossil fuel gas network connections*, https://www.apga.org.au/sites/default/files/uploaded-content/field_f_content_file/230420_apga_submission_-_act_gas_connections.pdf

In Victoria, the RAB of gas transmission and distribution infrastructure is a third of the size of that of electricity infrastructure, but delivers a third more energy, and can support peak demand 60% higher. Relevant to customer interests, gas infrastructure also generates only 27% of the revenue of electricity, which is related both to the capital cost of the infrastructure and ongoing operational expenditure. Similarly, ACT gas infrastructure delivers 80% of the capacity of electricity infrastructure at 40% of the cost.

Analysis by the ARENA-funded Australia Hydrogen Centre further shows that the cost of converting gas infrastructure to deliver 100% hydrogen comes at a fraction of gas asset RAB. Analysis on South Australian and Victorian gas distribution networks shows that conversion of the gas network and all gas appliances to 100% hydrogen would increase distribution network stay-in-business capital expenditure to 2050 by 11-12% in present value terms[11]. This small cost of conversion indicates that today's low cost of gas infrastructure will be retained when delivering renewable gases, even hydrogen, through existing gas infrastructure.

New gas infrastructure

Where new energy transport and storage infrastructure is required, pipeline infrastructure is a cost competitive option. This has been shown through recent pipeline and powerline infrastructure projects:

- APA's 50km Western Outer Ring Main pipeline was completed in 2024 for approximately $185 million, or $3.7 million per kilometre. This project was in an urban environment, significantly adding to cost.
- APA's $560km Northern Gas Interconnect was completed in 2023 for a cost of $821,000 per kilometre.
- AGIG's 440km Tanami Natural Gas Pipeline, completed in 2019, cost $346 million or $786,000 per kilometre.
- The 360km HumeLink overhead transmission powerline project is expected to cost approximately $4.8 billion, or $13.3 million per kilometre.
- The proposed 400km Victoria – New South Wales Interconnector West overhead transmission project is expected to cost approximately $3.3 billion, or $8.25 million per kilometre. There are numerous reports that this cost will increase.

GPA Engineering's *Pipelines vs Powerlines* report provides further details on this relationship[12]. Both gas and hydrogen transmission pipelines consistently cost less to deliver the same quantity of energy across the same distance in comparison to electricity transmission powerlines. An example of this relationship can be seen in Figure 3, outlining

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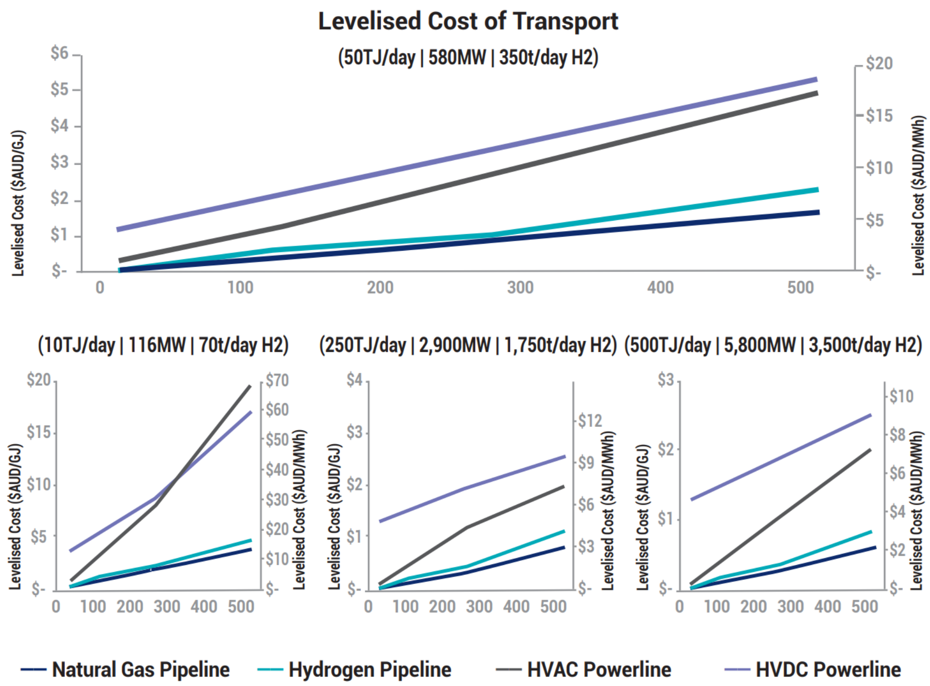
[11] Australian Hydrogen Centre, 2023, *100% Hydrogen Distribution Networks: Victoria Feasibility Study*, https://arena.gov.au/assets/2023/09/AHC-100-Hydrogen-Distribution-Networks-Victoria-Feasibility-Study.pdf; Australian Hydrogen Centre, 2023, *100% Hydrogen Distribution Networks: South Australia Feasibility Study*, https://arena.gov.au/assets/2023/09/AHC-100-Hydrogen-Distribution-Networks-South-Australia-Feasibility-Study.pdf

