Hydrogen: hype, hope, or hard work?

AARES Pre-conference Workshop
Net Zero Pathways

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Hydrogen: a quick primer

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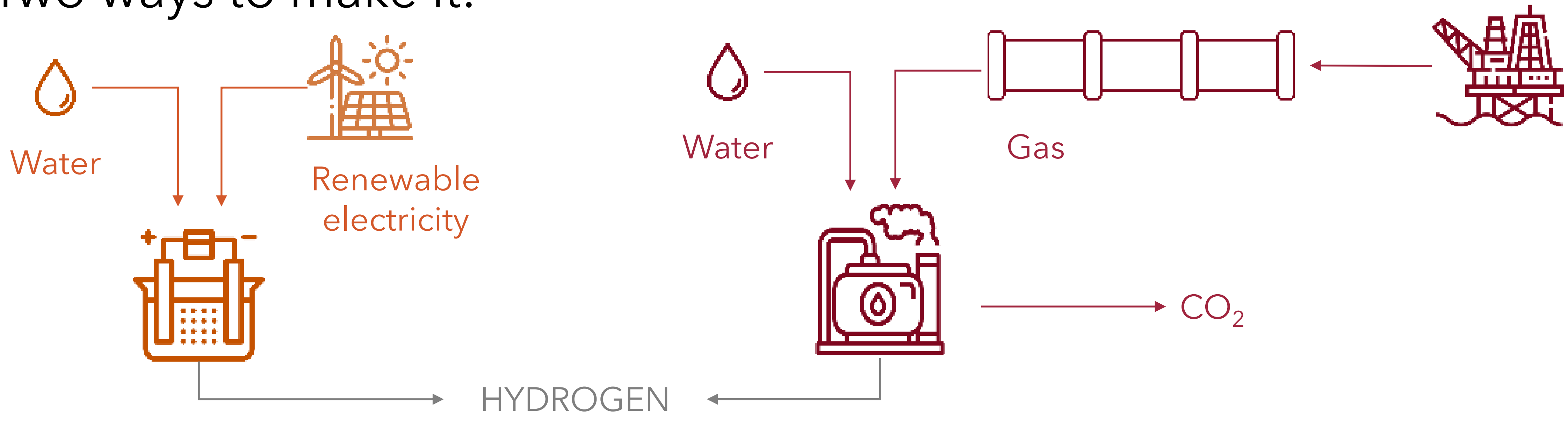
- Smallest, lightest, most abundant molecule in the universe
- Contains very large amounts of energy
- No emissions when burned
- Rarely occurs in nature
- Two ways to make it:



The hype

Hydrogen!

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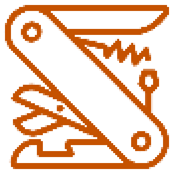
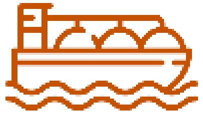


It's clean energy for everything!



It's the next big energy export!

It can solve the energy trilemma!

Hydrogen is second-best for most applications

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Application
Ammonia manufacturing: replace grey hydrogen with green hydrogen in the Haber-Bosch process
Alumina refining: replace natural gas with green hydrogen for high-temperature heat for calcination
Iron making: replace blast furnace and coal with direct reduction using green hydrogen
Electricity generation: replace gas generators with green hydrogen for back-up electricity
Synthetic fuel: replace fossil fuels with fuels synthesised using green hydrogen and carbon for aircraft
Methanol manufacturing: replace grey hydrogen with green hydrogen in the methanol synthesis process
Long-distance road freight transport: replace diesel vehicles with green hydrogen in fuel cell vehicles
Cement manufacturing: replace fossil fuels with green hydrogen for high-temperature heat for clinker calcination
Other manufacturing: replace natural gas with green hydrogen for medium- and low-temperature heat
Residential and commercial heating and cooking: replace natural gas with green hydrogen for combustion
Oil refining: replace grey hydrogen with green hydrogen for lowering the sulfur content of diesel
Light vehicles: replace petrol and diesel vehicles with green hydrogen in fuel cell vehicles
Liquid hydrogen exports: produce hydrogen for export in liquid hydrogen tankers

It's expensive

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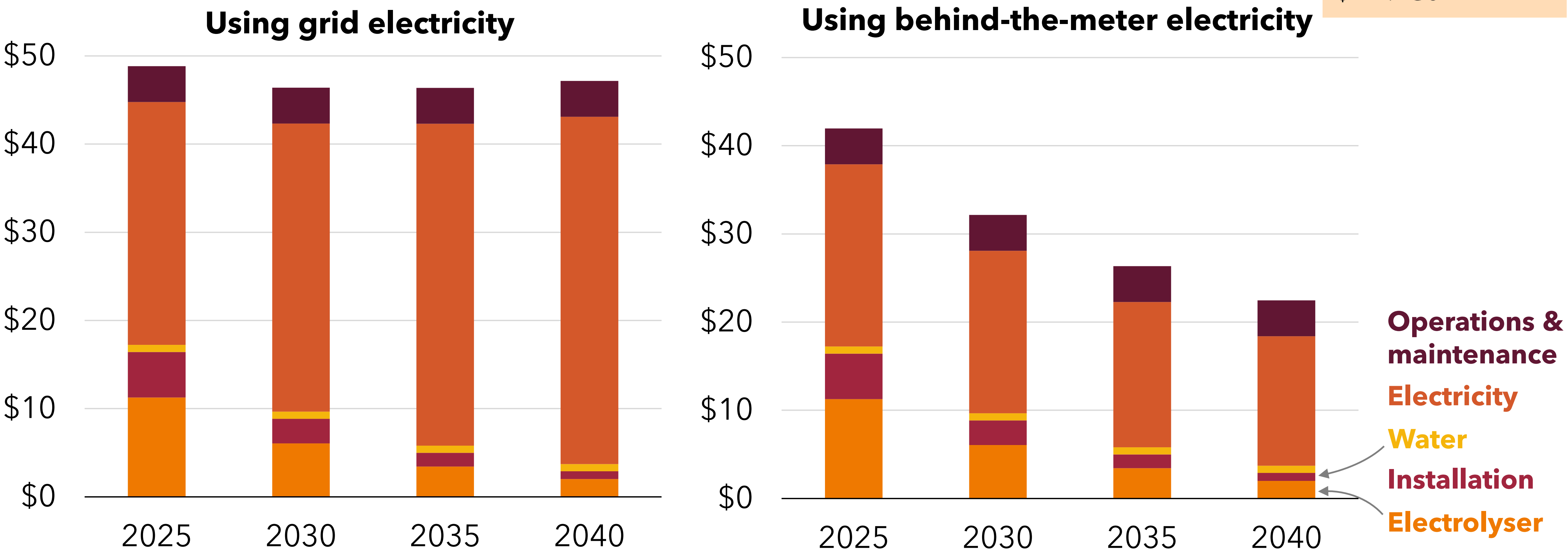
AU$/GJ of hydrogen

Current gas price
$12 / GJ



Notes: Hydrogen costs are in real 2023 dollars, levelized over 20 year project life.

Source: Grattan analysis. Aurecon (2022), Graham et al. (2023), IPART (2020), IRENA (2020), Newborough and Cooley (2021), and Oakley Greenwood (2022).

Export thinking has changed

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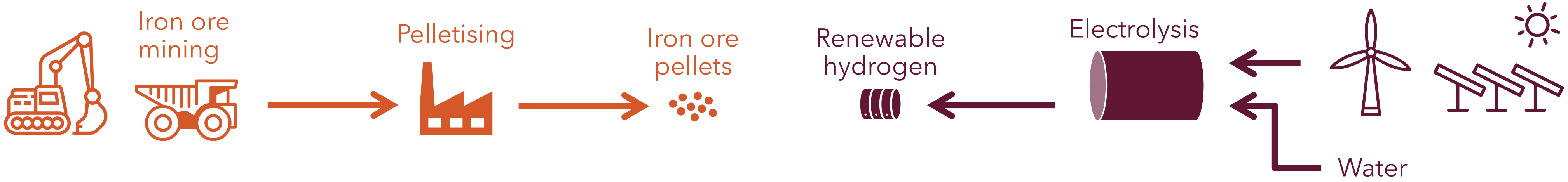


