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REPORT

TREASURY MODELLING ASSUMPTIONS ON CLIMATE CHANGE MITIGATION POLICY: KEY ISSUES

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1. BACKGROUND AND OVERVIEW

The Minerals Council of Australia commissioned Concept Economics to provide an analysis and critique of the Australian Treasury's key climate change modelling assumptions, as outlined in the document *Climate change mitigation modelling: Summary of assumptions and data sources*, released on 3 October 2008. These assumptions provide critical input into Treasury modelling of emissions reduction scenarios and, ultimately, the knowledge base on which decisions about an Australian emissions trading scheme, including targets and trajectories, will be made later this year.

The Treasury is using a suite of models including three Computable General Equilibrium (CGE) models: the Global Trade and Environment model (GTEM), G-Cubed and the Monash Multi Regional Forecasting (MMRF) model. These are being complemented with the use of bottom-up, sector specific models covering the electricity sector, the transport sector and land-use change and forestry sectors. The most significant of these latter models are the electricity generation sector models of McLennan Magasanik and Associates (MMA). The Treasury states that, where possible, it has applied a harmonised set of assumptions across the models.

One of the most problematic elements in the Treasury assumptions concerns what are in effect embedded marginal abatement cost (MAC) curves in the models arising from the interaction, inter alia, of electricity technology capital cost assumptions, commodity price projections and assumed rates of energy efficiency improvement. A marginal abatement cost curve shows the cost (say in dollars per tonne) of reducing emissions for a particular sector in a given economy. Marginal abatement cost curves can be constructed for whole economies but such curves would have no applicability in CGE models.

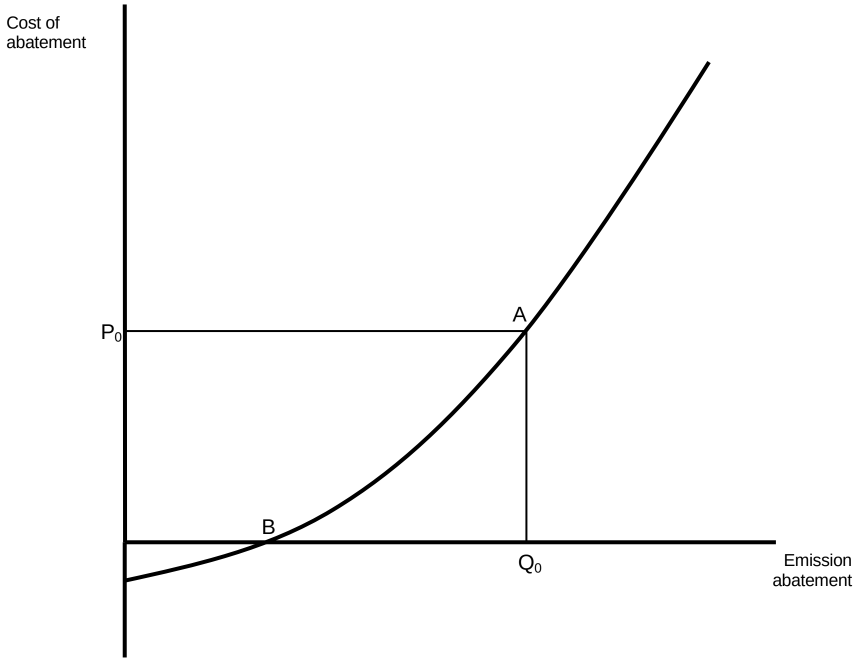
The stylised curve in Figure 1 shows that at low levels of abatement, emission abatement may actually provide benefits (so-call 'no regrets' policies). However, as the abatement task increases, the cost of abatement rises at a faster rate. Emission abatement is brought about through a variety of mechanisms: fuel switching, substituting away from energy toward other factors of production such as labour and capital, changing consumer behaviour, structural change in the economy and, ultimately, reducing economic output.

The MAC curve can be thought of as a schedule of abatement options (or opportunities) organised by cost. Under a market-based mechanism, such as an ETS, in response to the price signals the market determines the scheduling of the emission abatement options based on their cost effectiveness.

The relevant marginal abatement cost curves are said to be embedded in the models. It is unclear how this has been achieved and what features in the original models have been replaced by the new MAC curves. This could only be determined if full model documentation is released.

Based on the interaction of several key Treasury assumptions, there is a substantial risk that the modelling process will produce unrealistically low carbon prices and results which underestimate the costs associated with particular emissions reduction targets. The assumptions surrounding the energy transformation task in Australia appear especially optimistic, including the assumption that carbon capture and storage technologies will be available on a commercial scale from 2020 and deployed in the case of coal CCS technologies at a carbon price of $45 per tonne of CO_2-e.

Figure 1: Stylised marginal abatement cost curve



Though it has not been possible in the time-frame for this analysis, it is important also to scrutinise the industry-level MAC curves for fugitive emissions (pp. 28-30), especially for sectors such as coal where it is well known that achieving significant emissions reductions is becoming increasingly difficult.

