GRATTAN
Institute

# Restructuring the Australian Economy to Emit Less Carbon:
## Detailed Analysis

John Daley and Tristan Edis

**Founding members**

**Senior Institutional Affiliates**

Founding Members



National Australia Bank

**Institutional Affiliates**

Arup

Urbis

## Grattan Institute Report No. 2010-2 April 2010

This report of detailed analysis accompanies a publication: *Restructuring the Australian economy to emit less carbon: main report*. The main report can be downloaded from the Grattan Institute website

This report was written by John Daley, CEO, and Tristan Edis, Research Fellow. Katherine Molyneux, Helen Morrow, Marcus Walsh and Julian Reichl provided extensive research assistance and made substantial contributions to the report.

We would like to thank the members of Grattan Institute's Energy Reference Group for their helpful comments, as well as numerous industry participants and officials for their input. The opinions in this report are those of the authors and do not necessarily represent the views of Grattan Institute's founding members, affiliates, individual board members or reference group members. Any remaining errors or omissions are the responsibility of the authors.

Grattan Institute is an independent think-tank focused on Australian public policy. Our work is thoughtful, evidence-based, and non-aligned. We aim to improve policy outcomes by engaging with both decision-makers and the community.

For further information on Grattan Institute's Energy program please go to:
        http://www.grattan.edu.au/programs/energy.php

To join our mailing list please go to:
        http://www.grattan.edu.au/signup.html

## Table of Contents

# 1. Scope and methodology

## 1.1 Scope

This report focuses on the impact of carbon pricing on Australian industry and households, understanding how carbon pricing will affect their costs and competitiveness. It does this through adopting a carbon price reflective of what is likely to occur over the next 10 years according to Australian Treasury modelling - $35 per tonne of $CO_2$.[1]

The report does not investigate:

- The merits of pricing carbon through a tax rather than a cap and trade scheme

- Dynamic interactions when carbon pricing causes an industry to reduce production, potentially reducing carbon pricing

- The impacts of carbon pricing on the cost of capital

- Support for the electricity industry aimed at ensuring continuous supply

These are all important issues, but beyond our core focus: what would be the static impact of a carbon price on the costs and competitiveness of Australian industry and households

This report is relevant whether carbon pricing is imposed through a **tax** or through a **cap and trade** scheme. In practice, these

legal forms may converge, particularly if tax rates are adjusted in light of actual emissions, or cap and trade schemes include floor and ceiling prices.[2] However, the optimal legal regime for carbon pricing is beyond the scope of this report. The primary impact on industry will probably be the level of the carbon price, rather than whether that level is set by a tax, or by a cap and trade scheme.

The precise form of carbon trading scheme may have a more subtle effect on the economy, by creating additional uncertainty about future profits. There is more certainty if the carbon price is fixed (or at least bounded by a cap and floor), and if there is greater legislative commitment not to change the scheme for an extended time period. Normally uncertainty will be reflected by a higher cost of capital. Uncertainty may also result in high cost but low emissions producers not investing until it is clear that carbon prices will be above a certain level, while low cost but high emission producers do not invest until it is clear that carbon prices will be below a threshold. This is a particular issue for electricity generation.[3] However, modelling the impacts of this kind of uncertainty is beyond the scope of this report, which focuses on the static price impacts of a carbon scheme.

### 1.1.1    Sectors examined

In addition to looking at the impact on households, this report analyses in detail the effect of a carbon price on Australian production facilities exposed to international competition in the

---

[1] Australian Government Treasury (2008)

[2] Hepburn (2006)
[3] International Energy Agency (2007b)

following industries that will be recipients of free carbon emission permits worth several billion dollars:

- Alumina refining

- Coal mining, in particular black coal

- Liquefied Natural Gas production

- Steel production

- Cement clinker production

- Aluminium smelting

- Oil refining

Other industries will also see cost increases as a result of a carbon price, however for most this cost increase will be only small. For some of the industries where the cost increase is more significant, particularly electricity generation and water supply, they are not exposed to international competition and hence will face the same regulatory requirement as their competitors. They will have the potential to pass on a substantial proportion of the carbon cost to their customers through higher prices and any adjustment will be constrained to movements in production and jobs between facilities within Australia. The remaining industries which are exposed to international competition, and would see significant increase in costs are worthy of analysis. However most of these industries are small (in some cases only one facility) and their relative impact on Australia's emissions is minor which led to their exclusion from scope. Future study would be most

worthwhile in the area of chemicals and non-ferrous metal smelting (other than Aluminium).

