April 2024

Renewable gas target modelling

Overview of methodology and results

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Agenda

1. Methodology and assumptions
2. Gas Transition Model results
3. Economy-wide results
4. Discussion and questions

Additional detail on assumptions at end of slide pack if required

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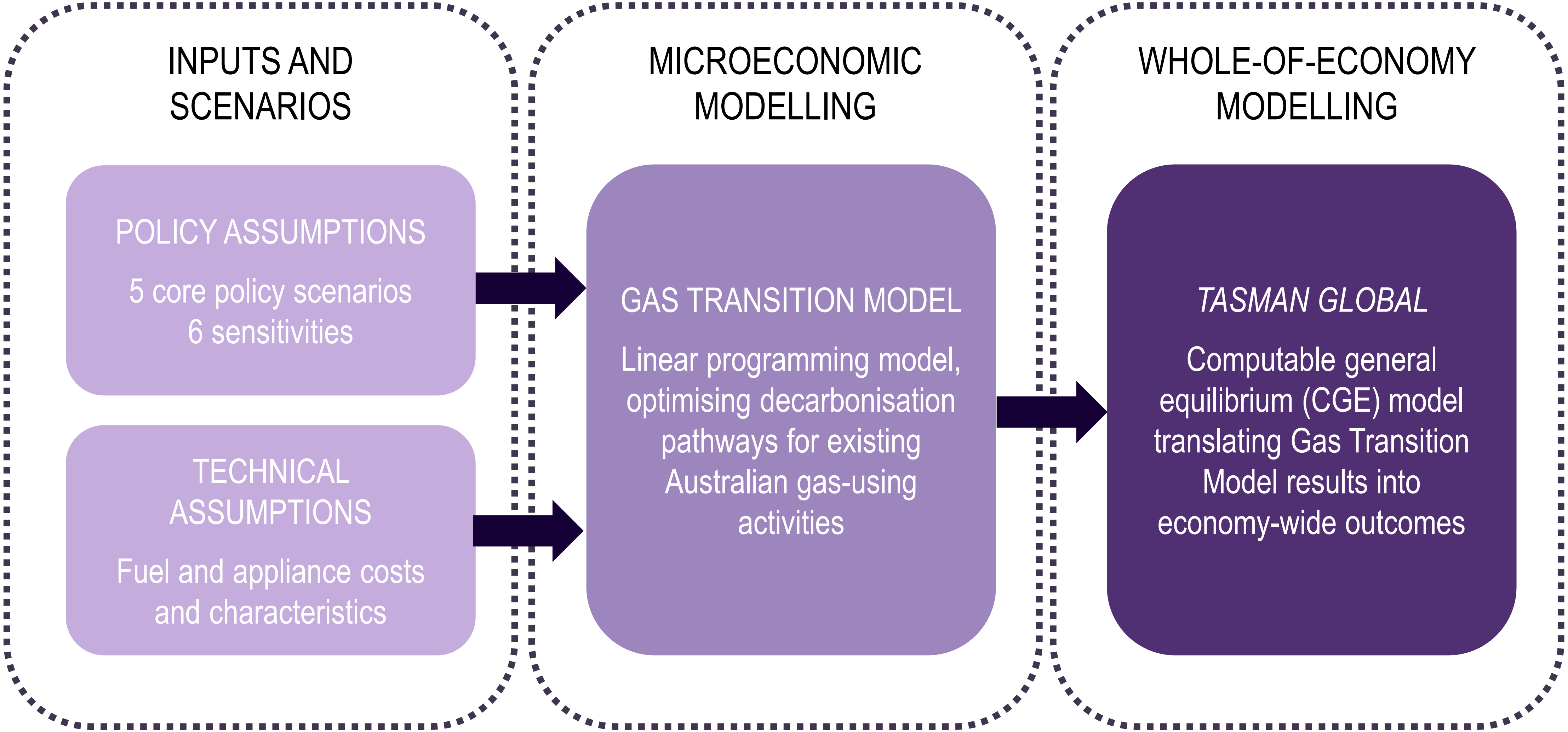
Modelling scope

FUELS	Natural gas → Electricity; Hydrogen; Biomethane
IN-SCOPE ACTIVITIES	Residential; Industrial; LNG own use; Commercial; Gas processing and transport
OUT-OF-SCOPE ACTIVITIES	GPG (other than on-site); New hydrogen-based industries; Exported gas; Scope 3 emissions

Methodology overview



Scenarios and sensitivities

No emissions reduction assumption	NO ACTION SCENARIO
Common carbon budget	THEORETICAL EFFICIENT POLICY SCENARIO OPTIMAL RENEWABLE GAS TARGET SCENARIO ELECTRIFY EVERYTHING POSSIBLE SCENARIO
Earlier emissions reductions	ACCELERATED RENEWABLE GAS TARGET SCENARIO

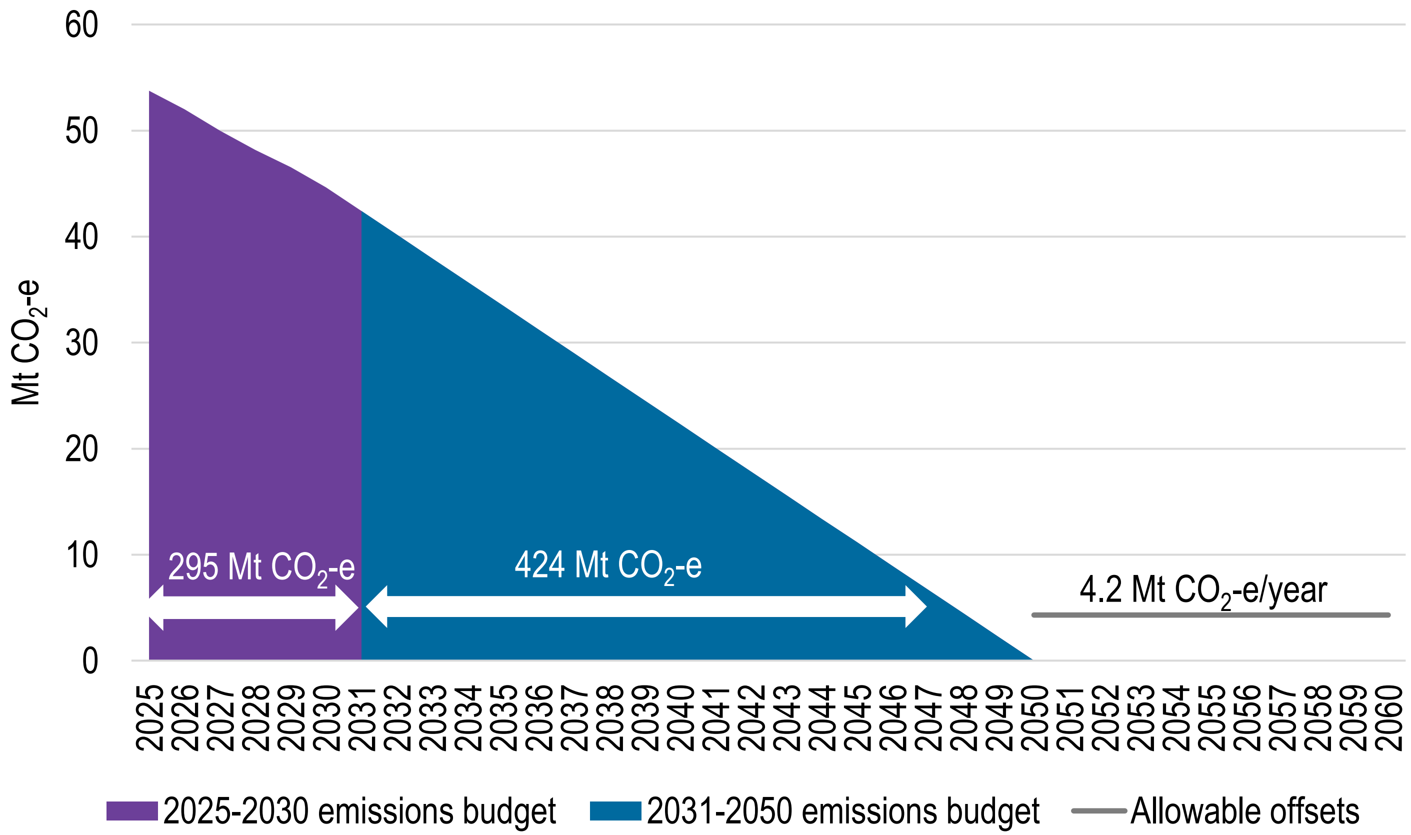
Sensitivities on technical assumptions	
High Renewable Gas	High Electrification
High Hydrogen	High Biomethane
Hydrogen Cost	No Biomethane

Technical assumptions

Assumption	Approach/key sources
Wholesale electricity price	ACIL Allen PLEXOS modelling based on ISP assumptions
Natural gas costs	ACIL Allen *GasMark* modelling
Hydrogen costs	ACIL Allen modelling based on ISP solar and wind traces, AEMO and CSIRO capex assumptions
Biomethane costs and availability/volume	Bioenergy Roadmap assumptions
Carbon budget	See next slide
Use of offsets	No offsets allowed prior to 2050. Offsets volume limited to 4.2 Mt CO_2-e/year from 2050. Offset cost of $321/t$CO_2$-e in 2050.