Reference case assumptions for metal prices and energy commodities also raise a number of sector-specific issues and point to inadequate care in verifying key model assumptions against real world data and industry trends. This is illustrated below in the cases of aluminium and gas.

Another significant omission in the Treasury assumptions paper is the absence of assumptions concerning the scale and timing of binding emissions reductions by other leading economies. Assumptions about comparable action internationally will have a critical impact on the modelling results and on the costs to Australia and to specific sectors of the economy of meeting particular targets.

2. THE REFERENCE CASE

Reference case assumptions are important because they condition the economic path against which the costs associated with the policy scenarios and shocks are assessed.

Treasury has relied on recent forecasts from international organisations and Consensus Economics for variables such as economic growth, population/participation and productivity. For the most part, these broad macroeconomic assumptions are relatively uncontroversial. As noted above, sectoral level elements of the reference case are more open to contention. Hence while there is not much to be debated in terms of the relevant aggregates (including aggregate emissions), significant controversy surrounds the breakdown of production and emissions growth in relation to individual sectors in the reference case.

3. TECHNOLOGY ASSUMPTIONS

3.1. ELECTRICITY TECHNOLOGY ASSUMPTIONS

Key electricity technology assumptions in the Treasury modelling (Table 21, p. 24) are reproduced in Table 1. In addition to the original data in the table the implied capital costs of each type of power plant in 2050 have been added as the final column of data.

Table 1: Assumed technology characteristics

Fuel/technology	Thermal efficiency		Capital costs	Capital cost de-escalator		Capital costs
	2010	2011 – 2050	2010	2010 – 2020	2021 – 2050	2050
	%	% p.a.	$/kW s.o.	% p.a.	% p.a.	$/kW s.o.
Black Coal						
Supercritical coal (dry-cooling)	38	0.48	1879	0.5	0.5	1538
Ultrasupercritical coal (US)	41	0.48	2255	0.5	0.5	1845
Integrated gasification combined cycle (IGCC)	39	1.20	2673	1.5	1.0	1700
IGCC with carbon capture (CC)	32	1.30	3688	1.5	1.0	2345
Ultrasupercritical with CC and oxyfiring	30	0.58	2997	1.0	0.5	2332
USC with post-combustion capture	28	0.58	2482	1.5	0.5	1836
Brown Coal						
Supercritical coal with drying	35	0.48	1972	0.5	0.5	1614
Supercritical coal	33	0.48	2289	0.5	0.5	1873
Ultra supercritical coal with drying	37	0.48	2366	1.0	0.5	1841
IGCC with drying	37	1.20	2788	1.0	1.0	1865
Integ. drying gasification combined cycle (IDGCC)	37	1.20	2732	1.5	0.5	2021
IGCC with CC and drying	30	1.30	3886	1.5	0.5	2874
IDGCC with CC	32	1.30	3026	1.5	0.5	2238
Co-firing with biomass or gas in supercritical plant	35	0.48	2169	0.5	0.5	1775
Post-combustion capture without drying	28	0.58	2761	1.5	0.5	2042
Post-combustion capture with drying	26	0.58	2575	1.5	0.5	1905
Natural Gas						
Combined cycle gas turbine (CCGT) - small	49	0.60	1467	0.5	0.5	1200
CCGT - large	53	0.60	1334	0.5	0.5	1092
Cogeneration	72	0.60	1740	0.5	0.5	1424
CCGT with CC	46	0.70	2001	1.0	0.5	1557
Renewables						
Wind			2134	0.5	0.5	1746
Biomass- Steam			2598	0.5	0.5	2126
Biomass - Gasification			2784	1.5	1.0	1770
Concentrated solar thermal plant			4176	1.5	1.0	2656
Geothermal - Hydrothermal			2227	1.0	1.0	1490
Geothermal - Hot Dry Rocks			2413	1.5	0.5	1785
Concentrating PV			4640	1.0	1.0	3104
Hydro			2320	1.0	0.5	1805

Source: MMA and Concept Economics analysis

In choosing to rely on MMA technology assumptions for plant capital costs and capital cost de-escalators, Treasury appear to have dramatically underestimated the cost of transforming Australia's current electricity generation capacity to one based on near-zero emissions technologies. In some cases, capital costs for new plant appear to be roughly half current industry estimates given the rapid escalation in capital costs over recent years.