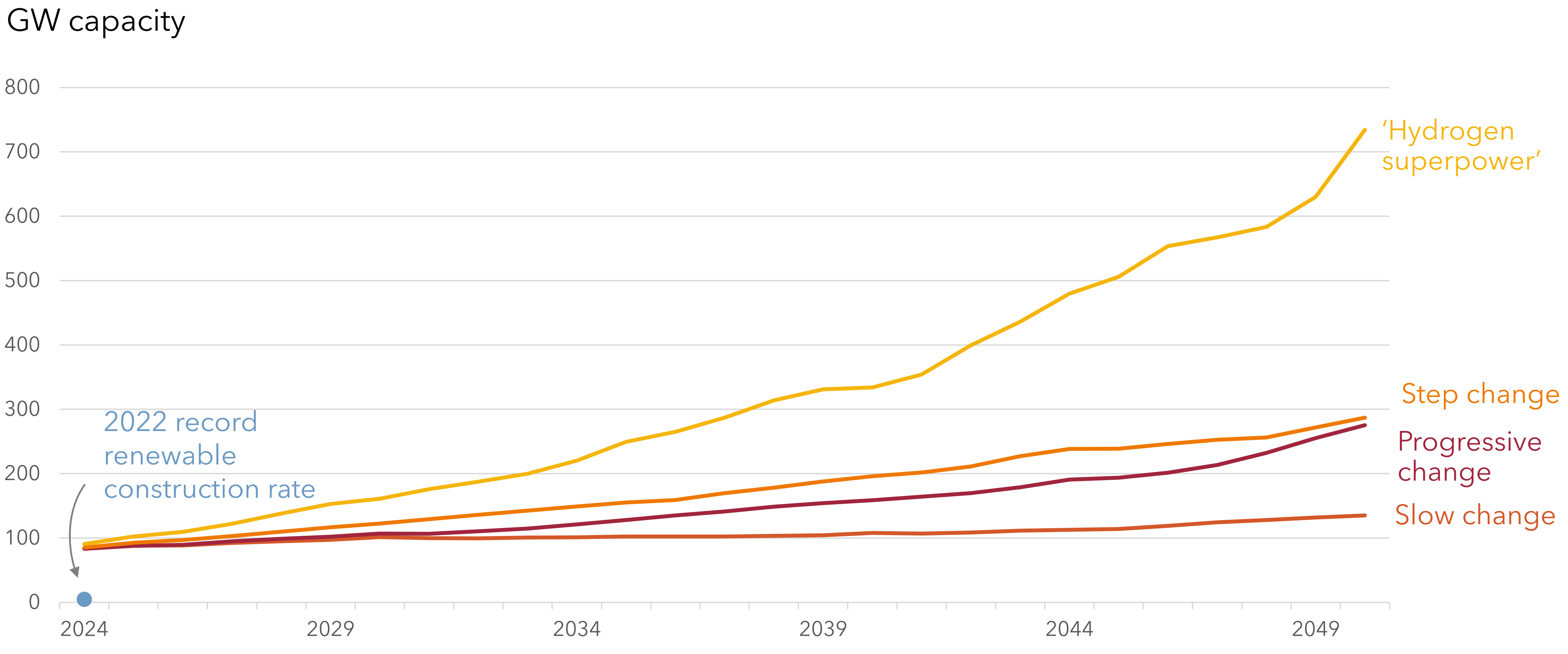
Old thinking

- Ship the iron ore
- Ship the hydrogen

New thinking

- Combine the iron ore and the hydrogen in Australia
- Ship the iron (or steel)

We would struggle to build the electricity required



2022 ISP

Most households save money today by using electricity rather than gas

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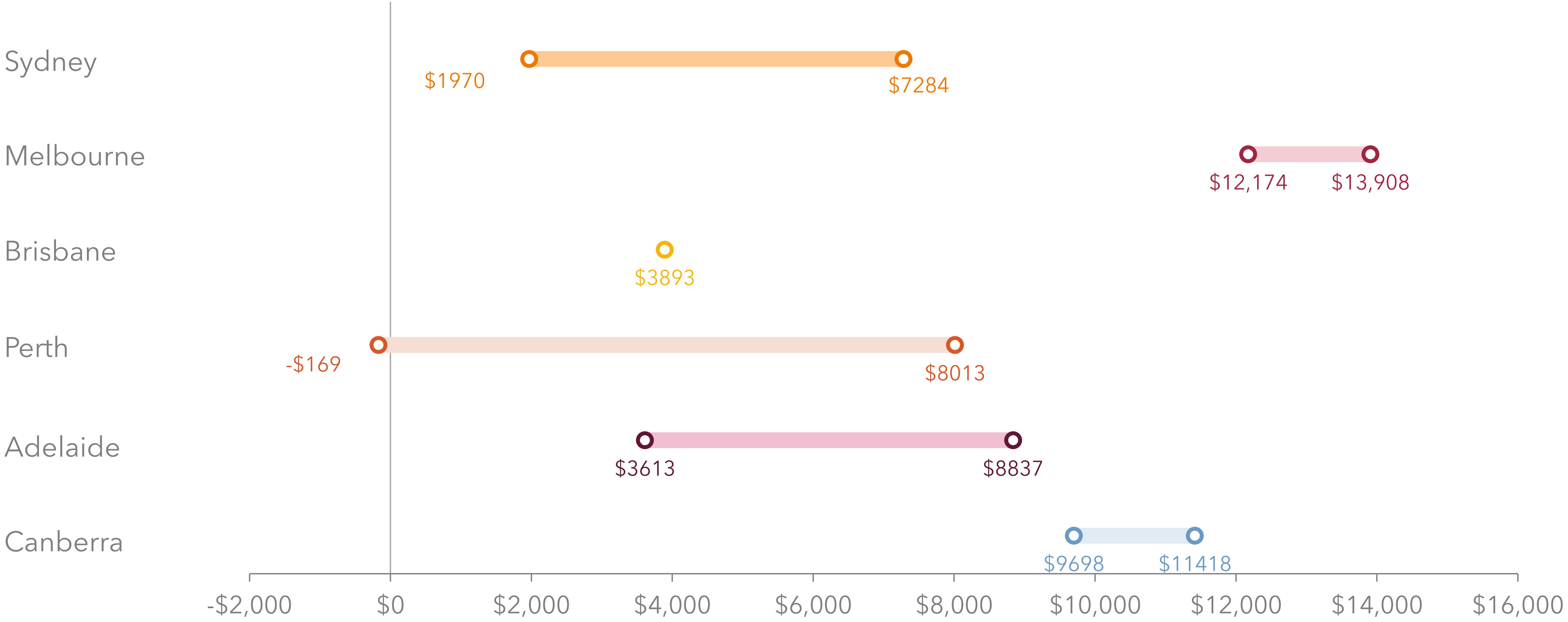
Estimated household savings range from all-electric homes ($/year)



Source: Grattan analysis. See Appendix B

The hope

Australia needs to be strategic about hydrogen

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Develop a hydrogen industry capable of supplying reliable, low-cost hydrogen for Australian industries where it would add greatest strategic value.

Where to start?

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Application	Technical alternatives	Supply chain complexity	Abatement potential	Export readiness	
Ammonia manufacturing					Good bets
Alumina refining					
Iron making					
Electricity generation				N/A	Maybe
Synthetic fuel					
Methanol manufacturing					
Long-distance road freight transport				N/A	
Cement manufacturing					
Other manufacturing					
Residential and commercial heating and cooking				N/A	Forget it*
Oil refining					
Light vehicles				N/A	
Liquid hydrogen exports*			N/A		

*unless someone else underwrites it

The hard work?

Policy recommendations

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Deliver cheap, green, reliable electricity