Carbon budget

Source	ACIL Allen assumptions based on Australian Government emissions projections and Safeguard Mechanism Statement of Reasons.
Notes	Straight-line extrapolation from 2030 emissions levels to net zero in 2050.



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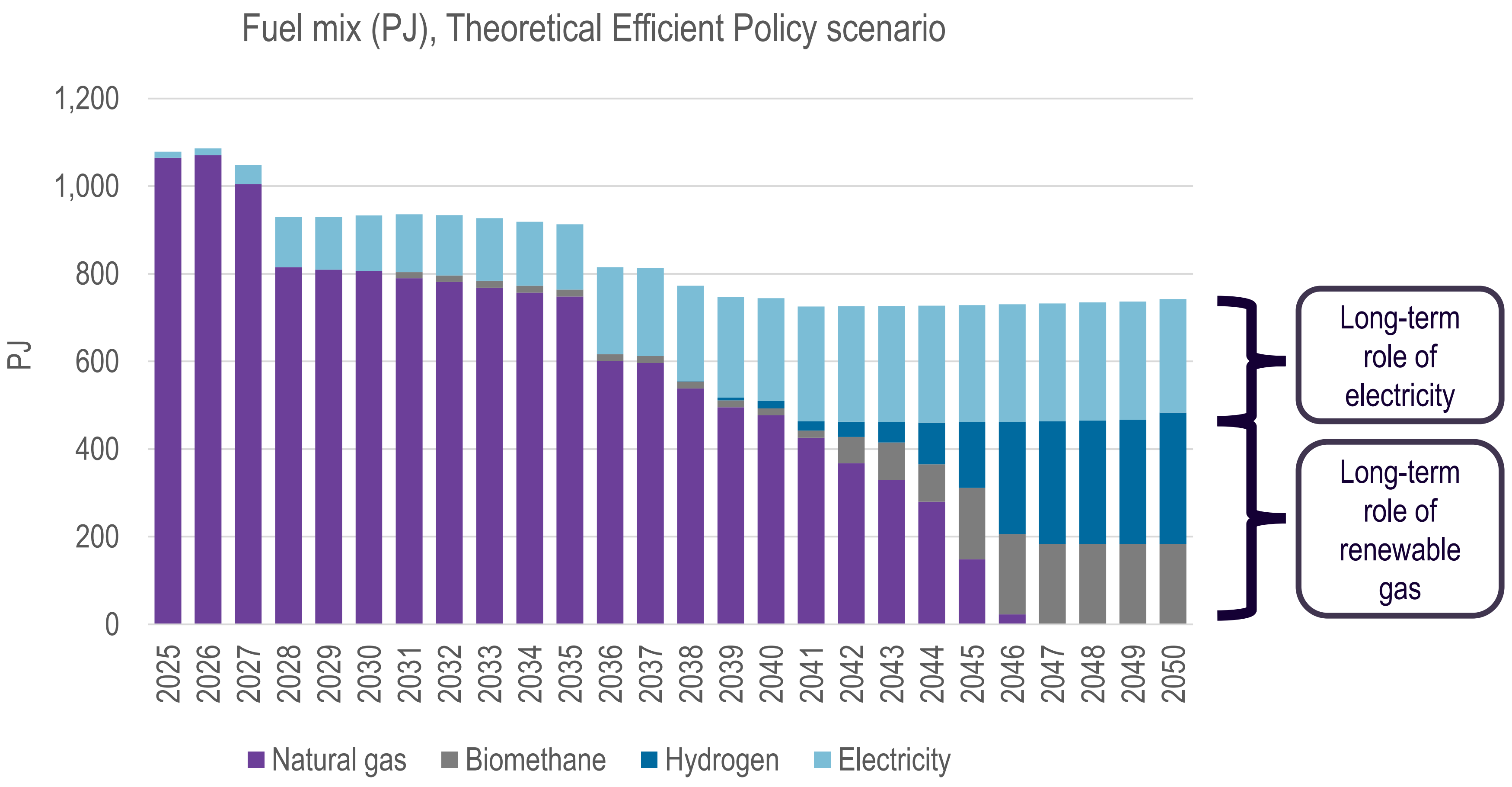
Theoretical Efficient Policy scenario and sensitivities

The modelling shows a prominent role for renewable gas



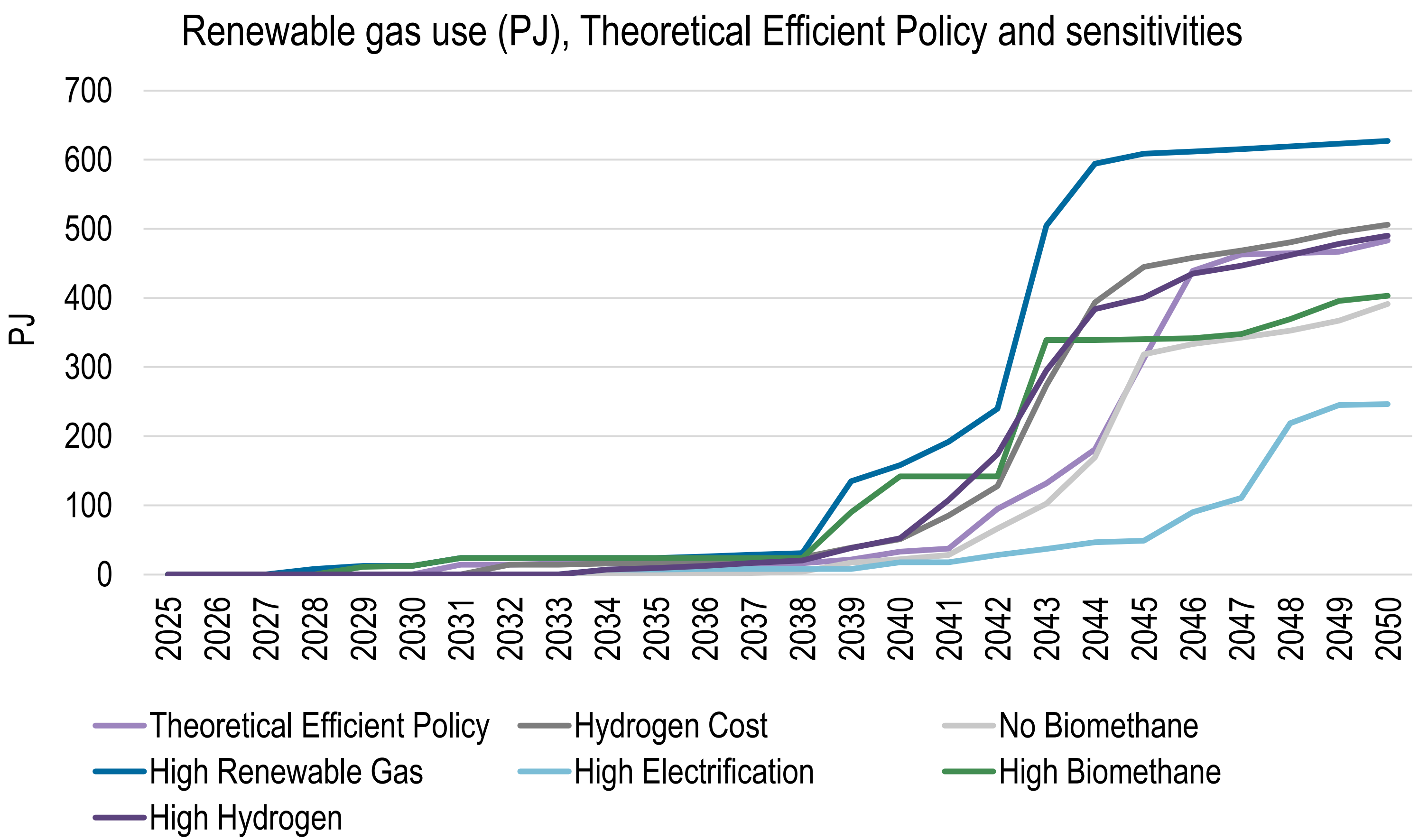
- Renewable gas provides about two-thirds of the long-term energy delivered to today's gas users, in our core scenario
- Electricity provides the remaining third
- Both hydrogen and biomethane play a role in this transition

POLICY INSIGHT
Renewable gas and electrification work together to decarbonise gas-using sectors