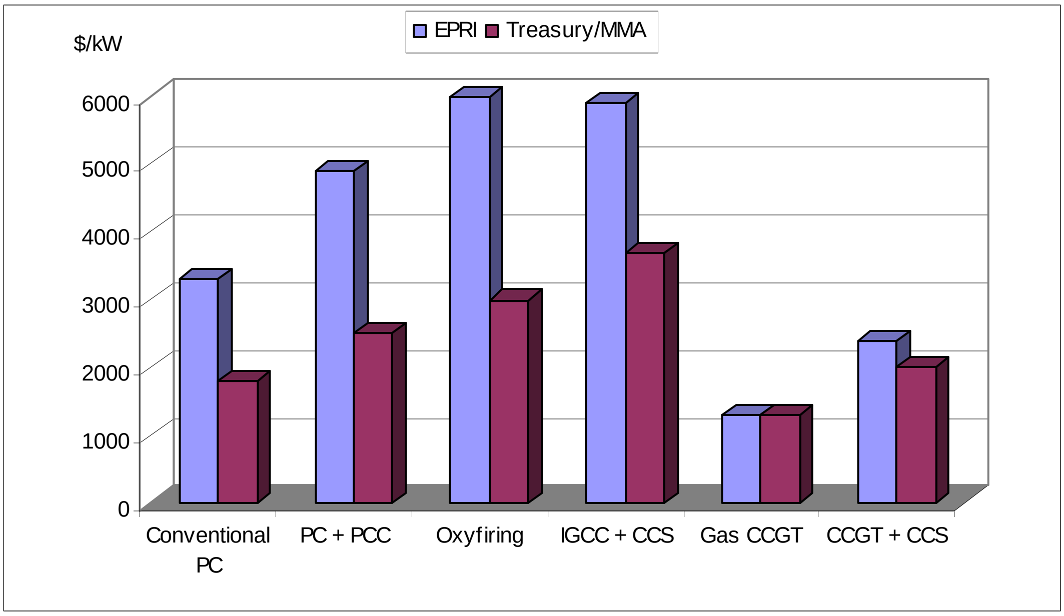
In the relevant chapter on energy transformation, the Final Report of the Garnaut Climate Change Review[1] also drew attention to the fact that:

> *Capital costs have risen markedly with particular impact on capital-intensive industries. Industry advice to the Review indicates that there have been increases of up to 60 per cent in construction costs per installed kilowatt of power plants since 2004, across all technologies.*

It seems unlikely that construction costs will fall back to the levels experienced earlier in this decade, at least in the long term. The problem of artificially low capital cost assumptions is especially acute in the case of conventional coal and carbon capture and storage (CCS) related technologies. This would appear to stem from a reliance on historical cost information as no new conventional coal-fired plants have been built in Australia since the early part of this decade.

As yet, unpublished data from a study conducted by the Electric Power Research Institute (EPRI) for the Australian Government point to the flawed nature of these assumptions. Concept Economics' understanding of the broad discrepancy between these different sets of data is illustrated in Figure 2.

Figure 2: Comparative electricity generation capital costs



The likely result based on this more robust data is that the Government's climate change mitigation policy modelling will greatly underestimate the overall cost of deep cuts in Australia's stationary energy emissions.

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[1] Garnaut, R., *The Garnaut Climate Change Review: Final Report*, Cambridge University Press, 2008, p. 472.

3.2. CARBON CAPTURE AND STORAGE

The Treasury document assumes carbon capture and storage technology is available on a commercial scale from 2020 in both Australia and the world, with the timing of deployment dependent on current and expected future electricity demand and the carbon price. Again, however, the costs of deployment appear to have been significantly underestimated based on an assumption that coal CCS technology is generally deployed at a carbon price of $45 per tonne of $CO_{2\text{-}e}$. Work by Concept Economics suggests a more realistic carbon price spectrum of between $60-$90 per tonne before such technology is economically viable.

International studies of the cost of CCS also suggest that the cost of CCS deployment is much higher than that assumed by Treasury. CCS will only be deployed if the cost per tonne of CO_2 avoided is lower than the carbon price. The International Energy Agency has estimated the cost of carbon capture and storage to be between USD40 (AUD57) and USD90 (AUD128) per tonne of CO2 captured and stored.[2] A separate study cited by the United States Congressional Research Service estimates the cost of capture, storage and monitoring (but not transport) at between USD43 (AUD61) and USD89 (AUD127).[3]

4. METAL PRICE ASSUMPTIONS

A second, related set of concerns surround reference case assumptions for metal prices. These are important both in their own right and because they are one of two factors (along with technological progress) driving capital costs over time in the MMA analysis. With MMA assuming that 25 per cent of capital costs reflect commodity costs, Treasury’s reference case assumptions for aluminium and steel provide critical input for build costs on new power plants and electricity transmission lines.

The relevant metal price indices (Chart 6, p. 25) are reproduced in Figure 3.