Use carbon pricing appropriately

Unblock construction constraints

Use sector-wide policies to remove barriers to hydrogen use

$/$

Industry policy to develop green commodity exports

Find out more

Read the report:
grattan.edu.au/report/hydrogen-hype-hope-or-hard-work/

Listen to the podcast:
https://www.youtube.com/c/grattaninstituteaustralia

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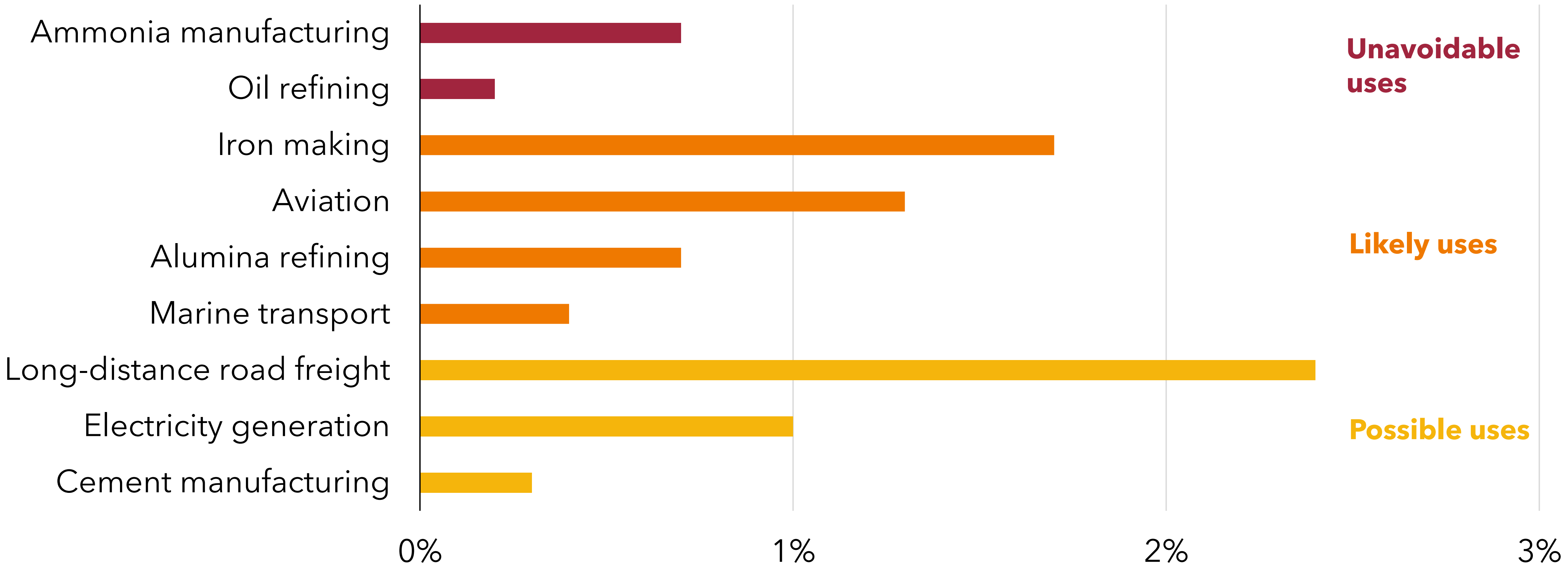
Hydrogen-based processes could help to abate some carbon-intensive processes in Australia

Emissions due to processes that could be replaced with hydrogen-based processes, % of Australian emissions



Notes: All numbers are for 2020 or 2019-20 except oil refining, which is for 2022. This is a scenario analysis of the maximum scope 1 domestic emissions abatement that can be achieved if all carbon-emitting processes that could technically be replaced by zeroemissions hydrogen-based processes are replaced (see Appendix A). Marine transport and aviation use total domestic marine and aviation emissions. The categorisation of processes is by whether they are likely to require green hydrogen to decarbonise. Some minor uses are omitted for space. This is not a prediction of the abatement that will be achieved by the adoption of zero-emissions hydrogen-based processes.

Source: Grattan analysis of ABS (2020), Cement Industry Federation (2023), DCCEEW (2023a), DCCEEW (2023b), DCCEEW (2023c), DCCEEW (2023d), Deloitte and ARENA (2022), International Aluminium Institute (2023), Kildahl et al (2023), McConnell et al (2023), Rocky Mountain Institute (2020), Pardo and Moya (2013), USGS (2022), VDZ (2021, p. 11), and World Steel Association (2023).

World ammonia demand will remain steady across its current uses, and probably grow for new uses in shipping and power generation

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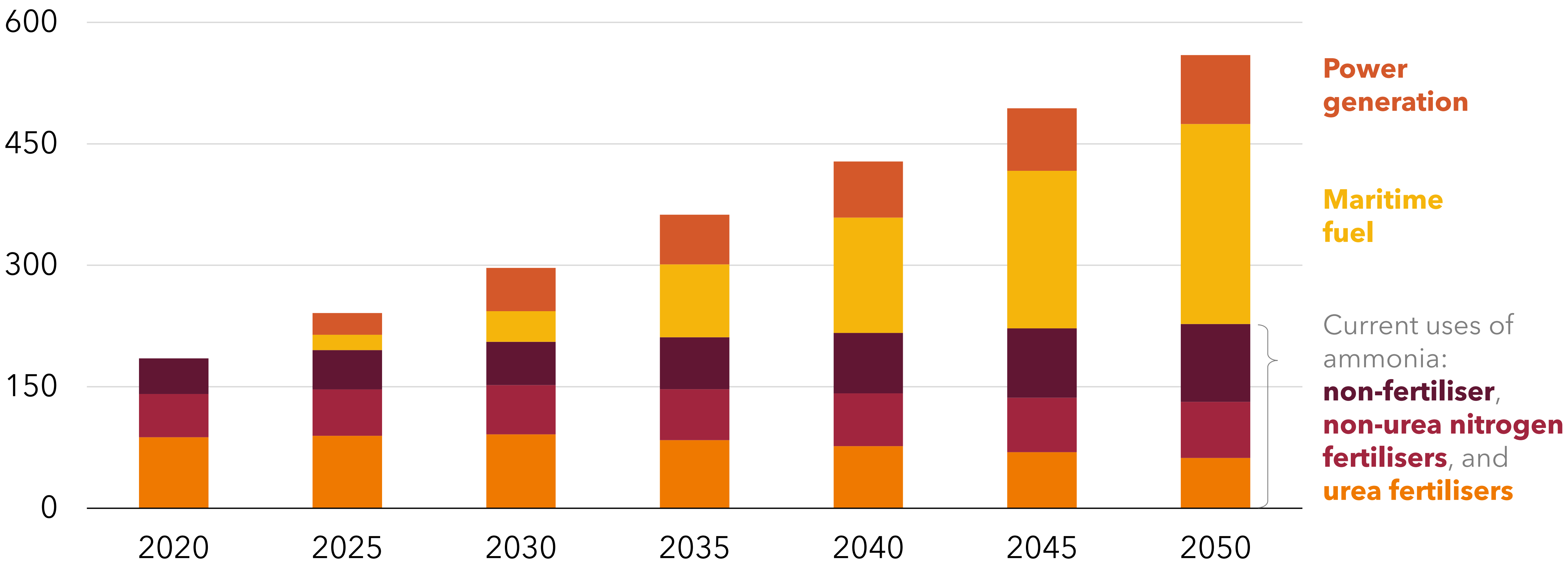
Demand for ammonia, million tonnes

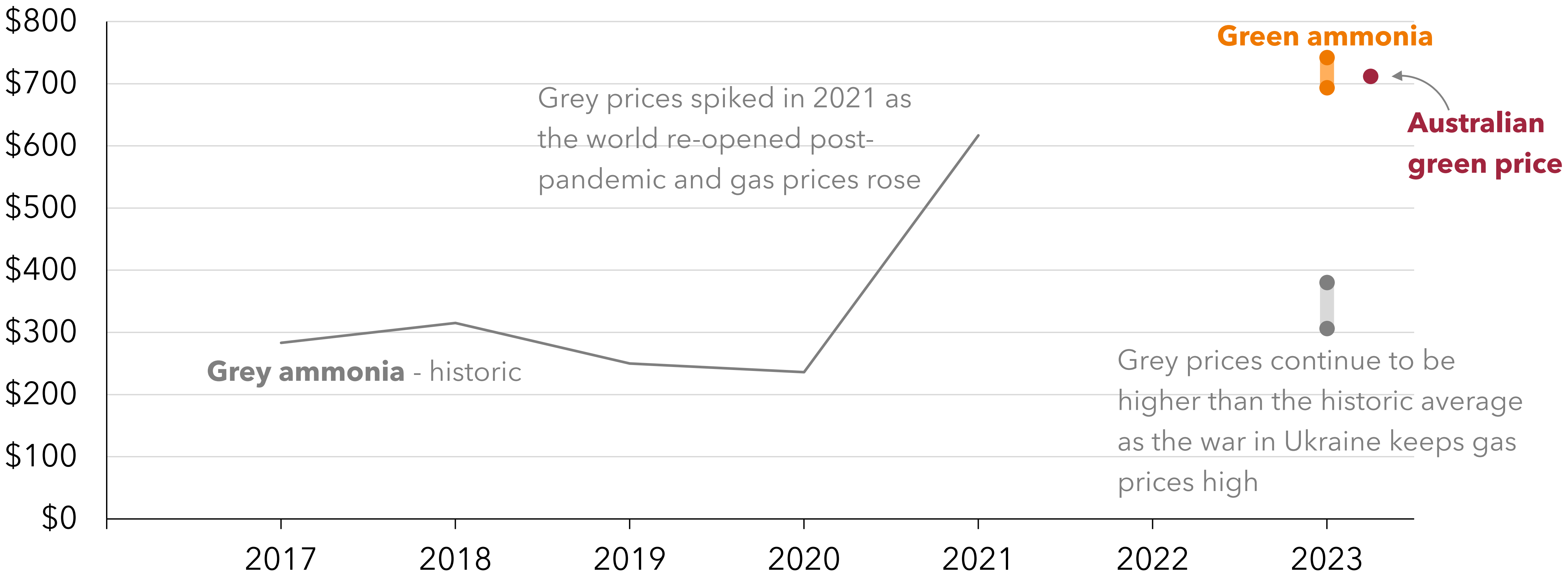


Note: Projections from the International Energy Agency's 2021 Net Zero Emissions by 2050 Scenario.