[12] GPA Engineering, 2022, *Pipelines vs Powerlines: A Technoeconomic Analysis in the Australian Context*.

the cost of energy transport for a range of energy capacity scenarios over 500km. This outcome has since been supported by academic research within the Future Fuels CRC.

Levelised cost of energy transport via pipelines and powerlines[13]



The economic benefits of new pipeline infrastructure extend beyond transport. GPA Engineering's research also examined the levelised cost of energy storage between pipeline, BESS and PHES energy storage solutions, finding that energy storage in pipelines can be hundreds of times cheaper than energy storage in utility scale batteries or pumped hydro. GPA Engineering found that energy storage in hydrogen pipelines can be 2-to-36 times cheaper than energy storage in utility scale batteries or pumped hydro, excluding the instances in which it is essentially free.

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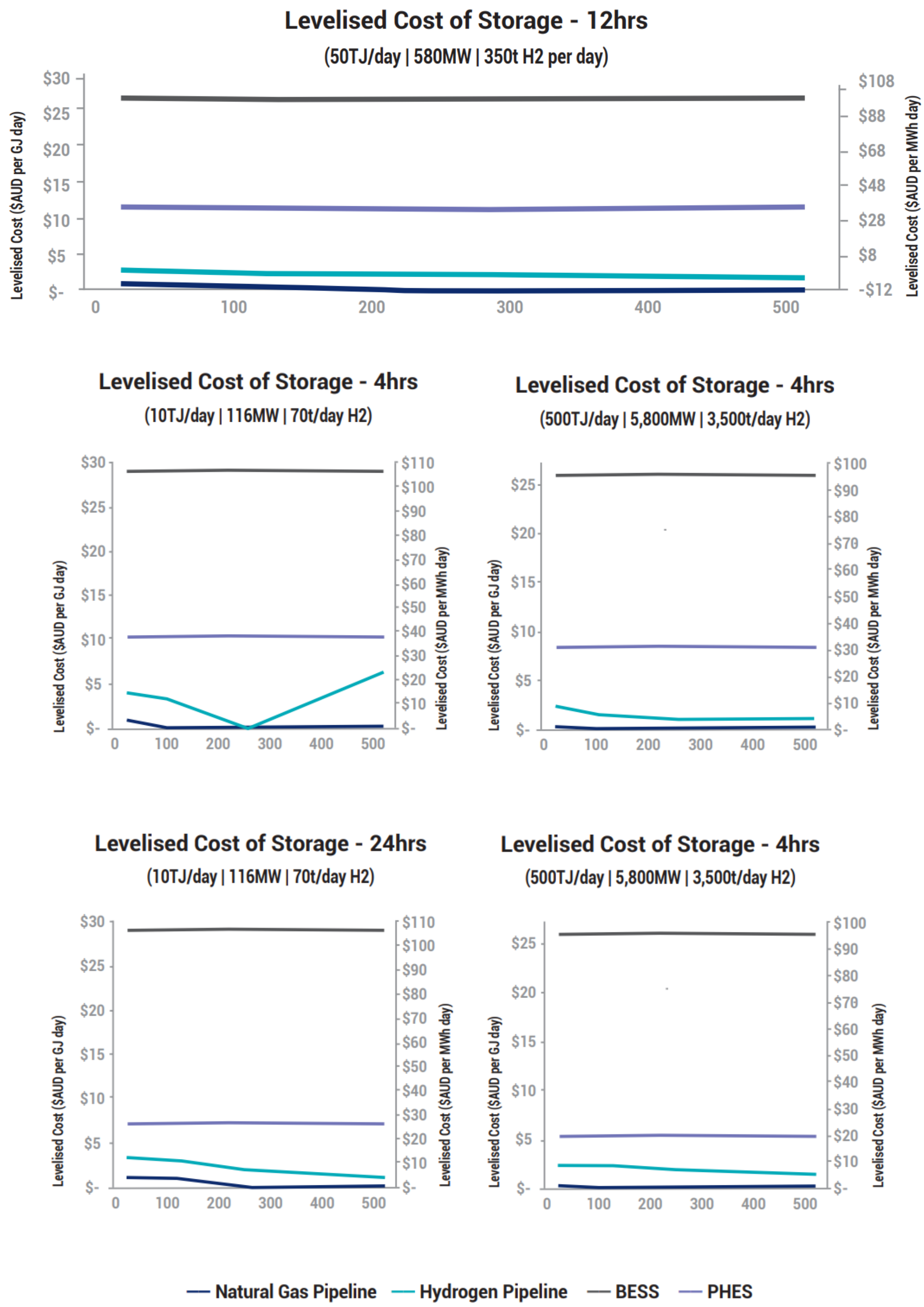
[13] Ibid.