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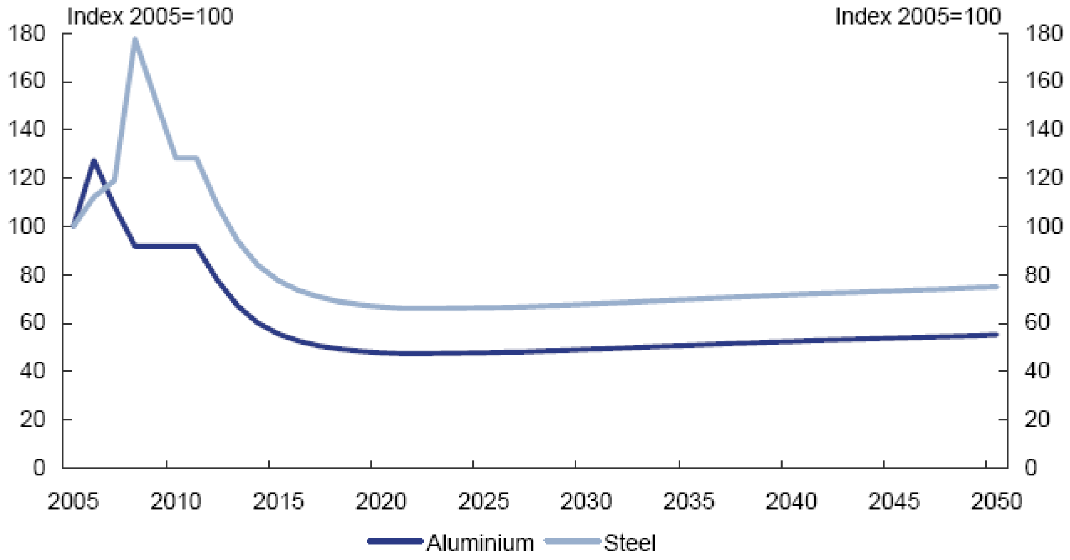
[2] Coal Industry Advisory Board, *Clean Coal Technologies: Accelerating Commercial and Policy Drivers for Deployment*, International Energy Agency, 2008.

[3] S. Julio Friedman, *Carbon Capture and Sequestration as a Major Greenhouse Gas Abatement Option,* November 2007, cited in Larry Parker, Peter Folger and Deborah D Stine, *Capturing CO_2 from Coal-fired Power Plants: Challenges for a Comprehensive Strategy,* CRS Report for Congress, August 15, 2008.

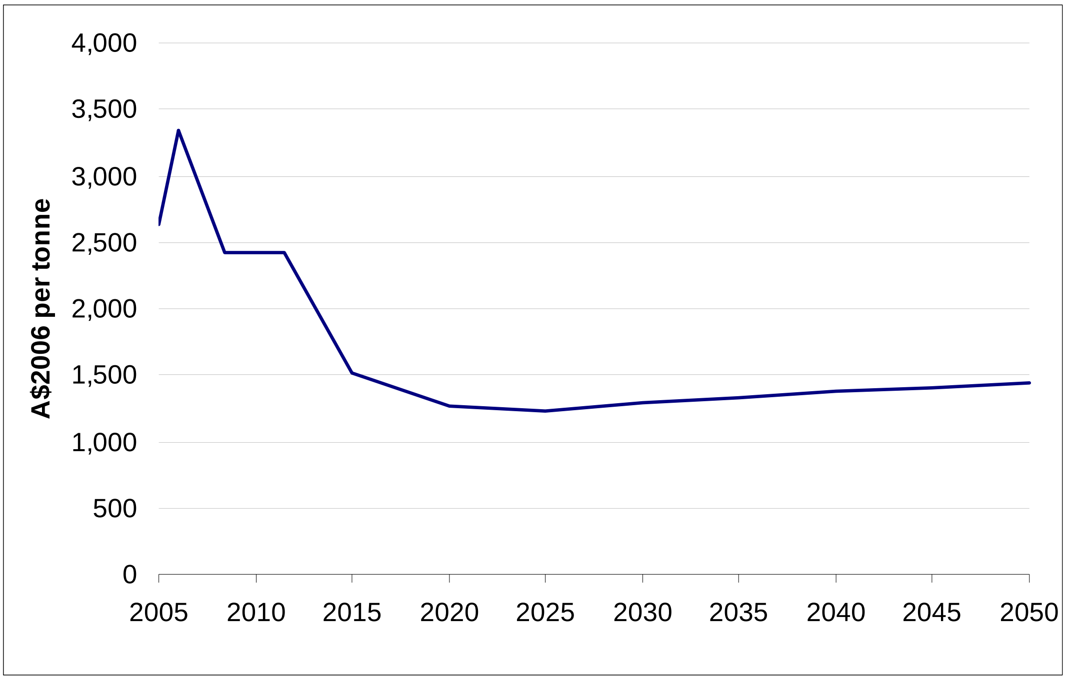
Figure 3: Index of metal prices in reference case (2006 $AUD)



Source: Treasury.