Source: Grattan analysis of IEA (2021).

Even with elevated world grey ammonia prices, green ammonia is significantly more expensive

Global ammonia prices, US$/t ammonia



Notes: Grey ammonia prices are cost-and-freight. Green ammonia prices are assessments of delivered prices less an average shipping cost of US$60/tonne ammonia, as at August 2023, and assume alkaline electrolysis. No price data available for 2022. 2023 prices vary by region, chart shows lowest and highest prices.

Source: Grattan analysis of Platts S&P Global (2023b), Shiozawa (2020), Statista (2023).

Under current policy settings, using green hydrogen to produce ammonia adds a considerable green premium

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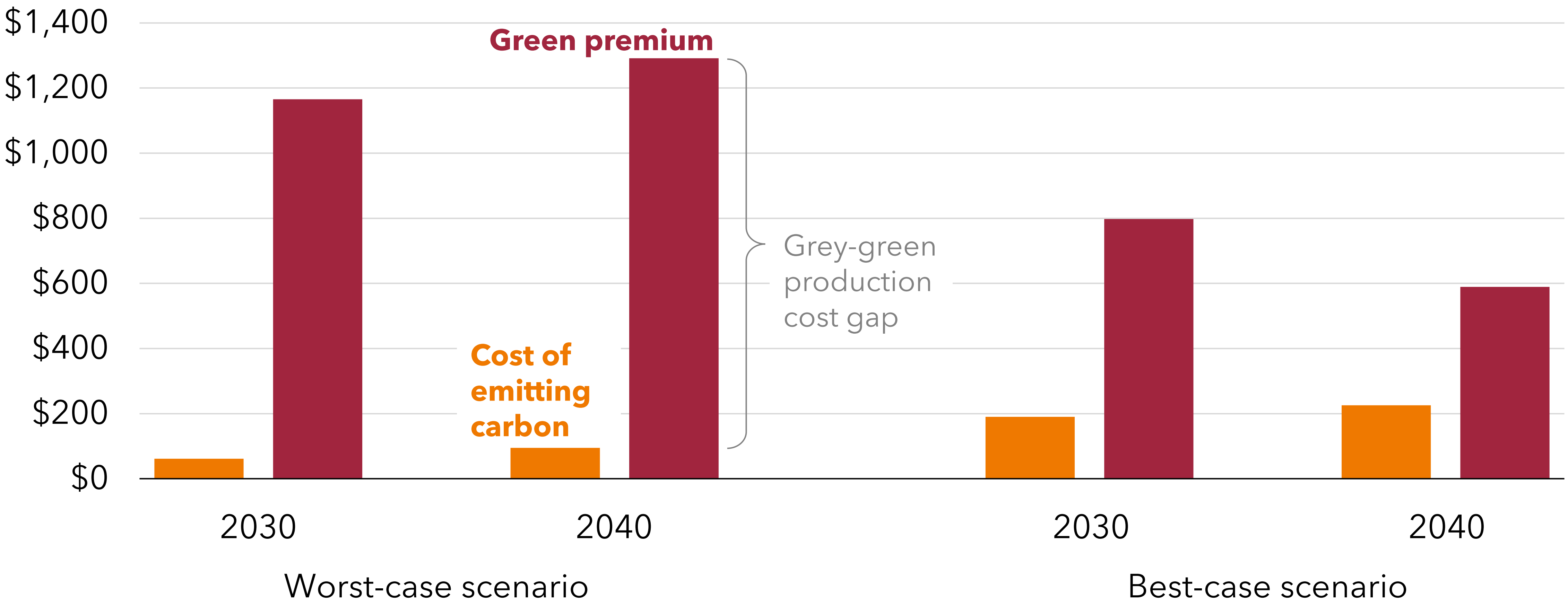
AU$/tonne ammonia, above current grey production cost



Notes: Existing ammonia plants face two choices: they can pay to emit carbon, or switch to using green hydrogen. For using hydrogen to be cost-competitive, the cost of emitting carbon must be higher than the green premium, which is the cost of using hydrogen less the money saved from not using gas. That is, the grey-green production cost gap should be close to zero or negative. Detailed descriptions of best- and worst-case scenarios can be found in Appendix B.

Source: Grattan analysis. See Appendix B for assumptions and sources.

Global aluminium production will increase due to demand for energy transition technologies, but will increasingly use recycled aluminium

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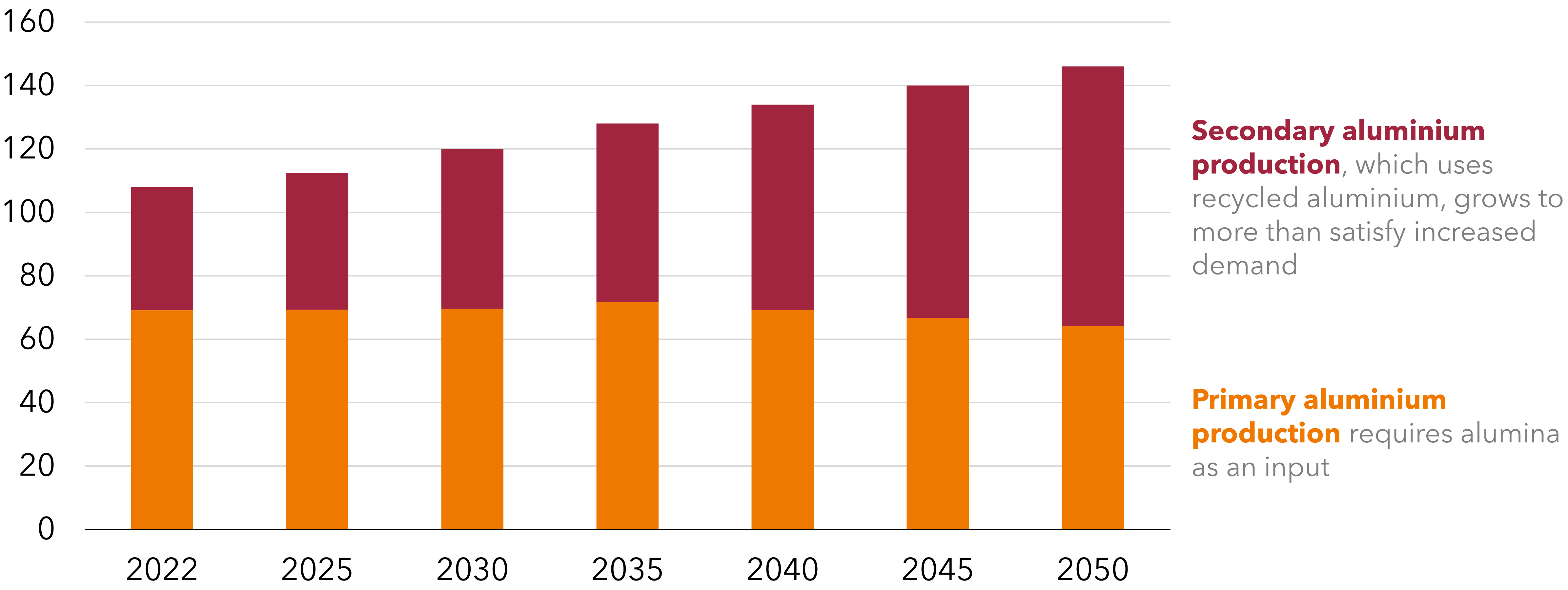
Aluminium production, million tonnes



Notes: Projections from the International Energy Agency's 2023 Net Zero Emissions by 2050 Scenario.

Source: Grattan analysis of IEA (2023b).