Nonetheless the scope of industries analysed in this study represents 70% of emissions from the emissions intensive and trade exposed sector of the economy and around a fifth of Australia's entire greenhouse gas emissions (including their indirect emissions from electricity consumption. In addition two of the sectors – coal and LNG - are expected to experience substantial growth over the next ten years.

## 1.2 Methodology

This report looks at the static impact of a carbon price on the costs and competitiveness of Australian industry and households. This approach is deliberately simple and readily transparent.

This static form of analysis is intuitively easier to understand than dynamic models that are more sophisticated in capturing the interactions between sectors, but require more complex workings and assumptions. Carbon pricing may **interact dynamically** with the economy. For example, with a cap and trade scheme, if a high emissions industry reduces production, the price of carbon permits would fall for other emitters. With our static analysis, we have not attempted to model these dynamic interactions, although the results of our static analysis may be useful for building this kind of dynamic model.

Ultimately both static and dynamic analyses are valuable in understanding the impact of carbon pricing. This report's analysis should be seen as a complement rather than a replacement for

dynamic modelling exercises such as the Australian Government's Treasury modelling of the CPRS.

In our static analysis the assessment process is quite simple and readily replicated by others. The aim is to assist in creating a more informed and participatory debate where argument centres on objective physical characteristics of actual facilities and markets, rather than abstract theoretical assumptions for which agreement may never be reached.

For households, we have identified the average current emissions intensity of the delivered energy goods they purchase – petrol, electricity and gas (in tonnes of $CO_2$ equivalent per unit of product) and simply multiplied this by the carbon price of $35. This is then overlayed against overall household expenditure to assess the significance of such price rises. The impact on other goods is not analysed because for households the impact of a carbon price on goods other than energy is likely to be very small.

For the industries in scope, we have determined the amount of $CO_2$ equivalent emissions (in tonnes) various facilities are likely to emit in producing a unit of production and then multiply this by $35 to assess the extent to which costs would be increased as a result of a carbon pricing scheme. We then use financial data published by the company that owns the facility or international production cost curves in conjunction with price data for the product in question (such as a tonne of alumina or coal) to assess how significant this carbon price cost increase would be. In particular the study seeks to understand whether the carbon cost increase would be so significant as to:

- make production unviable (costs would exceed revenue or margins would be reduced to such an extent that they would insufficient to support ongoing investment and cover depreciation);

- lead to a substantial deterioration in production cost competitive position relative to facilities overseas on international cost curves; or

- make investment in a new production facility unviable in the case of LNG (because the additional carbon cost would substantially change the economics and risk of the project investment).

In conducting this analysis we have sought to use price data that is likely to be a reasonable reflection of the future, rather than historical data that fails to reflect the emergence of China and India as major and rapidly growing sources of demand for industrial commodities. This is in line with the views of the major energy and resource commodity companies that operate in Australia, who universally project robust demand conditions over the next decade. However we have generally sought to avoid using prices from the very peak of the recent commodities boom in 2008. The data we have attempted to use are based upon:

- what major companies within the industry are suggesting are likely to prevail in the future; or

- benchmark or market exchange prices from late 2009 or early 2010 which partly reflect the downturn from the Global Financial Crisis but above the very depressed lows in early 2009 and well below the price peaks of 2008.

On the other hand the cost curve data we have utilised has generally been sourced from the 2007 and 2008 period reflecting a buoyant Australian dollar (in the realm of 0.85USD) and high input costs.

Where an industry has been assessed on the basis of the carbon cost impact on sales margins, we have attempted to use an average of margins extending over five years or longer.

Further detail on our approach to assessing each sector is outlined in the relevant section of this report.

### 1.2.1    Assumptions

The report also assumes

- A carbon price of $35/tCO_2

- Exchange rate of AUD$1:US$0.85

This report investigates the static impact of a carbon price of $35/tCO_{2-e}. This carbon price is broadly in line with what the Commonwealth Treasury forecasts would be required to reduce Australia's 2020 emissions to 5% below CO_{2-e} emissions in 2000.[4] This target is the policy of both the Labor Government and Liberal-National Opposition. Under current policy, Australia would only adopt more stringent targets if Australia's trade competitors also constrained carbon emissions – in which case carbon leakage will be less of a concern. While there will be substantial impacts beyond 2020, it is relatively speculative to predict the impact of technological and social changes beyond this period,

and we have not attempted to do so. Although more significant cuts, and higher or lower carbon prices are possible, we have not investigated whether this is desirable or likely. Instead, we have used a constant price to aid comprehension rather than undertake comprehensive scenario analysis. Generally impacts would change proportionately to a higher or lower carbon price and our analysis is sufficiently transparent that readers are able to make their own assessments of likely impacts from higher or lower carbon prices.