Renewable gas retains a significant role across a range of assumptions

- The volume and timing of renewable gas development is sensitive to assumptions
- However, even in the High Electrification sensitivity, we found a significant volume of renewable gas

POLICY INSIGHT
Even if technology trends favour electrification, multiple hundreds of petajoules of renewable gas will be needed to decarbonise hard-to-electrify sectors



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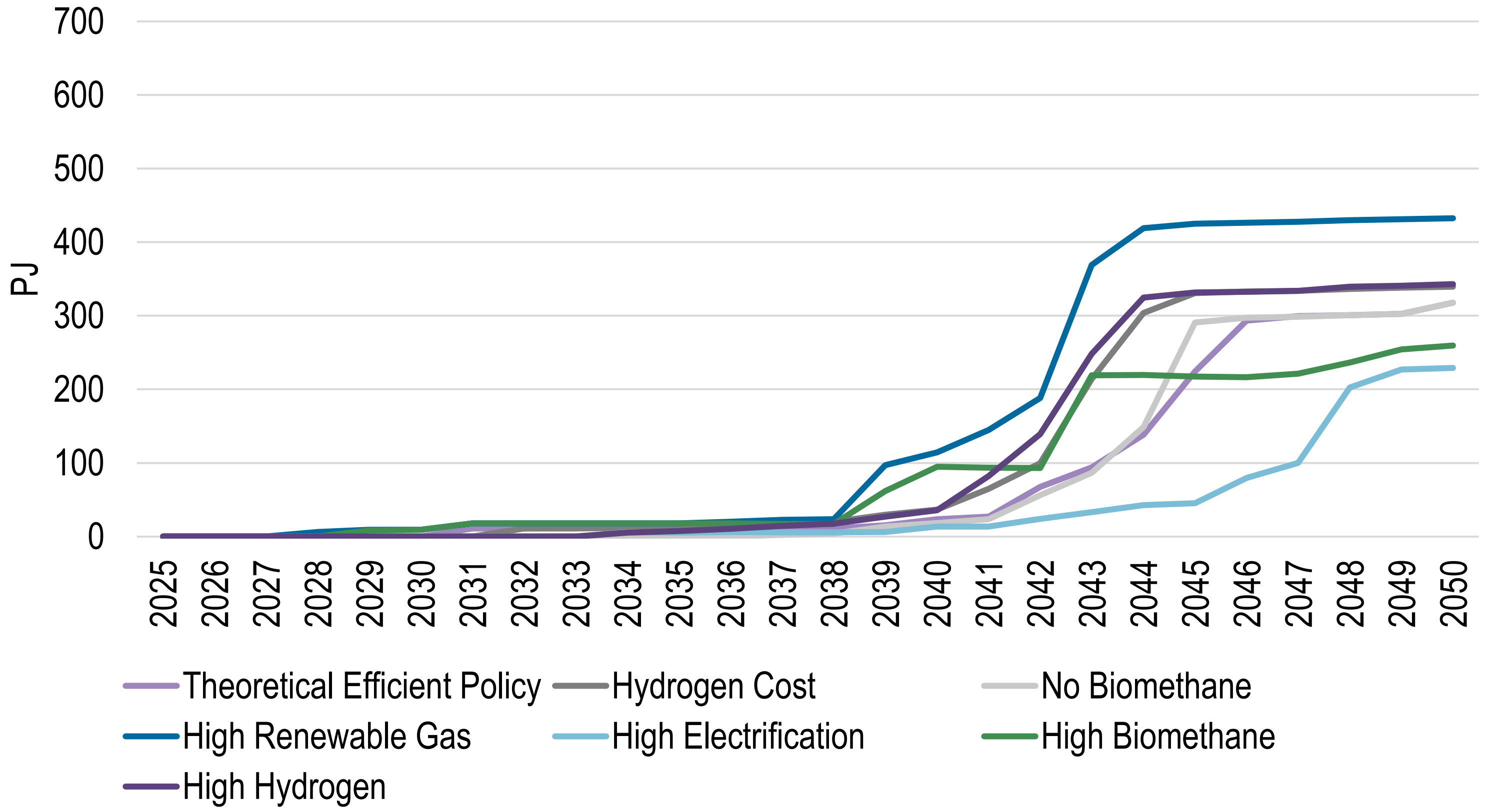
Industrial use of renewable gas is particularly robust

- Renewable gas demand was most robust in the industrial sector, with over 200 PJ demanded across all sensitivities
- This reflects the existence of large feedstock or high temperature process heat activities that are difficult or impossible to electrify

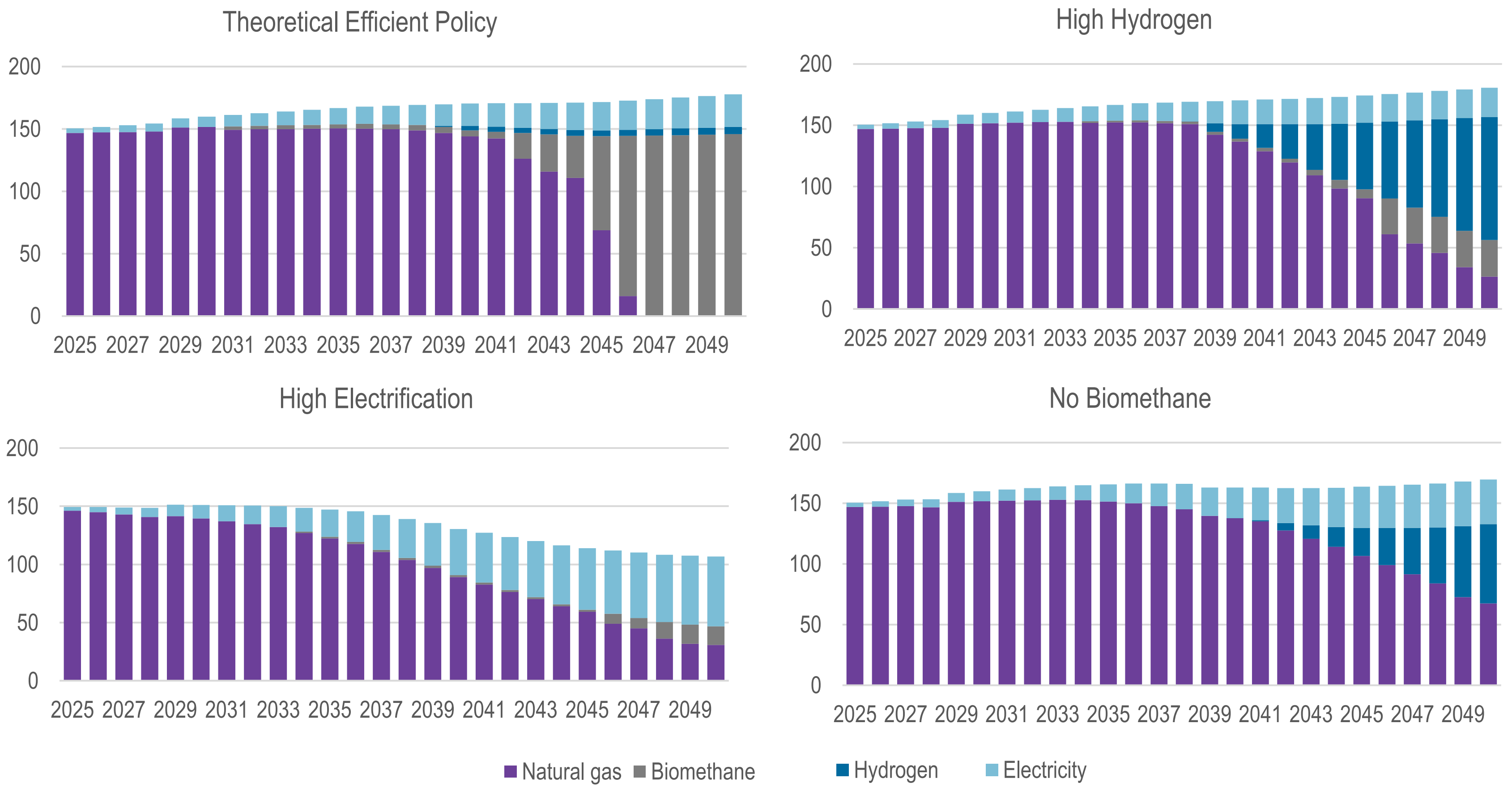
POLICY INSIGHT
Renewable gas will play an important role in ensuring a range of industrial activities remain viable in Australia in a decarbonising world

Industrial renewable gas use (PJ), Theoretical Efficient Policy and sensitivities



Sensitivity analysis shows a range of potential outcomes in the household sector

Residential fuel mix (PJ), Theoretical Efficient Policy scenario and selected sensitivities