Levelised cost of energy storage via pipeline linepack, BESS and PHES



Conclusion and recommendation

An IASR which does not include data relating to the cost of energy transport and storage via hydrogen pipelines or underground hydrogen storage risks overestimating the amount of electricity transport and storage required through ISP and NTNDP analysis. Doing so would not align with AEMO objectives under the NEO.

APGA recommends incorporating data from the GPA Engineering Pipelines vs Powerlines study into IASR assumptions and engaging with the Future Fuels CRC to secure access to underground hydrogen storage cost data.

Consultation questions

Since the 2023 IASR publication, what changes (such as environment, social, policy) do you consider most impact scenario development for the 2025 IASR scenarios?

The 2024 GSOO and ISP have in some respects been forced to take a more realistic view of the pace of transition, with uplifted projections of gas powered generation. This reflects a reality where the pace of transition is not as fast as previously forecast. AEMO is hampered however by restrictions in the NER as to what the ISP can consider in its development – it cannot consider gas infrastructure or storage infrastructure, and hence cannot consider gas supply chains.

The Rule Changes currently before the AEMC to better integrate gas into the ISP, and permit AEMO to consider these supply chains, are an extremely positive step.

Is AEMO's proposal as described above a suitable evolution of each scenario's parameters that will effectively support AEMO's functions in planning the transition?

Inclusion of electrification variables in each of the scenarios is an appropriate reflection of the pace of the current transition. "High" and "higher" electrification rates for Step Change and Green Energy Exports are likely still ambitious. Hence, APGA agrees with the approach of including a qualifier – "pace of adoption reflecting economic conditions." This should be used to consider a broader range of electrification possibilities, which also reflects current cost of living and inflationary pressures in the economy.

It is also appropriate to include separate parameters on emerging commercial and industrial loads such as data centres, as these have likely been improperly considered previously.