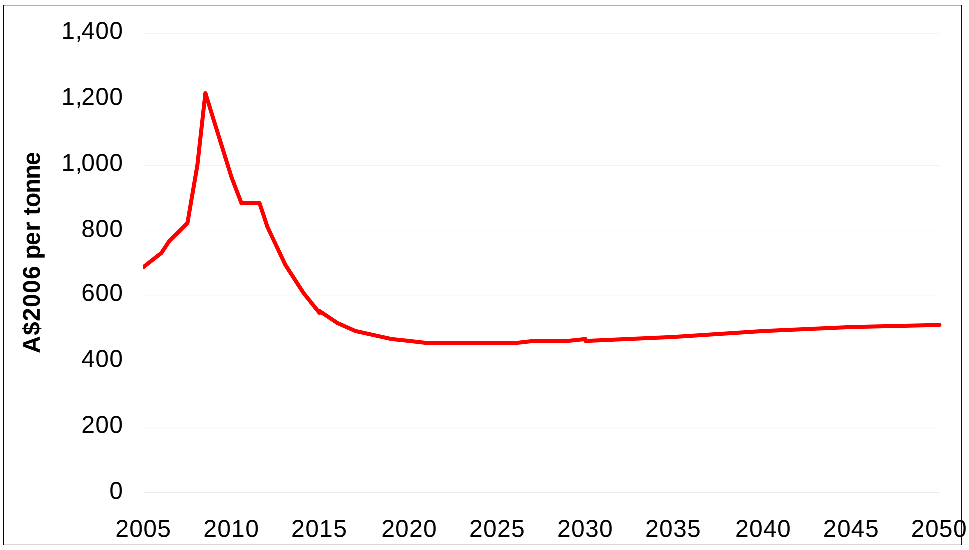
Focusing on aluminium, Treasury seem not to have adequately validated the models as projected prices appear to fall well below estimates of long-run marginal cost. When converted into prices (Figure 4), the projected price indices are at odds with both future global demand projections and independent assessments of the long-run marginal cost of production by groups such as CRU Strategies. If such prices were to materialise, all aluminium producers globally would be losing money by 2015. This simply cannot happen for sustained periods.

Figure 4: Implied Treasury aluminium price projection



The risk of a dramatic underestimation of metal prices in the reference case appears heightened by the fact that steel prices are projected to follow a similar price to the aluminium price, helping also to drive low capital costs of new power generation (Figure 5).

Figure 5: Implied Treasury steel price (based on hot rolled coil C&F Pohang)



In the case of aluminium, various other assumptions appear open to question, including the extent to which they point to a significant deterioration in the energy efficiency of the Australian aluminium industry relative to international competitors.

Energy efficiency improvement assumptions for non-ferrous metals (Table 17, p. 22) show significant variation between Australia and other countries from 2005 to 2100. At present the average consumption of electricity in Europe and North America is around 15.45KWh/Kg of aluminium produced compared to about 14.85KWh/kg in Australia. The rates of improvement assumed by Treasury would take these consumption figures to 3.03KWh/Kg in North America and Europe by 2100 compared with 9.22KWh/Kg in Australia. Apart from there being theoretical questions about the validity of the projected improvements in the European and North America industry there is no reason to believe that multinational firms in the aluminium industry would allow such gaps to open up given that smelter technology is readily transferable across countries within firms.

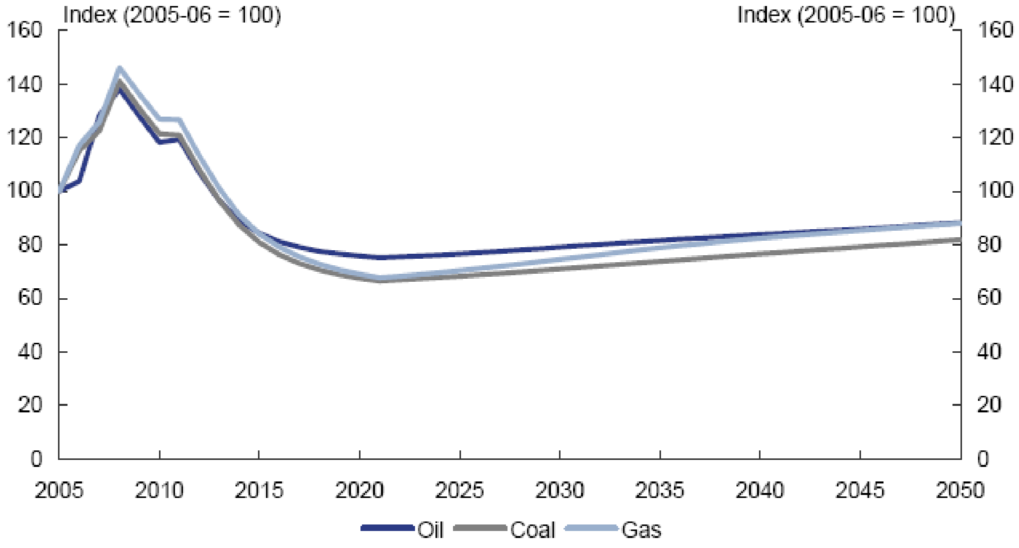
Together with the reference case metal prices and assumed declining aluminium usage in the Australian economy (Table 12, p. 18), these assumptions point to modelling output on aluminium being highly sensitive to the costs of a domestic carbon price.