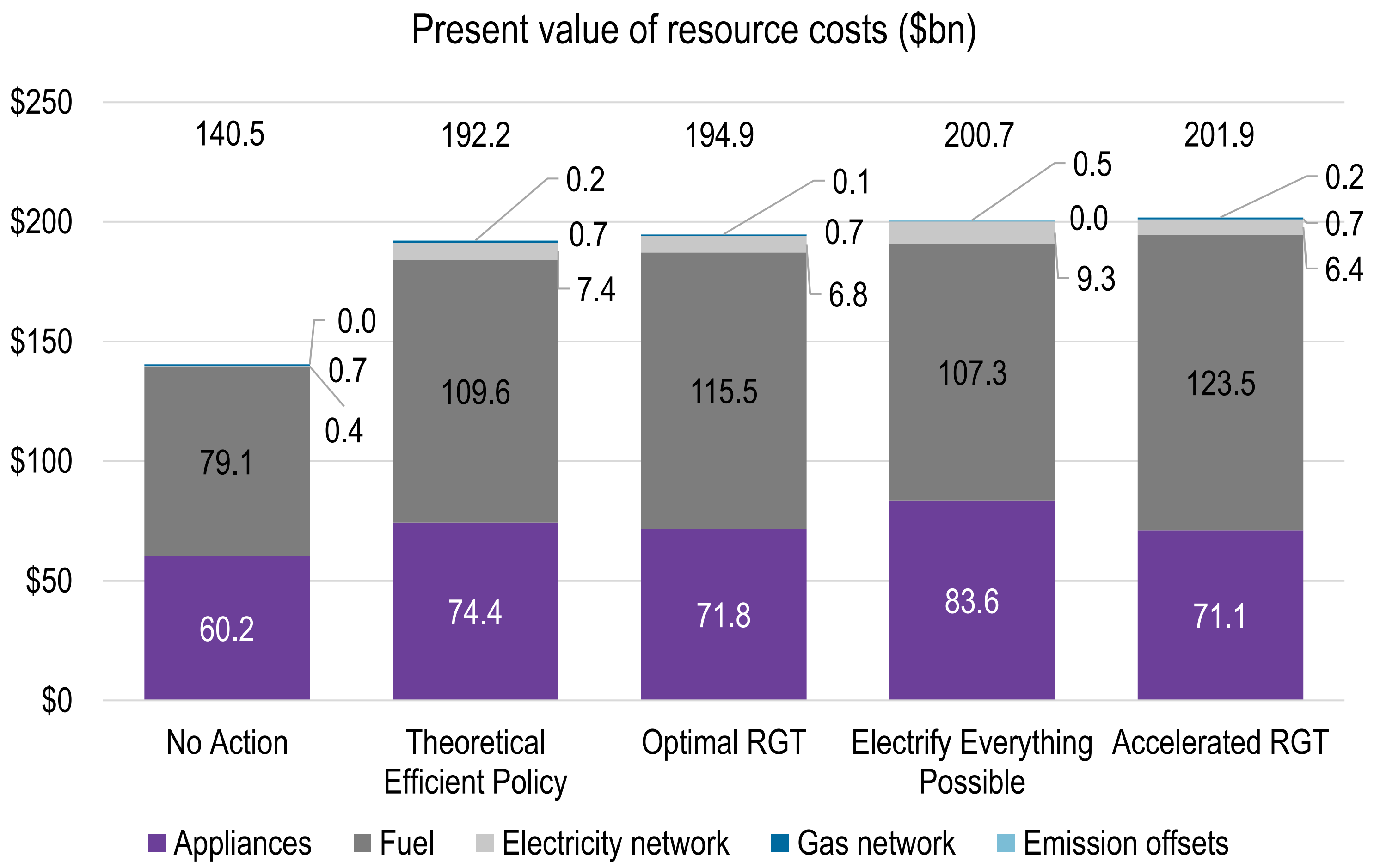
While the Theoretical Efficient Policy scenario showed a large role for biomethane in the long-run decarbonisation of households, sensitivity analysis showed that plausible shifts in assumptions could change this significantly

POLICY INSIGHT
A range of plausible pathways exist for decarbonising households, with significant potential roles for biomethane, hydrogen and electrification

Policy scenarios

Comparing the cost of policy scenarios

- This slide compares total cost of each policy scenario in present value terms
- The Theoretical Efficient Policy scenario is the lowest cost policy scenario, but it likely to be unachievable in the current policy environment
- The following slides consider the other policy scenarios in more detail



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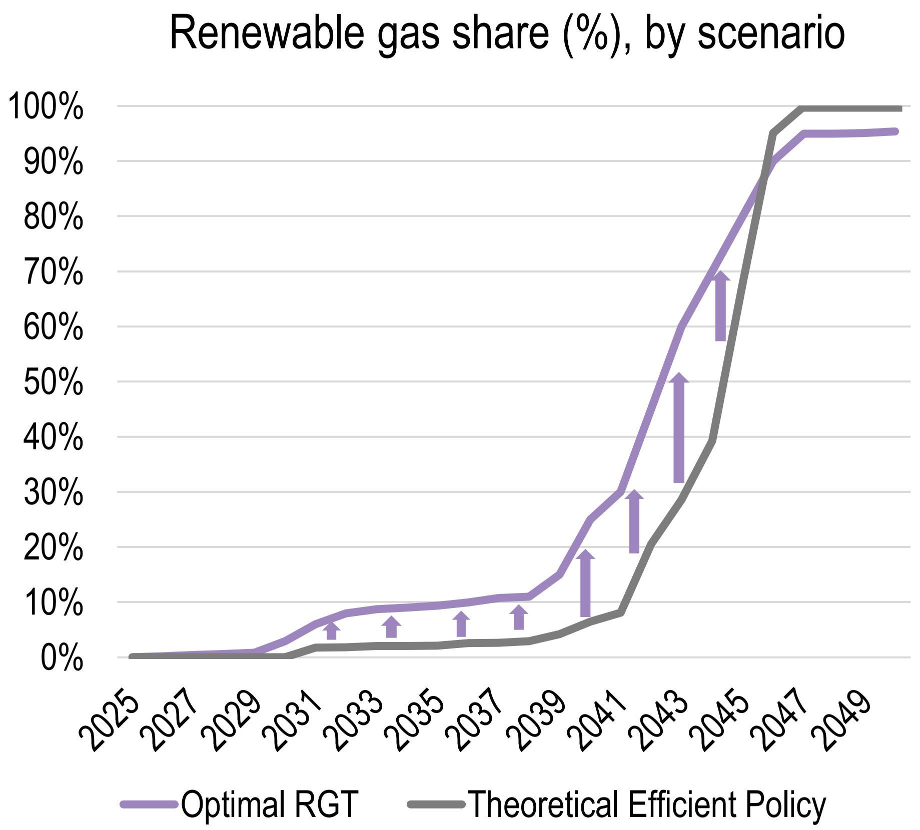
An Optimal RGT can be used to de-risk renewable gas development

- While an optimisation model with perfect foresight will leave renewable gas development until late (primarily in the 2040s), this is a risky strategy, as it ignores the human (skills) and logistical elements of scaling a new industry.
- An Optimal RGT can bring forward renewable gas development to reduce the risk of these constraints delaying the energy transition.