Throughout this report we have assumed a constant exchange rate of US$0.85 to the Australian dollar. We have also attempted to use cost curve data from the period of 2007 and 2008 that would be reflective of this exchange rate.

### 1.2.2    Data sources

This study has attempted wherever possible to use data derived from the actual companies and individual facilities being analysed. In circumstances where this was not available we have relied upon government and industry analyst sources and in some circumstances we've had to make some assumptions which are made transparent in the sections of the analysis in which they are used. In addition the report is comprehensively referenced so that readers can go back to source material to confirm accuracy.

Nonetheless no study of this scope and level of detail will be perfect. We have been heavily dependent on publicly available data in an area where much of the data is kept private within the companies concerned. We welcome and encourage feedback from others to assist us in improving the accuracy and rigour of the analysis.

---

[4] Australian Government Treasury (2008)

On this issue, an important reform would be for the National Greenhouse and Energy Reporting System to publish publicly the emissions data and any free permits allocation by individual facility. Based on our experience it seems highly likely that firms in the industries we have analysed could obtain a good understanding of their competitors' facility-level emissions intensity data, making us sceptical of claims that such information needs to be kept confidential for commercial reasons. However in terms of public accountability, it is extremely difficult for members of the general public to gather such information.  It does not seem unreasonable that members of the public should be able to know exactly where free permits are being allocated and how considering the considerable amounts of money at stake.

## 2. Principles of government support for affected industries

Government support for affected industries might be advocated on a number of bases, including:

- Coherence (avoiding higher emissions due to perverse policy)

- Welfare (looking after individuals and communities adversely affected)

- Stability (ensuring continuity of essential services)

- Transition management (preventing deadweight loss as companies adapt to the new regime)

- Fairness (preventing the burdens falling disproportionately on one part of society)

- Sovereign risk (preserving future government credibility)

- Fulfilling expectations created by specific government actions or programs

The first of these arguments – coherence - is investigated in detail by this report. Welfare is a legitimate concern, but should be targeted to the workers and communities affected. The continuity of essential services is a complex issue beyond the scope of this report. The other arguments do not apply to the introduction of carbon pricing in Australia.

### 2.1 Coherence to prevent perverse outcomes

If Australia imposes a carbon price, and other countries do not, there is a risk that industry will move from Australia to locations where it will emit even more greenhouse gases. This would be a perverse result, defeating the purpose of carbon pricing.

This perverse result, sometimes described as "**carbon leakage**" would only occur if:

- Carbon pricing makes an Australian industry internationally uncompetitive;

- In its new overseas location, the industry emits more greenhouse gases per unit of production;

- There are no offsetting government policies to support the Australian industry.

This is the most important argument for government support, investigated in detail by the remainder of this report.

### 2.2 Welfare of communities and individuals

Carbon pricing may particularly affect the welfare of some communities, particularly those that are based around an industry that is uncompetitive in a carbon constrained world. Government support should not slow the pace of economic change to soften the blow on the affected industries. Instead, government support should be targeted towards assisting the affected individuals and

communities to restructure, and therefore minimise the human and economic costs of unemployment.  The social safety net aims to do this; in addition localised programs for worker retraining, relocation, and education may help to minimise the human costs.

Transitional assistance to the companies particularly affected by carbon pricing is an expensive and clumsy means to support the welfare of the individuals and communities.  While it may slow the rate at which facilities close, this merely delays the inevitable.

A rapid transition does not necessarily increase long-term unemployment and decay.  As the Productivity Commission found, a high rate of economic change in a local area does not necessarily result in a shrinking economy and job losses; rather successful adjustment depends on how rapidly individuals and businesses reorganise their affairs to the new conditions.[5]

When government attempts to use economic policy to protect communities, it tends to do both badly: workers are stuck in unsustainable industries, and the local economy is not given the chance to innovate and produce the new industries that will employ workers of the next generation.[6]

When tariff barriers were removed, Australian governments typically provided restructuring funds to assist local communities to acquire new skills and promote new businesses, rather than providing funding to reduce the losses of the affected businesses.

A similar approach is appropriate for the introduction of carbon pricing.  The individual employees should be encouraged to

acquire new skills and opportunities in industries with a long-term future.