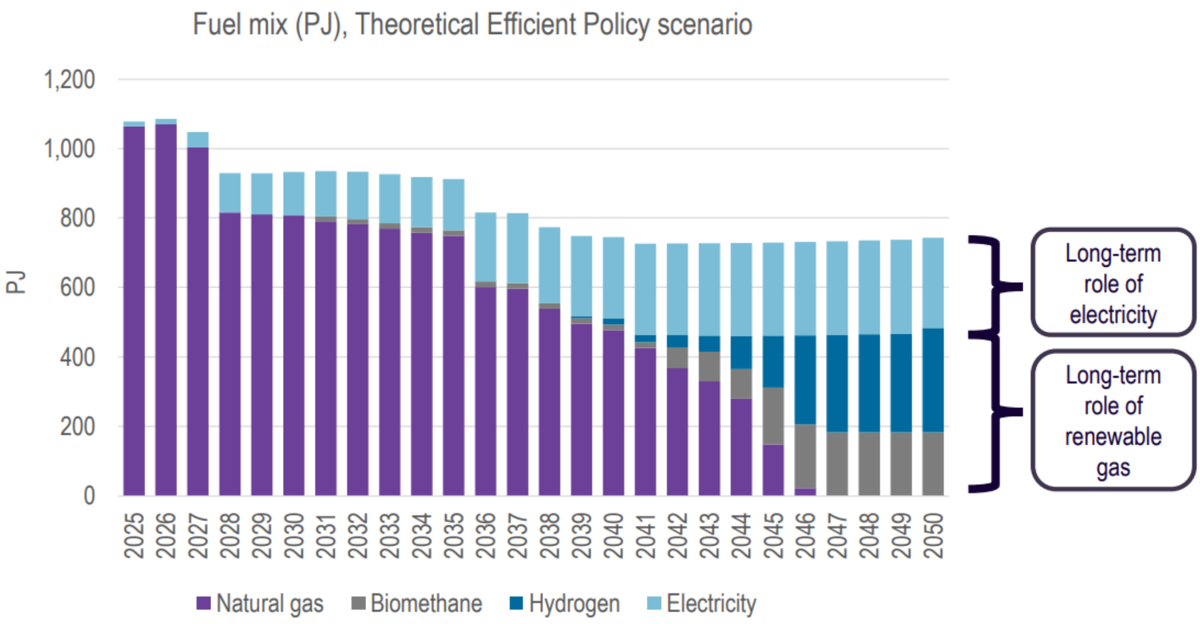
APGA also considers that the coordination of CER parameter may also be ambitious. In terms of households, it relies on how households choose to undertake electrification, the availability of smart metering, and considerable behavioural change on behalf of those households. This is an even taller order than presumed high rates of electrification.

What additional changes should be considered?

In anticipation of the Rule Changes to integrate gas into the ISP, AEMO should begin this work now by expanding its modelling for the IASR, and by considering the assumptions as described above.

ACIL Allen's gas decarbonisation analysis demonstrates a model which does not hamstring biomethane and hydrogen development in its assumptions. This analysis takes 100% hydrogen appliances and reasonable biomethane and hydrogen cost into account in modelling of least cost gas use decarbonisation. This analysis finds that the least cost decarbonisation pathway for Australian gas consumers is achieved through a combination of electrification, hydrogen and biomethane uptake.[14]

[14] ACIL Allen, 2024, *Renewable Gas Target - Delivering lower cost decarbonisation for gas customers and the Australian economy*, https://apga.org.au/renewable-gas-target



This finding has implications for gas and electricity customers alike. ISP core scenarios currently assume mass electrification of residential and commercial gas customers based on assumptions which exclude alternatives (100% hydrogen) or introduce them at artificially high prices (biomethane). A more realistic approach would not artificially exclude or assume unnecessarily high prices for alternatives with the result of unnecessarily high electrification.

Including unnecessarily high electrification rates (hence unnecessarily high electricity demand) in the ISP risks inefficient overinvestment in electricity transmission infrastructure. This is ultimately not in *the long term interests of consumers of electricity* with respect to price, safety and decarbonisation.