5. ENERGY COMMODITY PRICE ASSUMPTIONS

In addition to low projected metals prices, long-run energy price assumptions (Chart 4, p. 15) also appear questionable, as illustrated in Figures 6-9. While Treasury is able to point to International Energy Agency projections as the basis for gradually rising global energy prices, a key question is at what level prices will rise in real terms. As can be seen from Figure 6, Treasury projects that real energy prices will fall between now and around 2022 with West Texas Intermediate prices falling over that period to a little under $US50/bbl. At the same time coal and gas prices are also assumed to fall in real terms at similar rates. Such falls do not seem to be in line with the strong world growth assumptions adopted by Treasury.

Among the implications of relatively low oil and gas prices are fuel switching between coal and gas at carbon prices lower than those that appear realistic. In addition, the assumed divergence between oil and gas prices in the reference case (with gas becoming relatively cheaper between 2015 and 2020) also appears problematic in light of likely strong growth in demand for LNG flowing from demand for clean energy, particularly in coastal China.

Figure 6: Energy commodity price assumptions (Foreign currency – 2005-06 dollars)



Source: Treasury and IEA.

Figure 7: Implied Treasury oil price projection (based on WTI price)

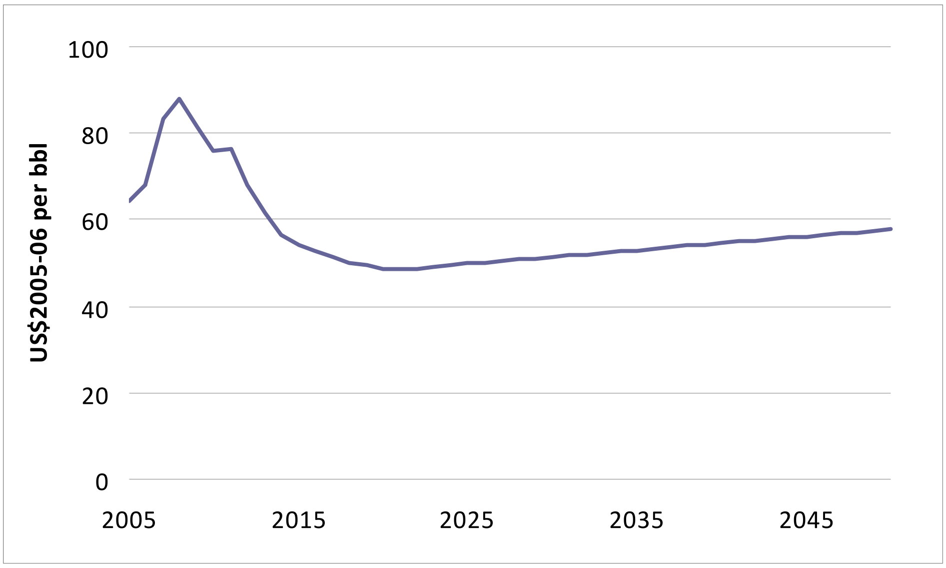


Figure 8: Implied Treasury thermal coal price projection (based on Australian unit export value converted to USD)