Effective support for redundant workers can and should be provided by Australia's social safety net, which is generally designed to address need directly, regardless of its cause.[7]

If a community is heavily dependent on a particular industry that becomes uneconomic, the whole community may be disrupted.  In these situations, it may be desirable for government to take special initiatives to minimise the pain of workers transitioning to new jobs.

For example, after the closure of the Nissan's Clayton car manufacturing plant in 1990, the Australian government set up an employment service office to oversee the retrenchment process.  The initiative was coordinated with both the union and with Nissan.  The office was able to organise the activity of local government and not-for-profits, as well as provide direct support.[8]

Effective labour adjustment programs must be designed with the aim of smoothing the transition of displaced workers into meaningful jobs of a similar calibre to those lost: a past emphasis on finding 'any job' for displaced employees has resulted in a large proportion of workers underemployed in casual jobs.[9]

The recent Commonwealth Forestry Industry Structural Adjustment Program provided a good example of this type of support.  Provision was made for up to a year of vocational

---

[5] Australian Government Productivity Commission (1998)
[6] McColl and Young (2005)

[7] Australian Government Productivity Commission (2001)
[8] Australian Government Productivity Commission (1997)
[9] Armstrong *et al.* (2008)

training, and wage support for new employers.  A relocation allowance was also available, and preparatory training was included for those workers who lacked the literacy or English language skills to take advantage of the offered vocational education.[10]

## 2.3 Stability of supply of essential services

There is an argument that government may need to support the electricity industry to ensure continuity of supply, although the facts would require careful investigation, and are beyond the scope of this report.[11]

## 2.4 Transition management

It might be suggested that intervention is required to assist companies to manage the **transition** to carbon pricing.  However, this would require evidence that there will be deadweight losses (such as closing plants that in the long-run would have been viable).  The proposed rate of degradation in the level of free permit assistance for EITE facilities is not particularly "transitional" – if this rate was maintained beyond 2020, the transitional arrangements would only conclude around the end of this century.

There is a long track-record of government interventions introduced as transitional measures that become near permanent features of the policy landscape. At present the government has scheduled a review of EITE assistance in 2014, yet the terms of reference[12] seem to be more heavily weighted towards increasing

rather than decreasing the rate of assistance. For example there are a number of conditions that are reasonably likely to be met which would mean that the decline in the number of free permits provided each year would be halted.

## 2.5 Fairness to prevent disproportionate impact

It might be argued that it is **unfair** that the burden of carbon pricing falls more heavily on some industries and that government support should soften the blow.  However, industries are not entitled to pollute more in the future just because they polluted more in the past. Compensation in these circumstances perversely encourages investment in activities that investors know or suspect will cause harm.  Compensation would protect investors from the future risk of paying for harm they cause to others while enabling them to profit in the meantime and indeed perhaps encourage expansion of the harmful activity in the knowledge that this might increase an entitlement to compensation in the future.

If governments intervene to compensate for the impact of general environmental or health regulation, this reduces the impact of the regulation on those who most need to change their behaviour. Intervention also delays industries restructuring to become more efficient in the new environment.  Legal doctrines about acquisition of property support this approach: while governments must compensate for property that they take and use for a different purpose, they are not obliged to compensate for the impact of general regulations.

Consequently, there are numerous examples of government regulation without compensation to control or ban a product in

---

[10] Australian Government, Department of Agriculture, Fisheries and Forestry
[11] See Section 1.1 for definition of the scope of this report
[12] Australian Government (2009a)

widespread use after scientific investigation shows that the product causes harm. Examples include tobacco, asbestos, mercury, air-pollutants that cause respiratory illnesses and lead in petrol.

It might be argued that requiring producers to pay for 100% of emissions and using the revenue to compensate households is effectively a redistribution from producers to households. Assistance for trade exposed industries might be seen as a mitigation of this redistribution. However, the Australian government has not sought to justify assistance on this basis.

Another suggestion is the assistance is required to create a "level international playing field". However, a level playing field is not an end in itself. Its purpose is to ensure that international trade results in the most efficient location for production. Carbon pricing has a different aim: encouraging production to move to the lowest cost location taking into account carbon costs. Free permits, although formally consistent, would delay desirable relocation to low cost low emissions locations.

Also Government intervention to protect the most affected industries slows the rate at which these industries adjust to the new structure of the economy. This potentially ultimately leaves them behind international competitors who "take their medicine early".