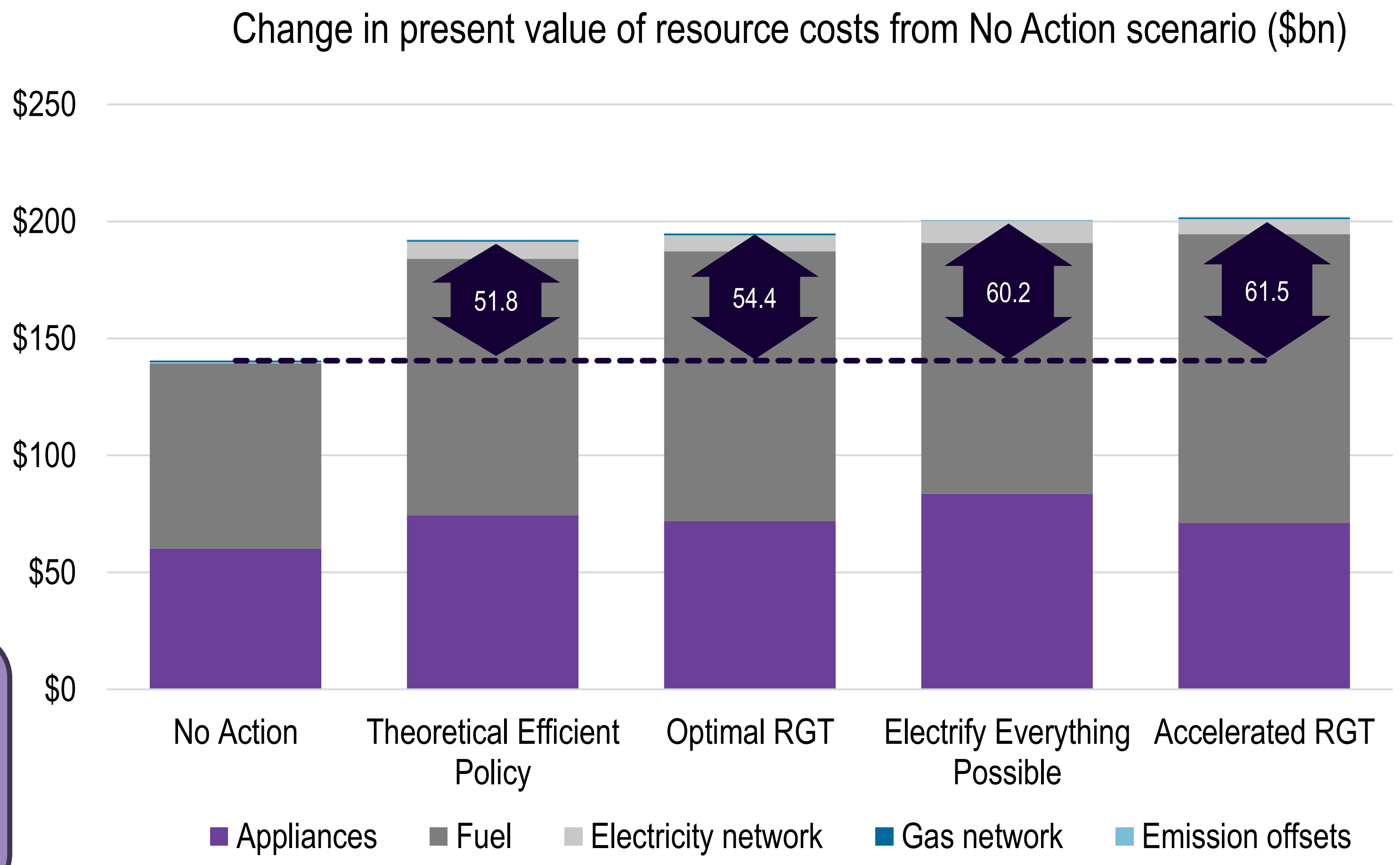
> POLICY INSIGHT
> An Optimal RGT can de-risk the development of the renewable gas industry



	Theor-etical Efficient Policy	Optimal RGT
2030	0%	3%
2035	2%	9%
2040	6%	25%
2045	68%	80%

Comparing the Theoretical Efficient Policy and Optimal RGT scenarios

Scenario	Cost relative to No Action	Cost of abatement ($/t$CO_2$-e)	Cost relative to TEP
Theoretical Efficient Policy (TEP)	51.8	$143	-
Optimal RGT	54.4	$150	2.6
Electrify Everything Possible	60.2	$165	8.4
Accelerated RGT	61.5	$164	9.7



POLICY INSIGHT
An Optimal RGT can decarbonise gas-using sectors at a cost only slightly higher than the theoretically efficient pathway

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Comparing the Optimal RGT and Electrify Everything Possible scenarios

Scenario	Cost relative to No Action	Cost of abatement ($/t$CO_2$-e)	Cost relative to TEP
Theoretical Efficient Policy (TEP)	51.8	$143	-
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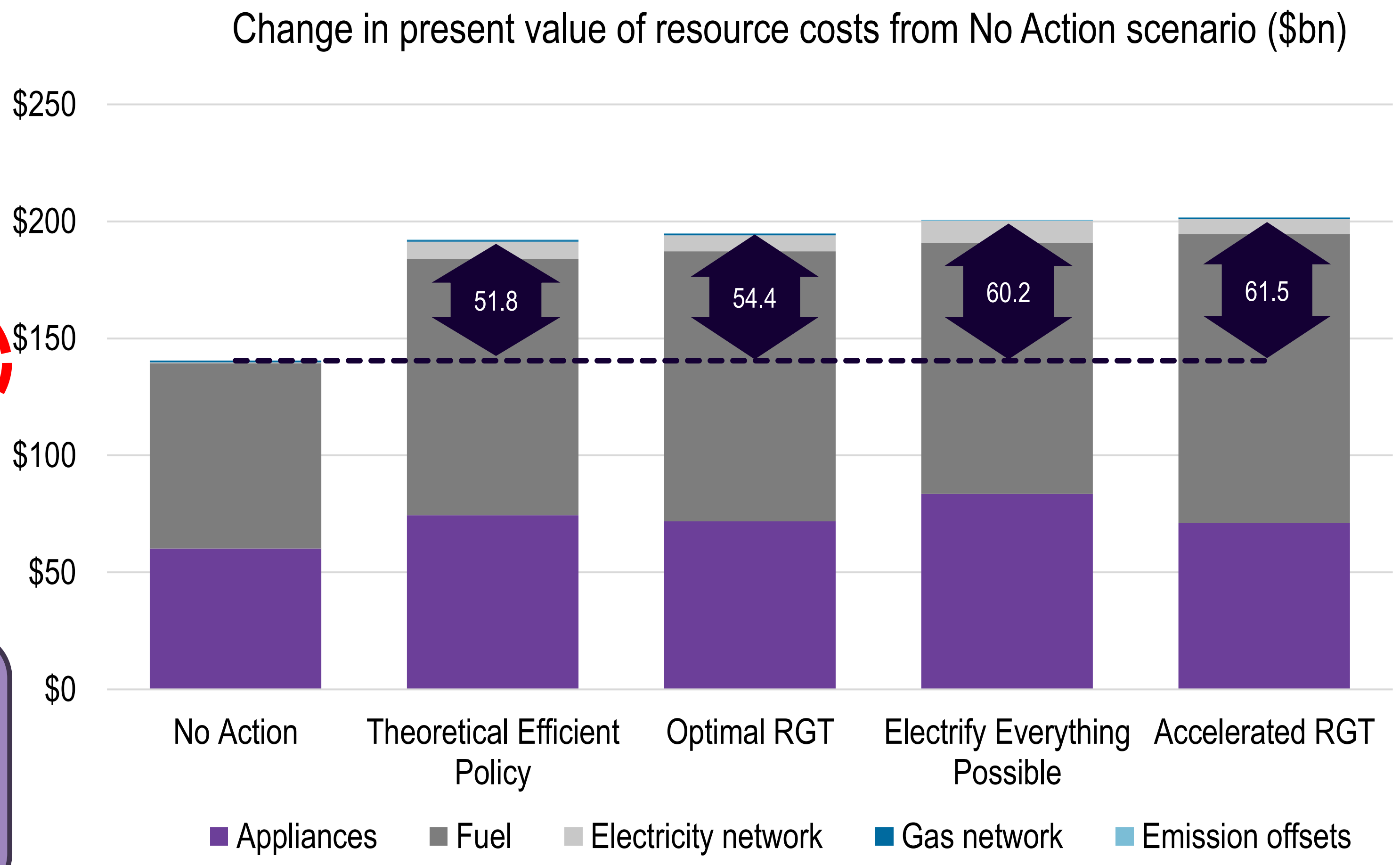
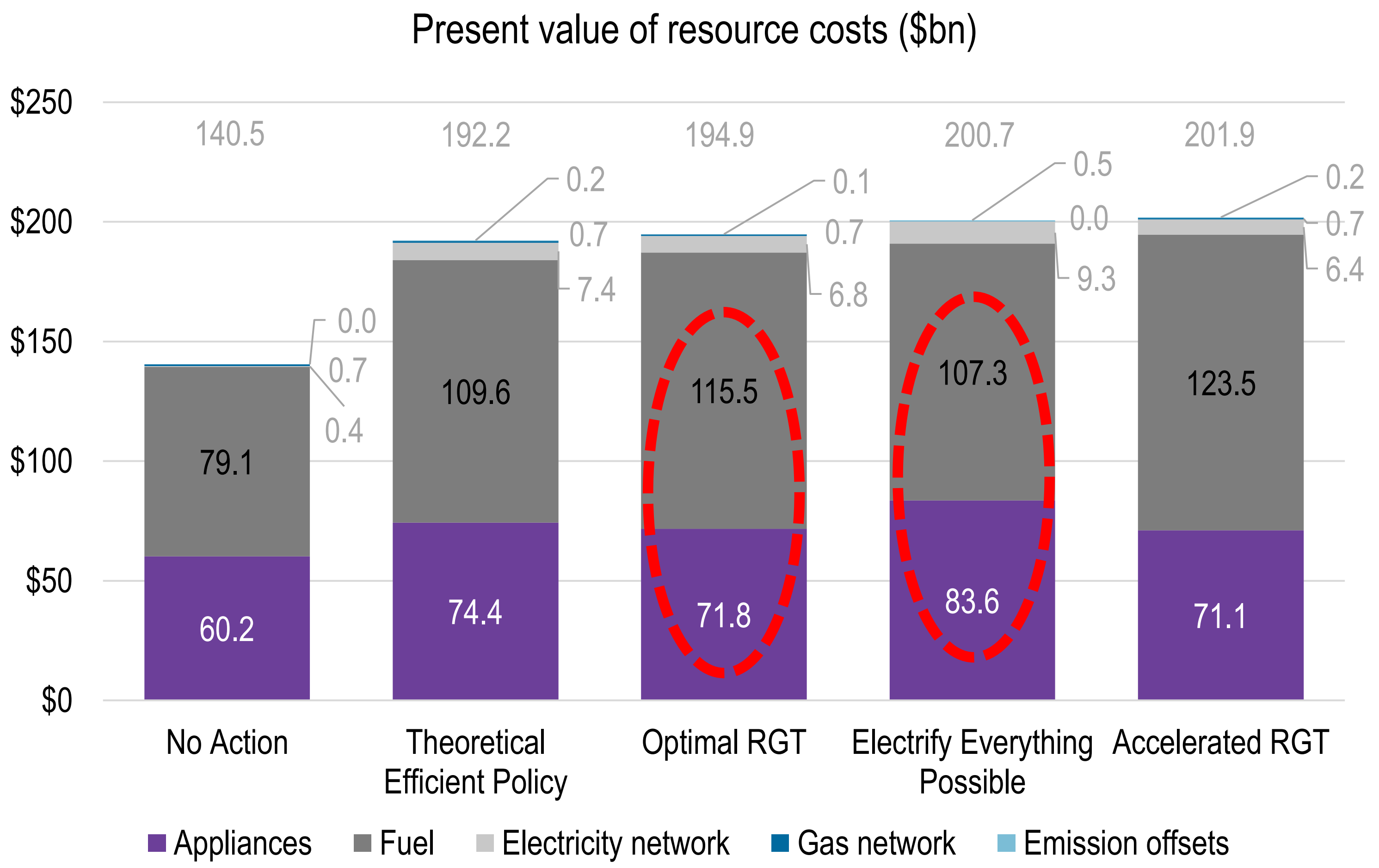