Australia is a significant producer of bauxite and alumina, but exports most of its alumina for smelting into aluminium overseas

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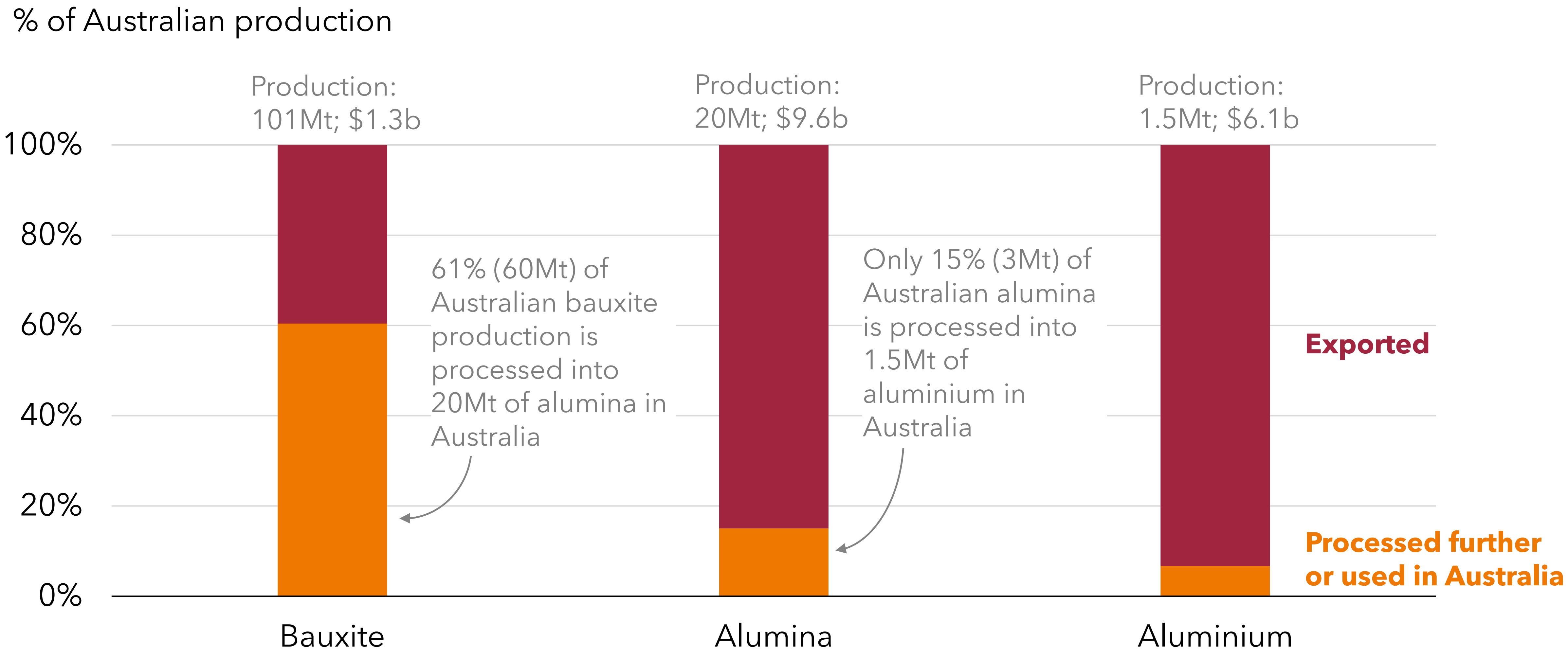

Note: Export figures for bauxite and alumina contain a small amount of each commodity not intended for use in aluminium metal production.

Source: Grattan analysis of Australian Aluminium Council (2023).

Under current policy settings, using green hydrogen for alumina calcination will not be competitive by 2040 even in the best-case scenario

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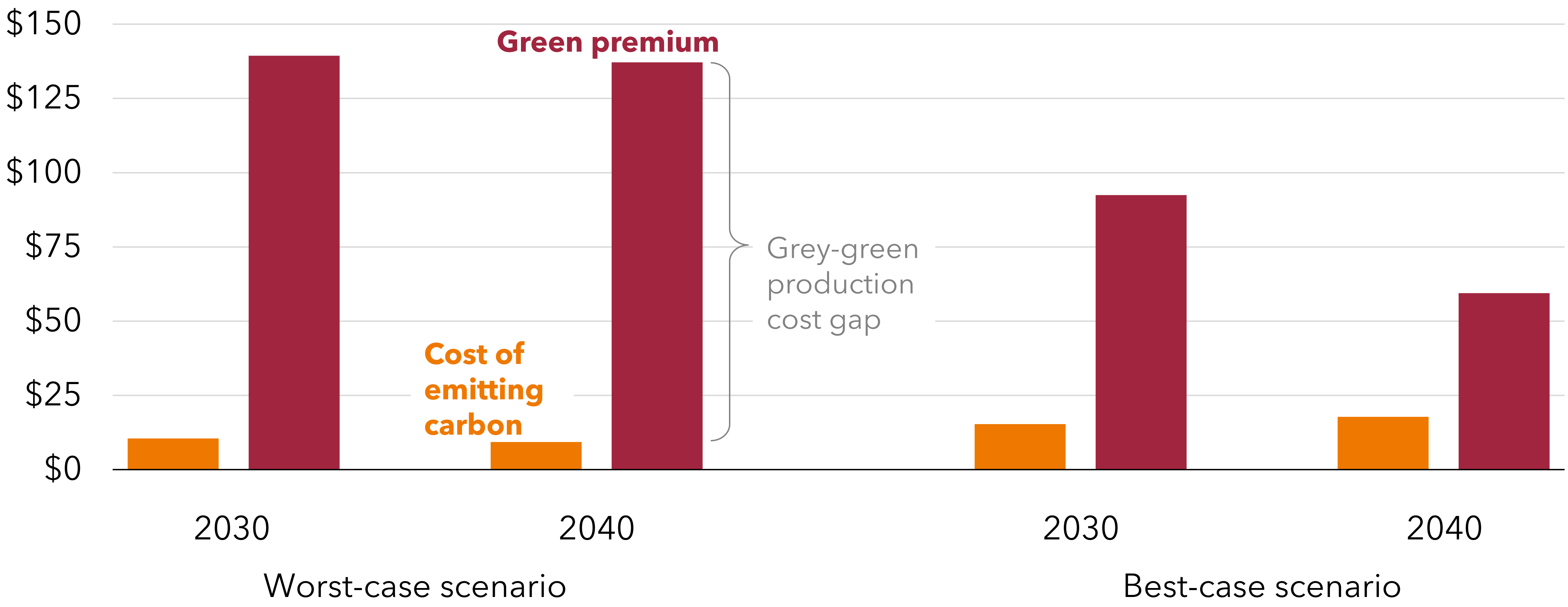
AU$/tonne alumina, above current grey production cost



Notes: Existing alumina plants face two choices: they can pay to emit carbon, or switch to using hydrogen. For using hydrogen to be cost-competitive, the cost of emitting carbon must be higher than the green premium, which is the cost of using hydrogen less the money saved from not using gas. That is, the grey-green production cost gap should be close to zero or negative. Detailed descriptions of best- and worst-case scenarios can be found in Appendix B.

Source: Grattan analysis. See Appendix B for assumptions and sources.

World steel production is likely to remain flat, and will increasingly use scrap rather than new iron manufactured using iron ore

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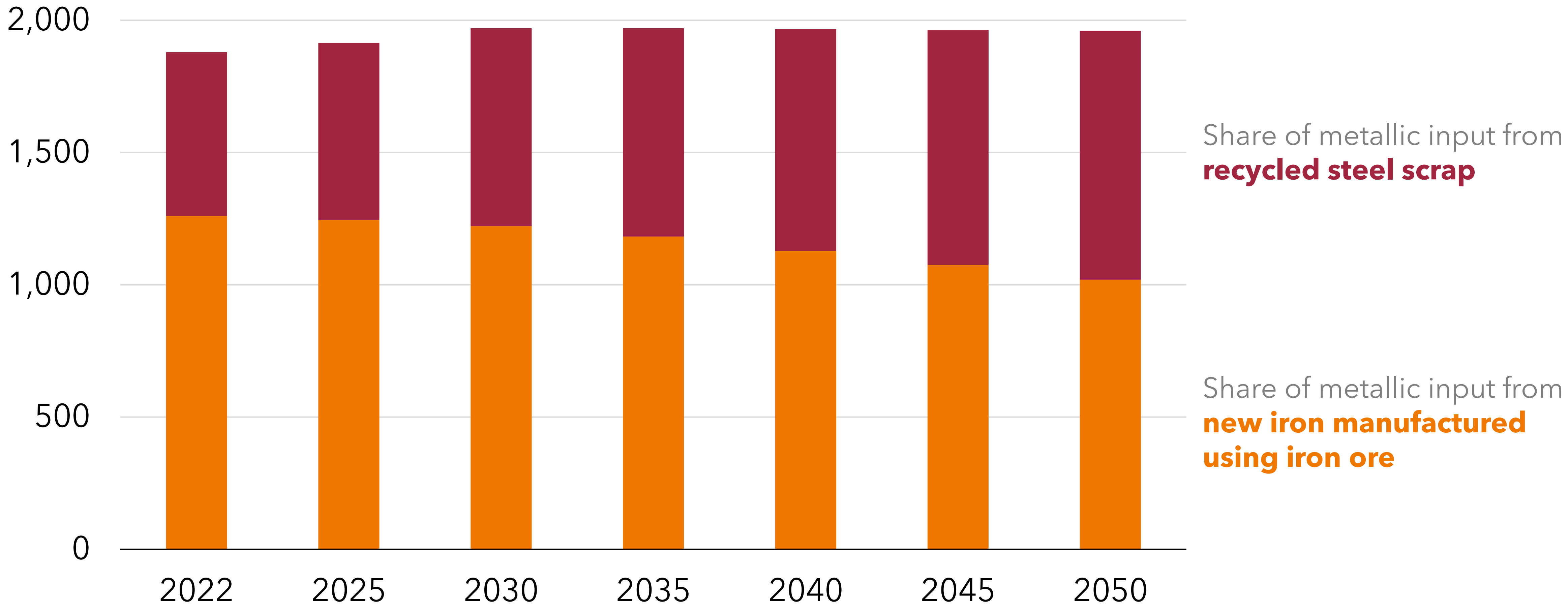
Crude steel production, million tonnes



Notes: Projections from the International Energy Agency's 2023 Net Zero Emissions by 2050 Scenario.