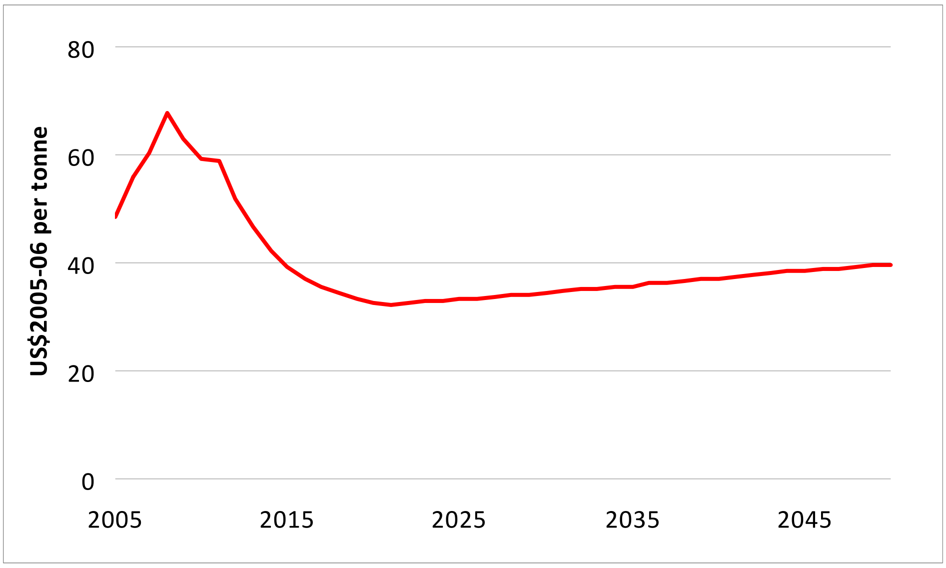
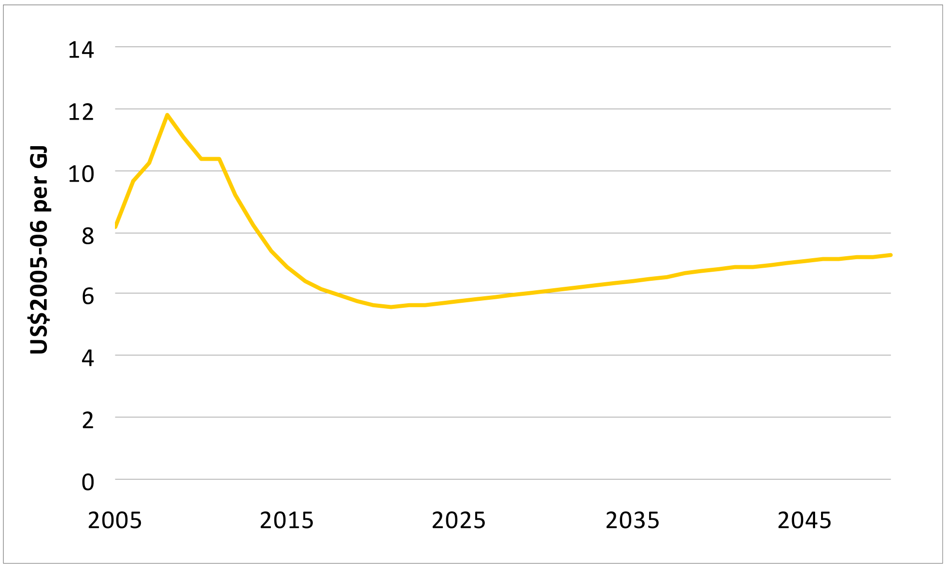
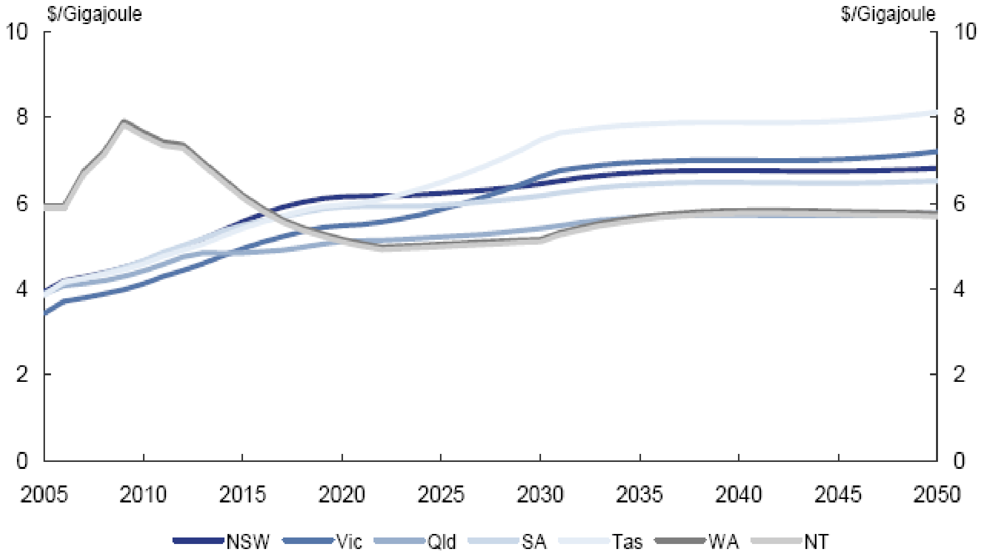


Figure 9: Implied Treasury gas price projection (based on Henry Hub price)



Within Australia, the assumption that east coast gas prices will not converge to international prices until 2029-2030 is at odds with the expected development of east coast LNG facilities within the next 10 years. More generally, it is unclear from Figure 10 how the projected domestic gas prices across jurisdictions (Chart 5, p. 17) are consistent with the internationalisation of the Australian gas market. The implied gas prices by state are shown in Table 2.