Governments are obliged, both morally and legally, to compensate if they acquire a property right.[13] However, this doctrine is aimed at situations where governments take the

resources of an individual or company, and use them to benefit others. The Australian Constitution does not protect individuals because general regulations affect how they can use their property.[14] The underlying ethical principles are general. For example, Australian and US legal courts apply very similar tests about when governments must pay compensation for acquiring property.

## 2.6 Sovereign risk

It is sometimes suggested that compensation is needed to avoid a perception that Australia poses a **sovereign risk**. However, there is no evidence that carbon pricing without compensation would create adverse perceptions of Australia.

Sovereign risk is usually defined as unexpected and dramatic changes to the business environment such that the expected return on investment based on an understood regulatory regime is severely undermined. The changes typically considered to be sovereign risks include political instability (i.e. revolution or forced appropriation with inadequate compensation), fiscal instability (i.e. government default),[15] monetary instability (i.e. printing money), regulatory inconsistency (i.e. rapid and unpredictable regulatory changes), and judicial uncertainty (i.e. poor rule of law).[16]

Australia would be pricing carbon later than many other countries, flagged the possibility of carbon pricing over a decade in

---

[13] Australian Constitution, s51(31)

[14] High Court of Australia (2009), paras 82, 147
[15] Hughes (1987)
[16] Fitzpatrick (1983)

advance,[17] and the government itself is not benefiting from any acquired asset. The Garnaut review found that it was unlikely that a carbon pricing regime would increase perceptions that Australia posed a sovereign risk relative to other countries.[18]

Although some other countries had adopted schemes in which producers only paid for a percentage of their emissions, it was an open possibility that Australia would adopt a scheme that required producers to pay for *all* emissions.

### 2.7 Fulfilling expectations

A final argument is that compensation should be paid to companies that have acted on the basis of **specific expectations** created by governments. However, governments have not created specific expectations that there would be no carbon pricing – indeed it has been a public and significant agenda item for Australian governments for several years.

Nor is there a strong basis for specific expectations that there would be compensation for a carbon pricing. Assistance for the impacts of a carbon price were only adopted as government policy in July 2007,[19] yet the vast proportion of industrial capacity for which compensation is being claimed was established well before this time. In addition any expectation of government

assistance was diluted within a few months of July 2007 by the Garnaut Review.

---

[17] In the lead up to the negotiations around the Kyoto Protocol in 1997, the Australian Government was a prominent advocate of the importance of market-based pricing mechanisms for controlling greenhouse gas emissions (for example see: Downer (1998)). Also in 1999 the Australian Government released a series of discussion papers proposing the establishment of a carbon trading scheme.

[18] Garnaut (2008b) p 397

[19] Australian Government (2007)

# 3. Alumina refining

## 3.1 Summary of analysis

Australia's alumina refineries are some of the lowest cost in the world and will remain competitive even when they pay carbon costs. They are likely to continue to have substantial profit margins. In addition, international alumina prices may increase to reflect carbon costs, as several of the marginal global alumina producers in Europe pay carbon costs. In the unlikely event that Australian production reduced, this would probably *reduce* global carbon emissions.[20] Consequently the industry assistance proposed under the draft CPRS is unnecessary.

Carbon pricing would encourage alumina refining in Australia to reduce its carbon emissions by using more gas rather than coal, using alternative fuels, and making more use of co-generation plants to minimise wasted heat.

## 3.2 Industry background

Alumina refining converts the mineral ore, bauxite, into aluminium oxide (commonly referred to as alumina). This intermediate product is converted into pure aluminium in aluminium smelters. Australia is one of the world's largest alumina producers, producing 19m tonnes generating $6 billion in exports in 2008.[21] Australia's seven alumina refineries employ 7,117 people.[22]
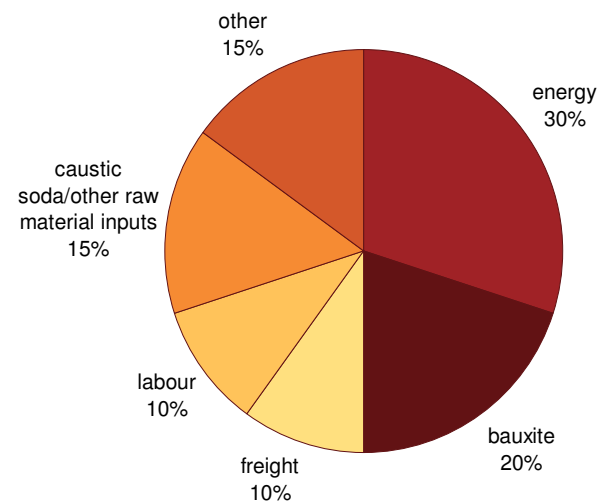
## 3.3 Industry economics

Australia's alumina refineries are some of the lowest cost in the world. This is because the refineries are close to extensive domestic deposits of high quality bauxite, and the cost of coal and gas to provide energy for the process is relatively low.