Source: Grattan analysis of IEA (2023b).

Under current policy settings, Australian production costs for green iron could approach cost-competitiveness in the 2040s

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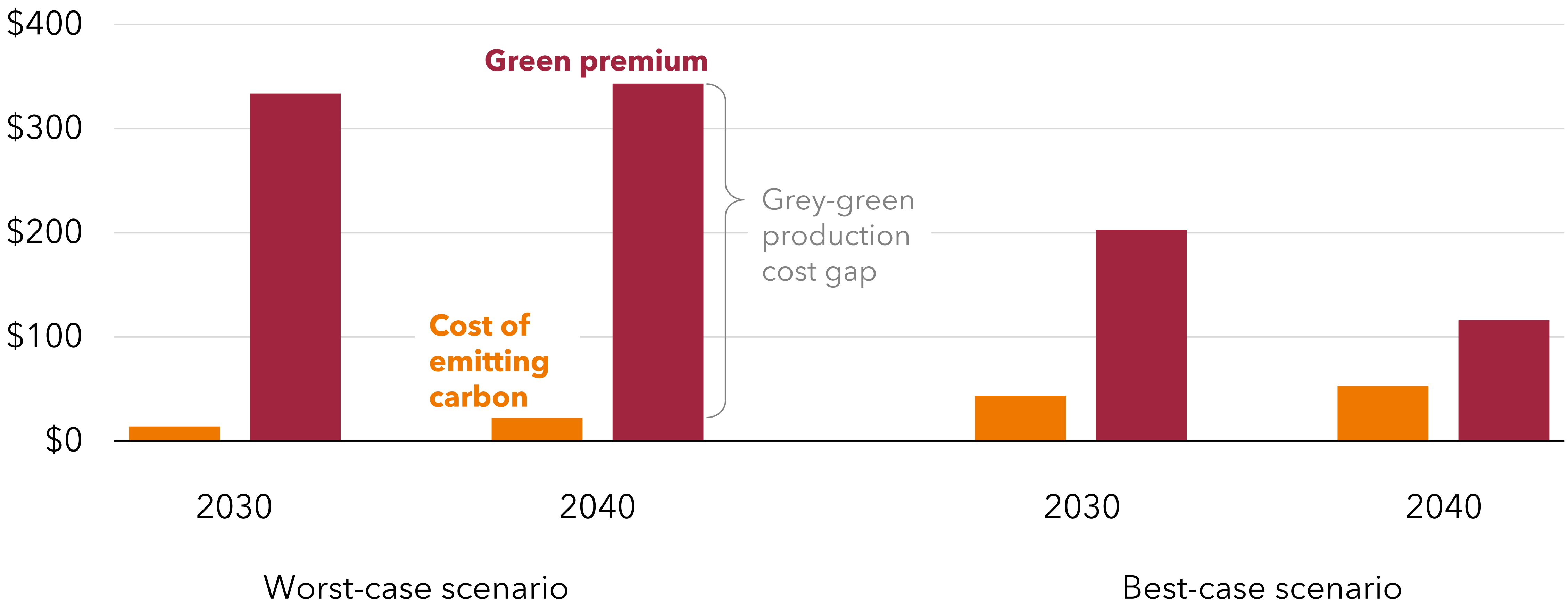
AU$/tonne iron, above current grey production cost

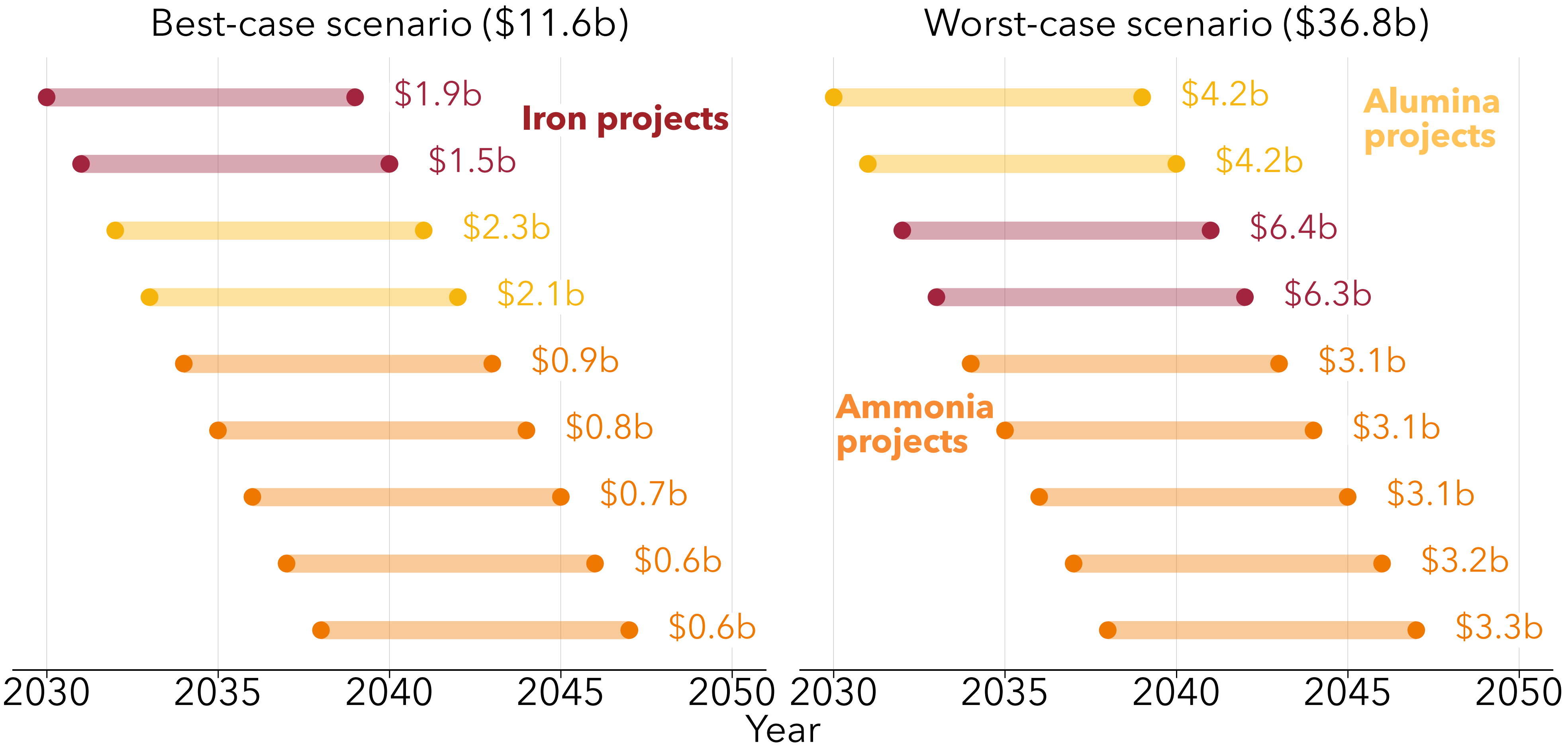


Notes: A company building a new iron plant faces two choices: it can use gas (and pay to emit carbon), or use hydrogen. For using hydrogen to be cost-competitive, the cost of emitting carbon must be higher than the green premium, which is the cost of using hydrogen less the money saved from not using gas. That is, the grey-green production cost gap should be close to zero or negative. Details of best- and worst-case scenarios can be found in Appendix B.

Source: Grattan analysis. See Appendix B for assumptions and sources

Supporting existing ammonia, alumina, and iron facilities to use hydrogen could cost between $11.6 billion and $36.8 billion over 18 years

Cost of support by project, AU$



Notes: Assumes facilities supported have production volumes equivalent to the average Australian facility in operation today. That is, ammonia plants average 0.4Mt of ammonia per year, alumina refineries average 3.4Mt of alumina per year, and iron facilities average 3.3Mt of direct reduced iron, which is what is needed to achieve the average crude steel production of an Australian integrated steelmaking facility (2.8Mt).