POLICY INSIGHT
A balanced policy approach that supports both renewable gas and electrification will reduce the long-term cost of the transition

Investment to support the transition

- Comparing the numbers highlighted in the red circles illustrates an important aspect of the transition
- Electrification requires relatively more investment by end-users in appliances, some of whom will be capital constrained
- Adoption of renewable gas involves relatively less investment by users, and more by energy suppliers

POLICY INSIGHT
A balanced policy approach that supports both renewable gas and electrification will reduce the investment burden for energy users



Understanding the cost of accelerated action

Scenario	Cost relative to No Action	Cost of abatement ($/tCO$_2$-e)	Cost relative to TEP
Theoretical Efficient Policy (TEP)	51.8	$143	-
Optimal RGT	54.4	$150	2.6
Electrify Everything Possible	60.2	$165	8.4
Accelerated RGT	61.5	$164	9.7

- While the Accelerated RGT scenario has higher costs in absolute terms than the Electrify Everything Possible scenario, it also achieves greater and earlier emissions reductions
- The per unit abatement cost of the two scenarios are comparable (see numbers highlighted in the red circles)

POLICY INSIGHT

Accelerating emissions reductions using an RGT will increase cost, but the unit cost of abatement remains essentially the same as an electrification-focused approach

Economy-wide results

The effects of inefficient policy mechanism are amplified at the whole-of-economy level

- The costs imposed by less efficient policies are magnified at the whole-of-economy levels due to:
  - Changes to taxes
  - Changes to real wage rates or employment.
- This translates to a whole of economy cost of over $30 billion in present value terms when comparing the Electrify Everything Possible scenario and the Optimal RGT scenario.

Scenario	Emissions (2025-2060)	Present value of resource cost (2020-2060)	Abatement cost	Change in real economic output (GDP) relative to No Action scenario (2020-2060)	Change in GDP relative to Theoretical Efficient Policy scenario (2020-2060)
	Mt CO_2-e	$b	$/tonne CO_2-e	$b	$b
No Action	1,591	$140			
Theoretical Efficient Policy	724	$192	$143	-$121	$0
Electrify Everything Possible	729	$201	$165	-$154	-$33
Optimal RGT	722	$195	$150	-$124	-$3
Accelerated RGT	714	$202	$164	-$150	-$29

Discussion and questions

Conclusions

- The modelling shows a significant role for renewable gas in decarbonising today's gas-using sectors.
  - This finding is robust to sensitivity analysis, though there is significant uncertainty over the timing and scale of renewable gas development.
- An RGT is an efficient policy to develop renewable gas and decarbonise gas-using sectors.
  - The modelling shows that it is slightly higher cost than the theoretically efficient, but practically unachievable, approach of using a broad-based carbon price.
  - The modelled pathways also ignore real world factors such as the need to develop skills and build confidence in emerging industries such as renewable gas, and so delay development later than what is likely to be desirable.
- A more heavily electrification-focused approach has higher overall costs, indicating the need for policy to strike a balance between electrification and renewable gas
- At the sectoral level:
  - the household sector has a range of plausible decarbonisation pathways involving both renewable gas and electrification
  - the industrial sector has a number of hard-to-electrify activities and renewable gas is likely to be essential.

For more information

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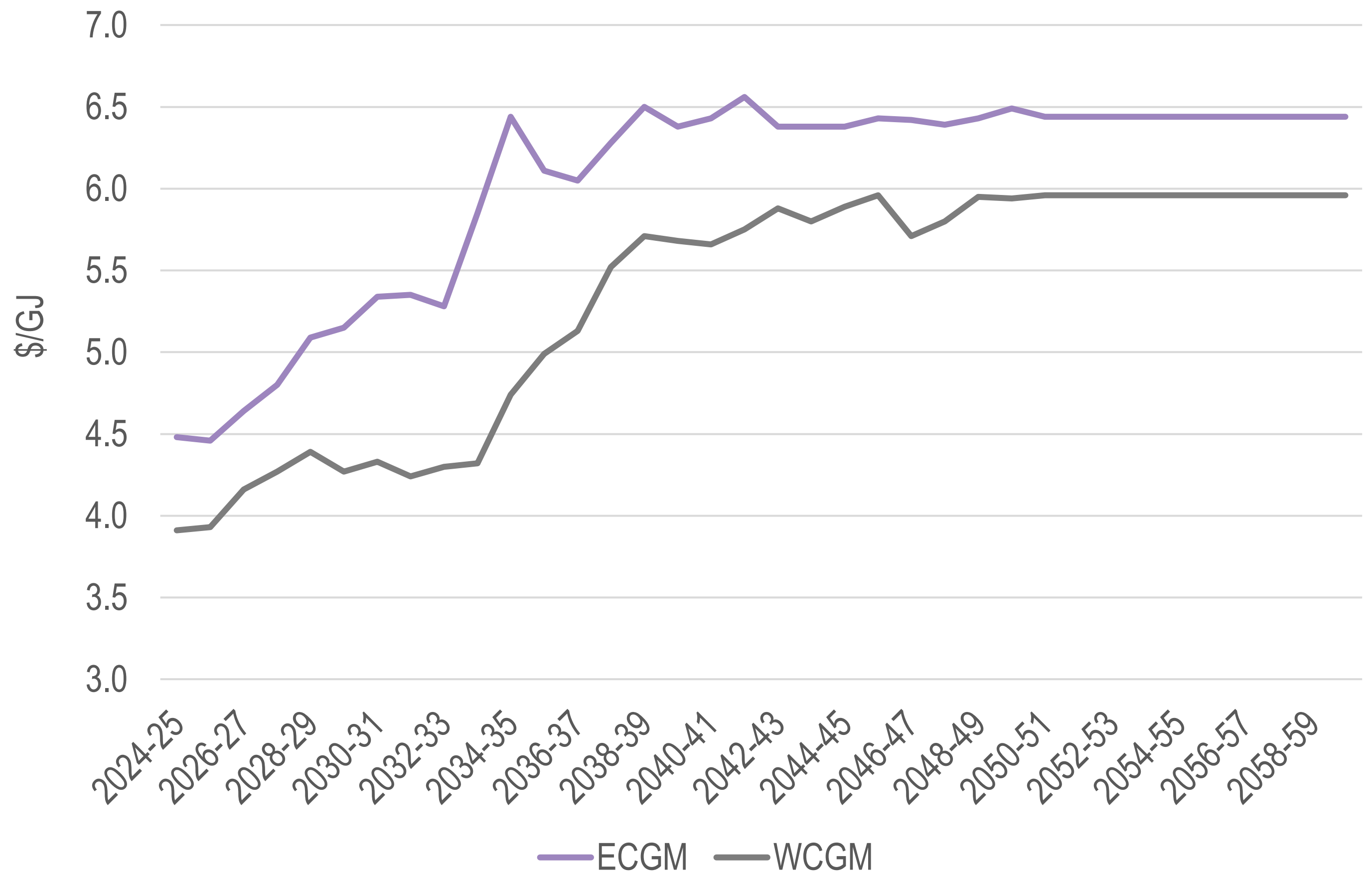
Additional detail on assumptions