Figure 10: Domestic Australian Gas Prices



Source: MMA

Table 2: Assumed domestic Australian Gas Prices

	NSW	VIC	QLD	SA	TAS	WA	NT
	$/GJ	$/GJ	$/GJ	$/GJ	$/GJ	$/GJ	$/GJ
2005	3.95	3.40	3.85	3.95	3.95	5.90	5.81
2006	4.20	3.65	4.00	4.20	4.20	5.90	5.81
2007	4.30	3.75	4.10	4.30	4.30	6.70	6.61
2008	4.40	3.85	4.17	4.40	4.40	7.20	7.11
2009	4.50	3.95	4.25	4.50	4.50	7.90	7.81
2010	4.65	4.07	4.40	4.65	4.65	7.65	7.56
2011	4.82	4.22	4.53	4.82	4.82	7.45	7.36
2012	4.95	4.40	4.68	4.95	4.95	7.35	7.26
2013	5.15	4.55	4.79	5.15	5.15	7.00	6.91
2014	5.35	4.72	4.80	5.30	5.30	6.60	6.51
2015	5.55	4.90	4.80	5.40	5.40	6.20	6.11
2016	5.70	5.05	4.82	5.55	5.55	5.90	5.81
2017	5.87	5.20	4.85	5.70	5.70	5.65	5.56
2018	5.98	5.30	4.90	5.75	5.75	5.40	5.31
2019	6.08	5.40	5.00	5.80	5.80	5.30	5.21
2020	6.10	5.44	5.10	5.85	5.85	5.15	5.06
2021	6.13	5.49	5.11	5.90	5.90	5.05	4.96
2022	6.14	5.52	5.12	5.90	6.00	4.98	4.89
2023	6.14	5.58	5.13	5.90	6.10	4.99	4.90
2024	6.15	5.70	5.14	5.90	6.30	4.99	4.90
2025	6.18	5.80	5.18	5.90	6.37	5.02	4.93
2026	6.20	5.95	5.20	5.92	6.60	5.06	4.97
2027	6.25	6.10	5.24	5.95	6.75	5.07	4.98
2028	6.30	6.20	5.28	6.00	6.92	5.08	4.99
2029	6.35	6.40	5.30	6.10	7.20	5.12	5.03
2030	6.40	6.58	5.37	6.12	7.40	5.15	5.06
2031	6.48	6.74	5.45	6.17	7.60	5.30	5.21
2032	6.55	6.78	5.50	6.25	7.70	5.42	5.33
2033	6.60	6.84	5.58	6.30	7.76	5.55	5.46
2034	6.64	6.88	5.60	6.35	7.77	5.62	5.53
2035	6.70	6.90	5.58	6.40	7.77	5.67	5.58
2036	6.72	6.92	5.63	6.45	7.80	5.72	5.63
2037	6.73	6.93	5.66	6.48	7.80	5.75	5.66
2038	6.73	6.93	5.69	6.49	7.80	5.78	5.69
2039	6.73	6.93	5.71	6.49	7.80	5.80	5.71
2040	6.73	6.93	5.70	6.49	7.80	5.82	5.73
2041	6.73	6.93	5.70	6.49	7.80	5.83	5.74
2042	6.73	6.93	5.70	6.48	7.81	5.80	5.71
2043	6.73	6.93	5.70	6.48	7.82	5.79	5.70
2044	6.73	6.93	5.69	6.47	7.83	5.78	5.69
2045	6.73	6.95	5.68	6.47	7.84	5.77	5.68
2046	6.73	6.97	5.67	6.49	7.85	5.76	5.67
2047	6.73	7.02	5.66	6.49	7.90	5.75	5.66
2048	6.73	7.05	5.65	6.49	7.92	5.74	5.65
2049	6.74	7.10	5.64	6.49	8.00	5.73	5.64
2050	6.75	7.15	5.64	6.49	8.10	5.73	5.64

6. INTERNATIONAL ACTION

A significant omission from the Treasury modelling assumptions paper is any guide to the basic assumptions concerning the scale and timing of binding emissions reductions by other leading economies. This is a substantial and critical shortcoming of the paper, and one that is hard to justify given the significant influence that comparable actions by others will have on the costs that will be borne by the Australian economy and by specific economic sectors.

For example, Treasury modelling based on an assumption or expectation that all major developed *and* developing economies will agree to comparable emissions reductions by, say, 2013 will inevitably produce a smaller impact on the Australian economy than a (more likely) scenario configured around slower and more haphazard action by major emitters. Given the wide spectrum of the options and their critical impact on the results, it is puzzling that a discussion of these assumptions was not included in the paper.

7. MODELLING CRITERIA AND TRANSPARENCY ISSUES

For stakeholders in industry, it remains important to stress with policy makers the need for a rigorous and transparent approach to economic modelling.

Credible assumptions should surround when low and zero emissions technologies will become commercially viable. The choice of the cost and level of deployment of a low-emissions backstop technology will determine the long-term permit price and overly optimistic technology assumptions provide a false sense of security about the ease of the abatement task. Models also need to take full account of the costs of deploying new technologies or of retrofitting old technologies.

Policy scenarios must be based on realistic assumptions about international cooperation. The modelling information released by the Garnaut Climate Change Review points to overly optimistic assumptions about the level of international participation in agreed global action, including among Annex B countries.

Finally, it is important that there be ‘common sense’ checks on model results as models can never be perfect representations of reality. The example of aluminium prices cited above highlights the dangers of failing to properly verify modelling assumptions with real-world data. Modelling results also need to be interpreted carefully given the propensity in some models to assume that capital is fungible such that assets can be retired easily and without significant cost. This pertains especially in areas with large, lumpy investments in assets such as coal mines and power stations.