Source: Grattan analysis of scenarios described in Figure 4.3, Figure 4.6, and Figure 4.8. Full assumptions in Appendix B.

Under current Australian policies, minimal savings result from avoiding carbon costs

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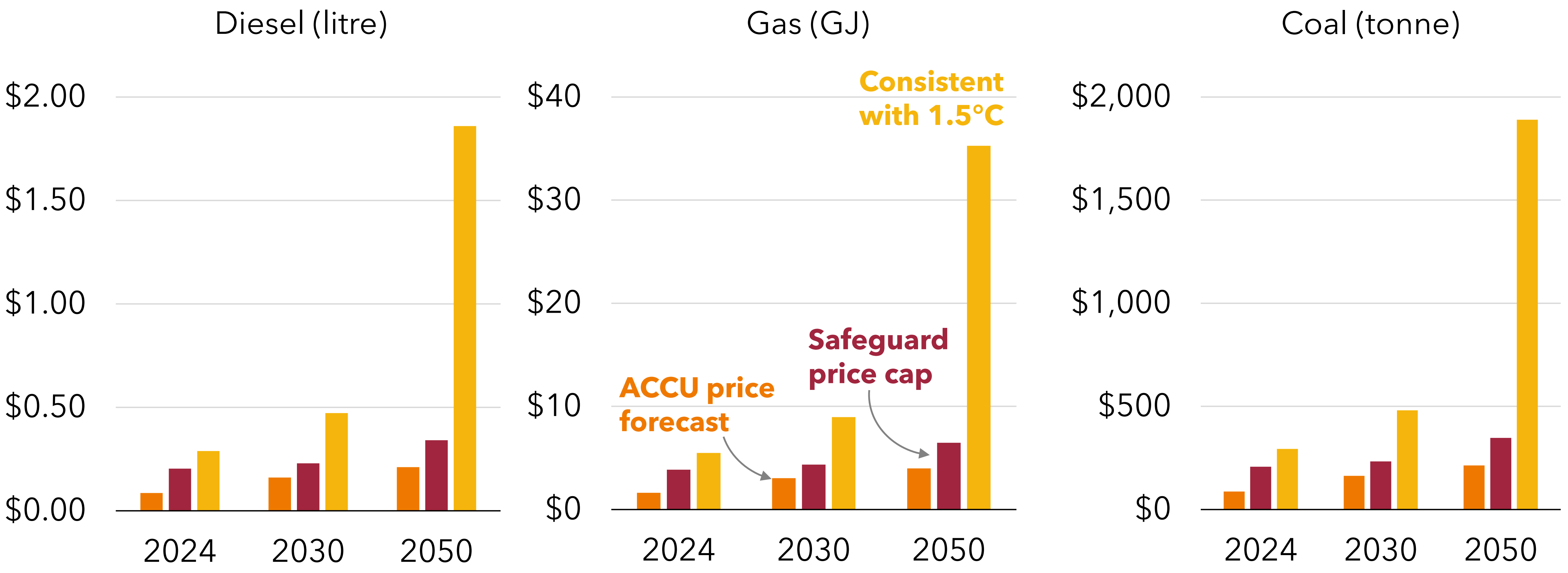
Carbon costs from fossil fuels, AU$



Notes: ACCU = Australian Carbon Credit Unit. Gas carbon costs are per gigajoule for combustion, not feedstock. Diesel carbon costs are per litre for use as transport fuel in a heavy duty vehicle meeting Euro IV standards. Coal carbon costs are per tonne of metallurgical coal.

Source: Grattan analysis of data from DCCEEW (2023c), Herd and Hatfield Dodds (2023), and Network for Greening the Financial System (n.d.).

Hydrogen costs dominate the green premium for ammonia, alumina, and iron

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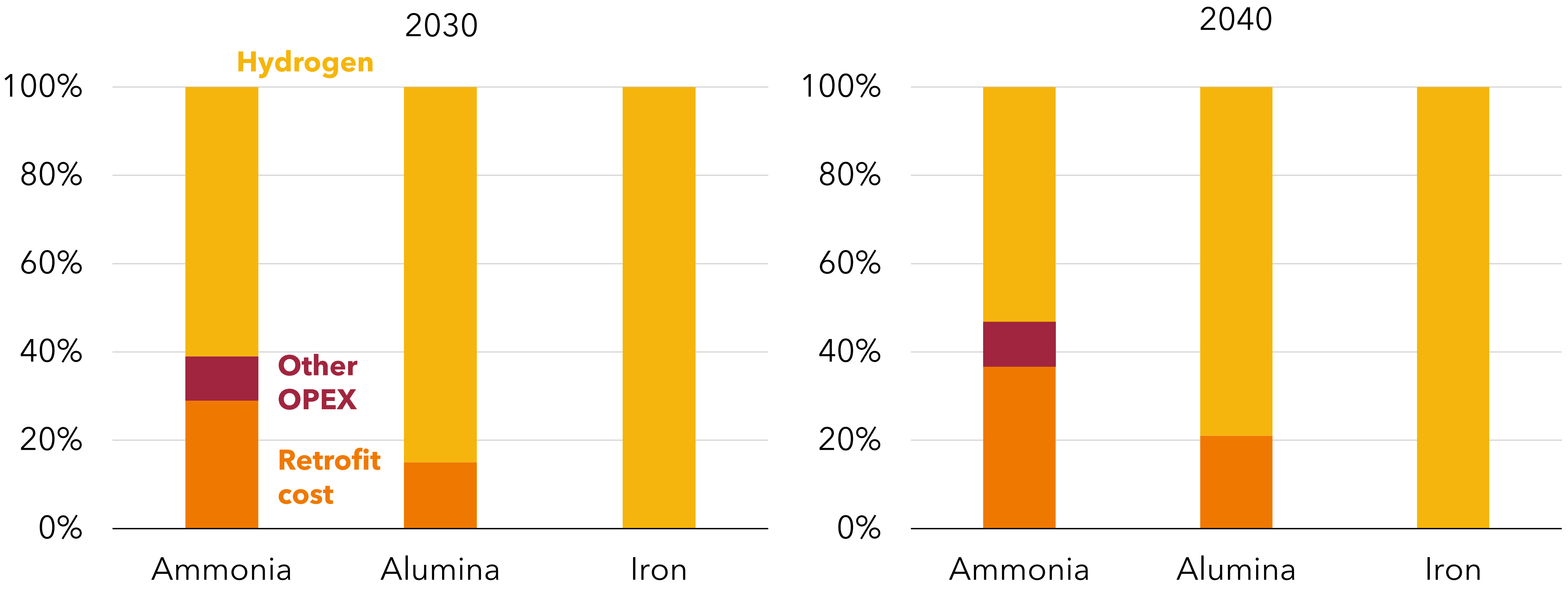
Breakdown of cost of using hydrogen



Note: No capex or other opex costs shown for iron because DRI plants have the same capex and non-fuel opex regardless of whether they use gas or hydrogen.

Sources: Grattan analysis. See Appendix B for assumptions and sources

Larger planned hydrogen projects are more likely to be using dedicated renewables