Sensitivity analysis assumptions

Sensitivity	Electrical appliance capex	Wholesale hydrogen cost	Wholesale biomethane cost	Biomethane availability (volume)
Hydrogen Cost		-20%		
No Biomethane				-100%
High Renewable Gas	+20%	-20%	-20%	+50%
High Electrification	-20%	+20%	+20%	-50%
High Hydrogen		-20%	+20%	-50%
High Biomethane		+20%	-20%	+50%

Wholesale natural gas costs

Source	ACIL Allen GasMark modelling
Notes	Costs reflect the change in productions costs due to a change in demand, not market prices. ECGM = East coast gas market WCGM = West coast gas market



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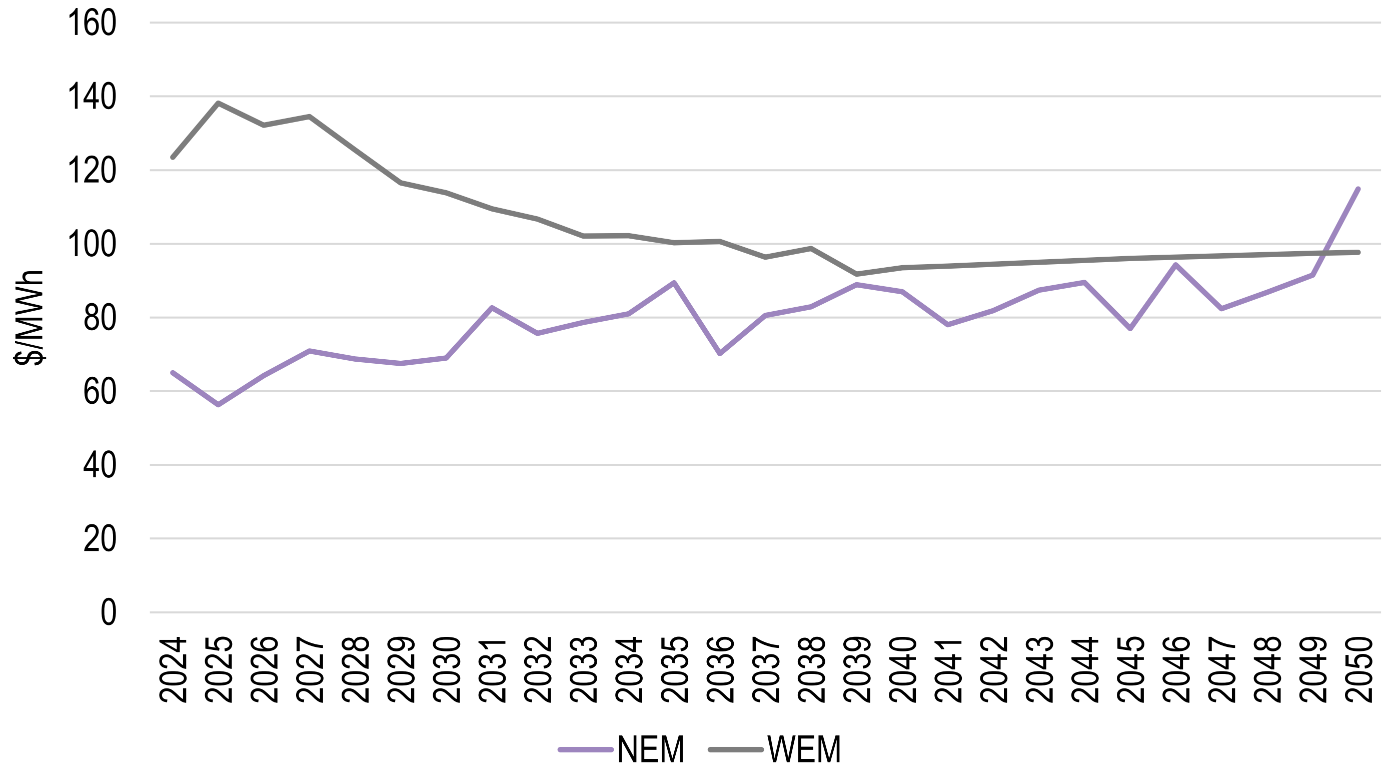
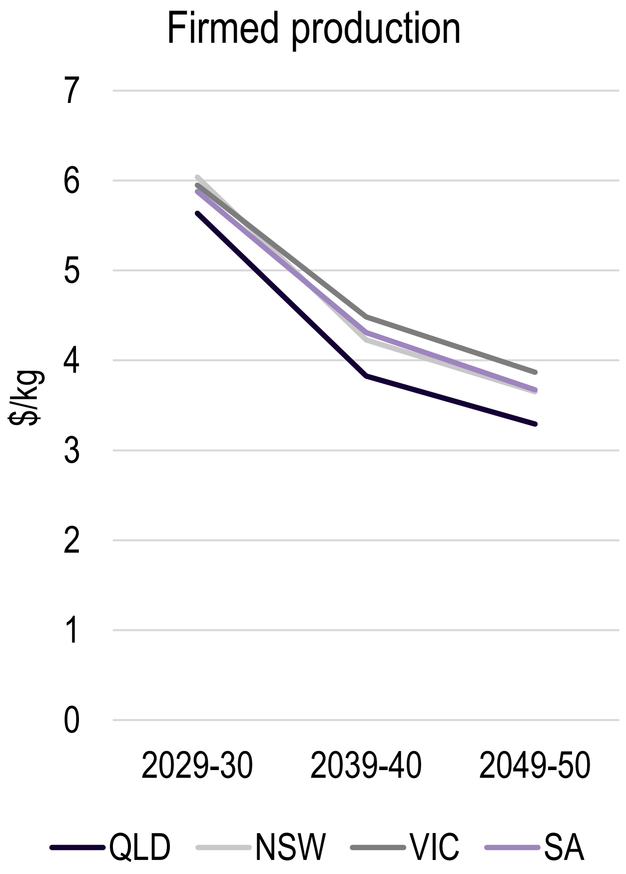
Wholesale electricity costs

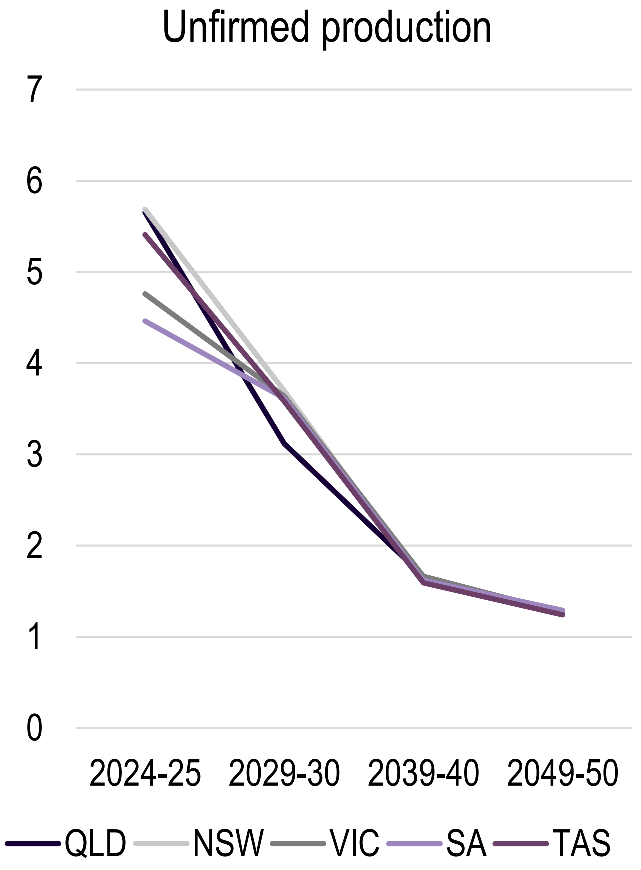
Source	ACIL Allen PLEXOS modelling
Notes	Costs reflect the change in generation costs due to a change in demand, not market prices. NEM = National Electricity Market WEM = Wholesale Electricity Market (WA)



Wholesale hydrogen costs

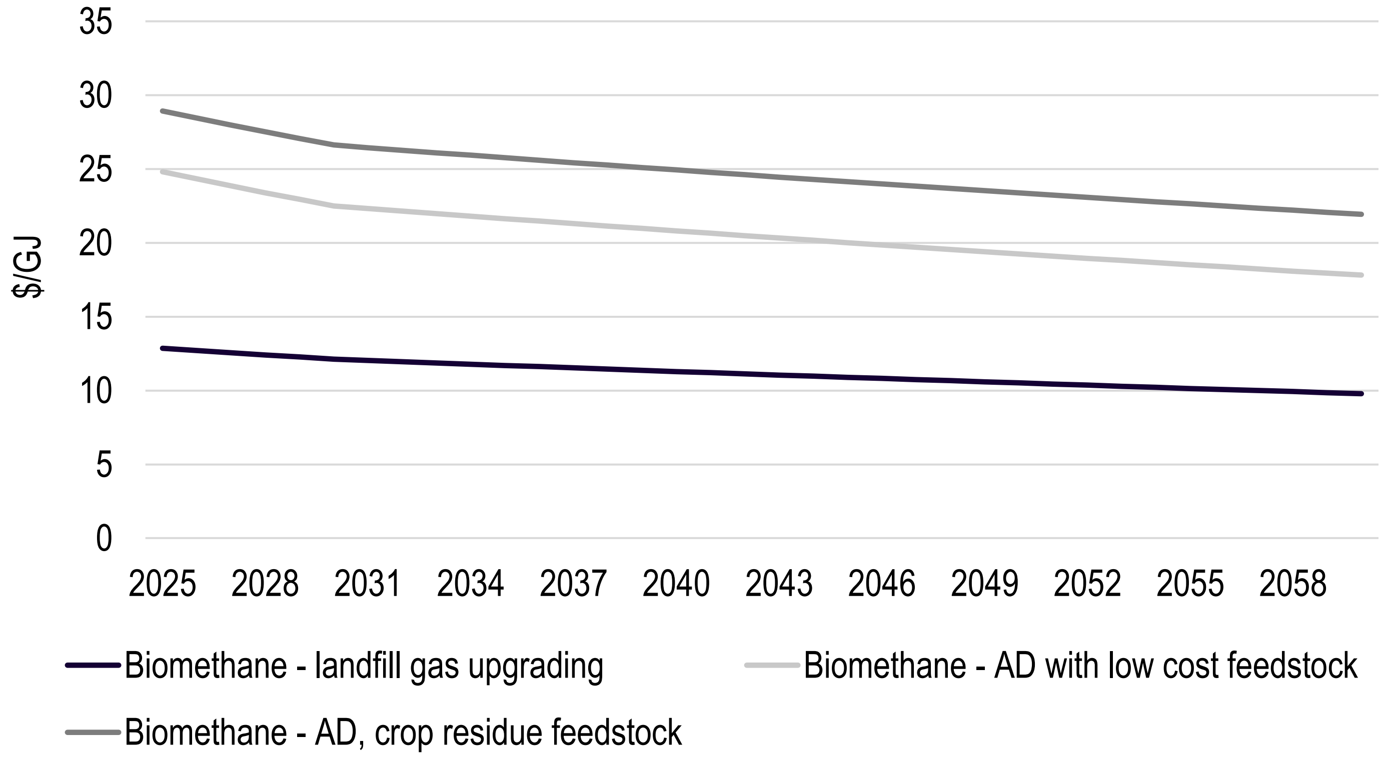
Source	ACIL Allen modelling using various sources: - AEMO ISP - CSIRO GenGost - APGA pipeline costs - PowerMark modelling
Notes	Firmed costs include pipeline delivery to nearest demand centre. Unfirmed hydrogen can only be used when blended into natural gas streams in limited quantities.





Biomethane costs

Source	Bioenergy Roadmap (Deloitte & Enea)
Notes	Low cost feedstock is available from concentrated waste streams such as wastewater or food processing. AD = anaerobic digestion



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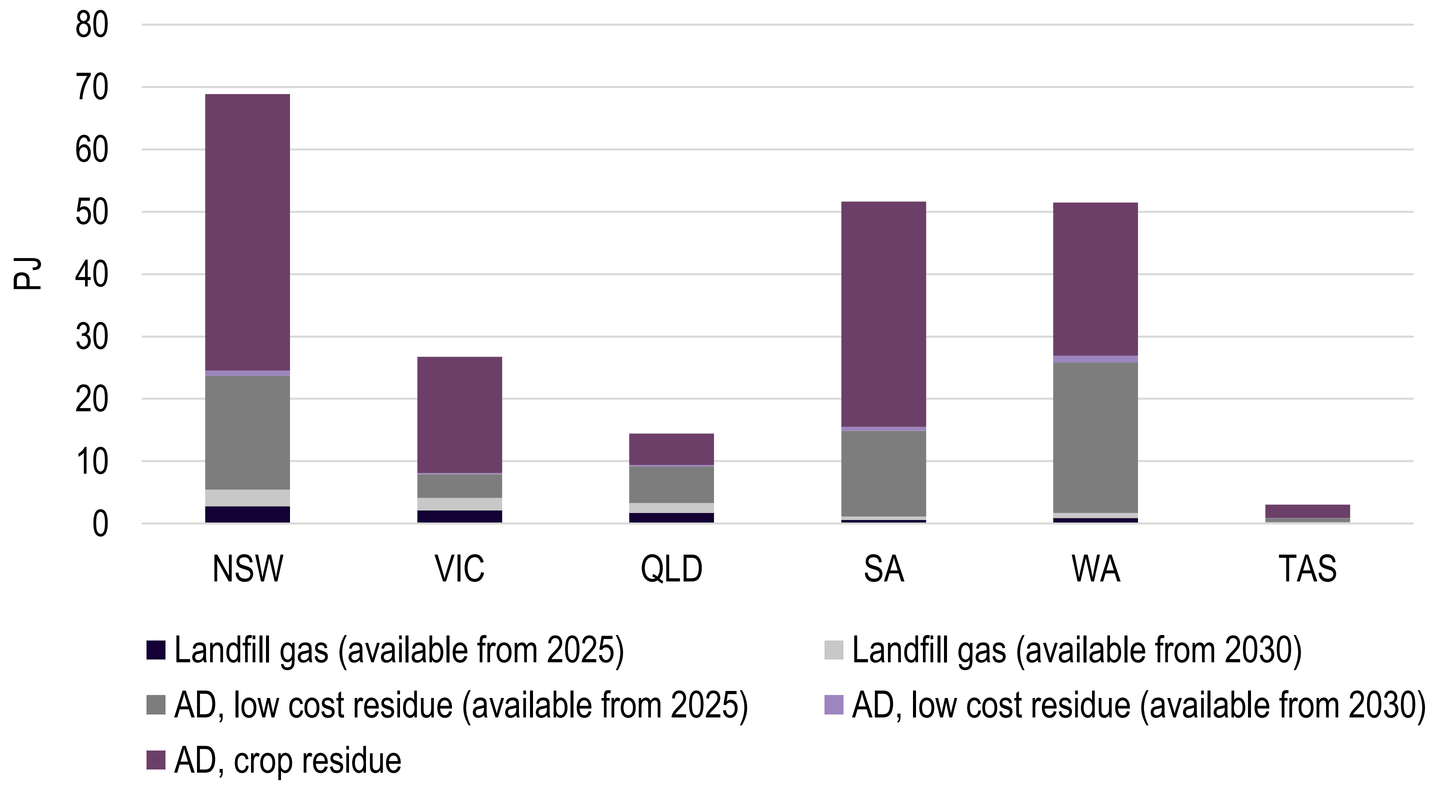
Biomethane volumes

Source	Bioenergy Roadmap (Deloitte & Enea)
Notes	Some sources are not made available to the model prior to 2030 due to assumed committed use under the Large-scale Renewable Energy Target (e.g. for electricity generation from biogas). AD = anaerobic digestion



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Activities and appliance efficiency

Activity	Sectors/ sub-sectors	Electrical appliance efficiency	Gaseous fuel appliance efficiency
Low temperature heat	Agriculture, food & beverage, other manufacturing, gas distribution	300%	85%
High temperature heat	Gas processing, food & beverage, pulp & paper, petroleum & coal products, other chemicals, iron and steel, other non-ferrous metals other manufacturing,	85%	65%
Compression	Gas processing, gas transmission, LNG	94%	30%
Ammonia synthesis	Ammonia and derivatives	N/A	N/A
Urea	Ammonia and derivatives	N/A	N/A
Glass making	Glass	85%	50%
Metal reheat	Fabricating, machinery and equipment, iron and steel	75%	65%
Calcining	Alumina	N/A	65%
Digestion	Alumina	330%	80%
LNG power generation	LNG	100%	36%
Cooking	Commercial, residential	85%	20%
Hot water	Commercial, residential	95-350%	85%
Space heating	Commercial, residential	300-400%	80%