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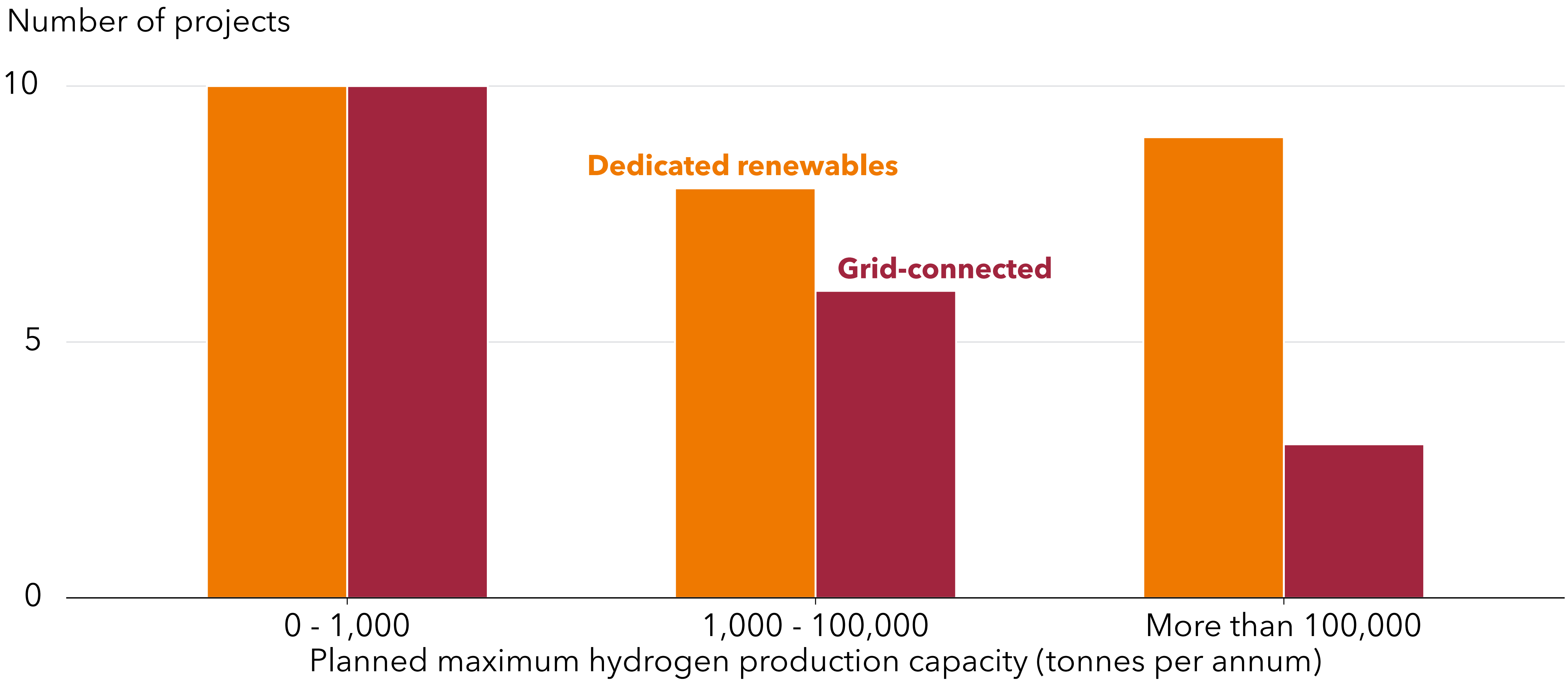

Notes: Includes all electrolysis hydrogen projects that were under construction or under development as at 5 September 2023. Projects without a reported hydrogen production capacity or power source are excluded.

Source: Grattan analysis of data from CSIRO (2023a).

Most energy demand in Australia for process heat is for low-temperature heat

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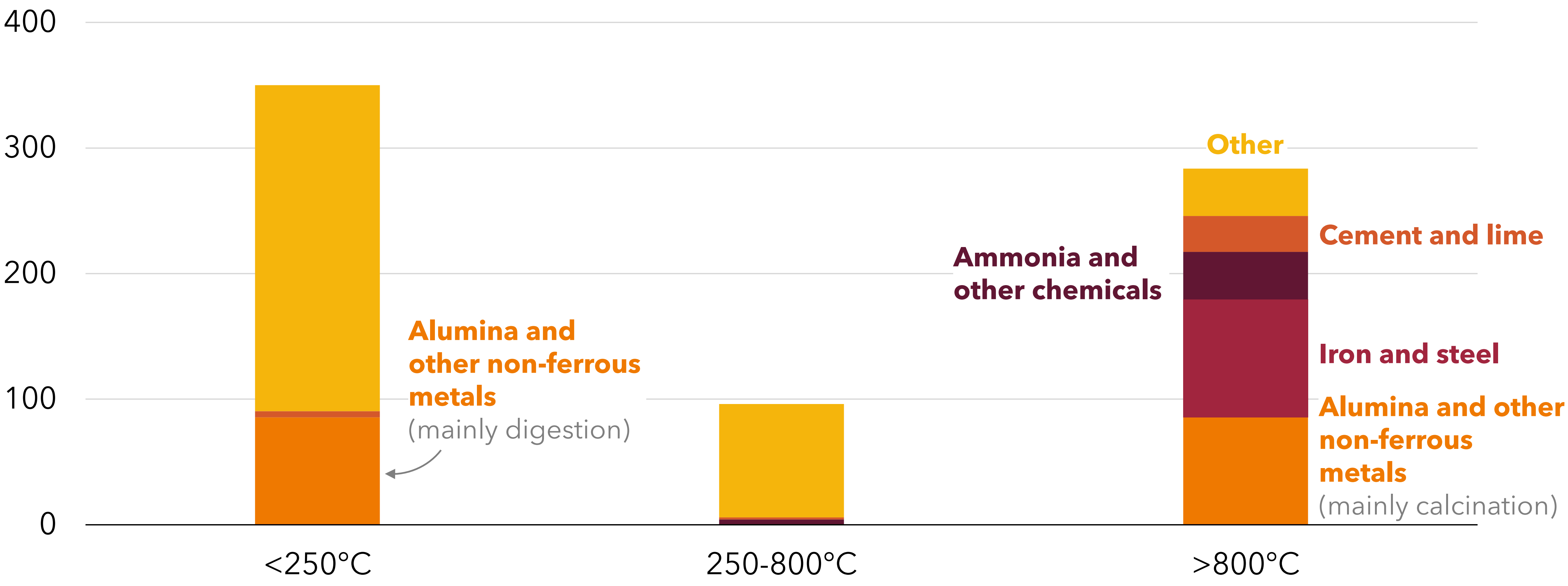
Energy use for heat, petajoules per year



Notes: For low-temperature heat (800∘C), the largest sources of demand in the 'Other' category are bricks and ceramics, glass and glass products, and petroleum refining. For medium-temperature heat (250-800∘C), the largest sources of demand in the 'Other' category are petroleum refining, food and beverages, and pulp and paper. For high-temperature heat (>800∘C), the largest sources of demand in the 'Other' category are bricks and ceramics, glass and glass products, and petroleum refining.

Source: Grattan analysis of ITP Thermal (2019).

Initially, fleet size has more impact on fuel cost savings than hydrogen costs, but this will change

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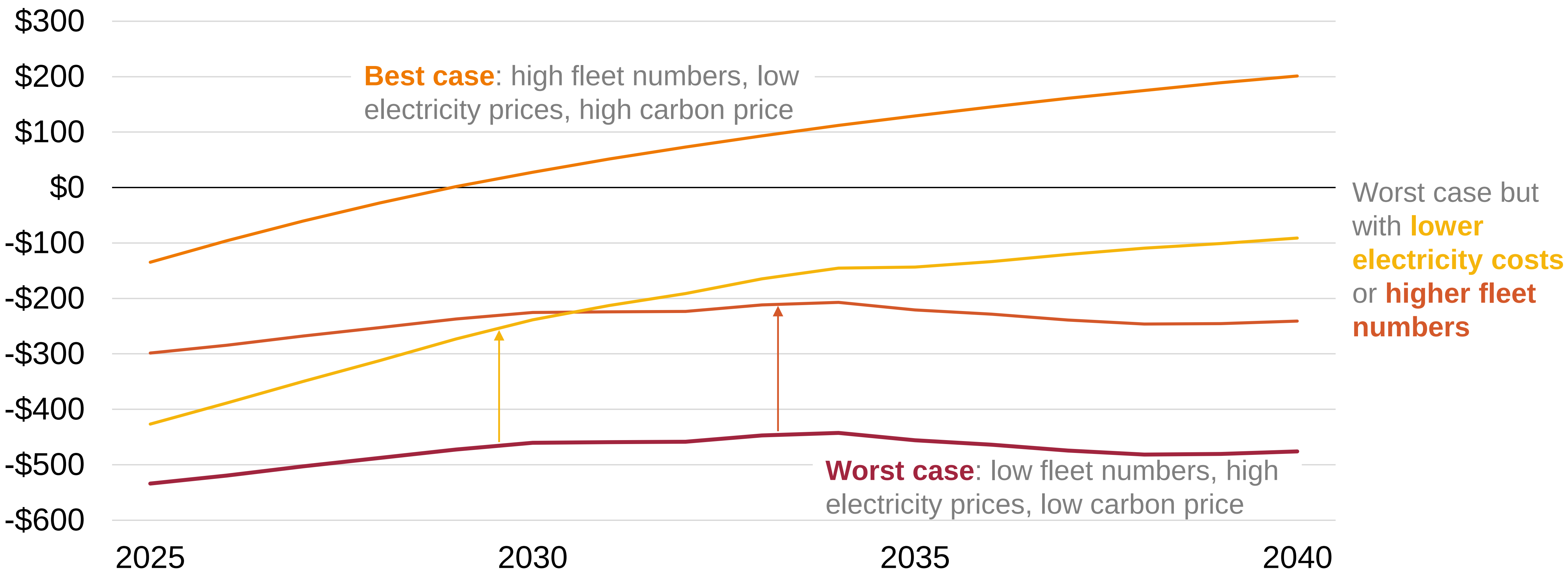
Fuel cost savings for a Sydney-Melbourne road freight trip



Notes: See Appendix B for assumptions and data sources.

Source: Grattan analysis.