The major costs in alumina refining are energy, raw materials costs, freight and labour, as shown in Figure 3.1.

**Figure 3.1 Alumina refining cost components**



*Source: Australian Aluminium Council (2000);* Pers. Comms. (2010a)

---

[20] The most vulnerable refinery, Gove, has relatively high emissions intensity
[21] ABARE (2009b)
[22] Hetherington (2008)

Alumina refining costs vary considerably between locations. In order of their importance to low-cost refining, these variations include:

- **Reliable access to cheap coal and gas** – energy is needed to produce heat and steam to convert bauxite to alumina, and energy costs are 30% of the average costs of production.

- **Location close to a bauxite deposit** – bauxite transport is around 10% of the average global cost of producing alumina but varies widely between locations. Although bauxite is often transported long distances, an alumina refinery located right next to the bauxite deposit can reduce freight costs to zero. By comparison some refineries pay bauxite freight costs of around US$50 to $60 per tonne of alumina production.[23]

- **Labour costs** – the nations of the former Soviet Union and China have particularly low labour costs.

- **Caustic soda/ash costs** – these vary depending on the nature of the bauxite deposit (the cost of caustic soda itself is relatively constant internationally).

- **A range of other costs** – these include government fees and charges and other operational items.

Australian alumina refineries have substantially lower costs on the two most important of these factors. Australia is the world's largest producer of bauxite ore, with the world's second largest reserves, as shown in Figure 3.2.

**Figure 3.2 Top ten bauxite deposit countries (deposit size billions of tonnes of bauxite)**
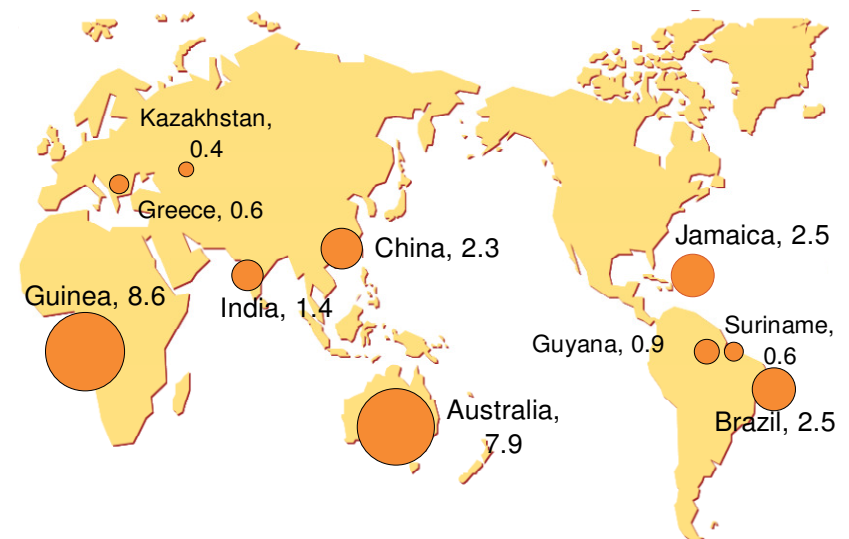


*Source: BHP Billiton (2008d)*

According to an Australian Aluminium Council report, "bauxite has a very low value to weight ratio, dictating that its refining take place in close proximity".[24] Because several refineries in Australia (Gove, Worsley, Pinjarra and Wagerup) are next to major bauxite mines, they have no freight costs. Indeed the Gove refinery remains competitive because its freight costs are so low, despite using very high cost fuel oil for energy. Other Australian refineries incur freight costs, but these are still low compared to those of

---

[23] Pers. Comms. (2009c)

[24] Australian Aluminium Council (2000)

many competitor producers.[25] In addition, Australia's refineries (other than Gove) have low energy costs due to substantial domestic supplies of cheap coal and gas.[26]

Consequently, Australia's alumina refineries are generally in the lowest cost third of producers in the world, as shown in Figure 3.3.

**Figure 3.3 International alumina refining cash costs**
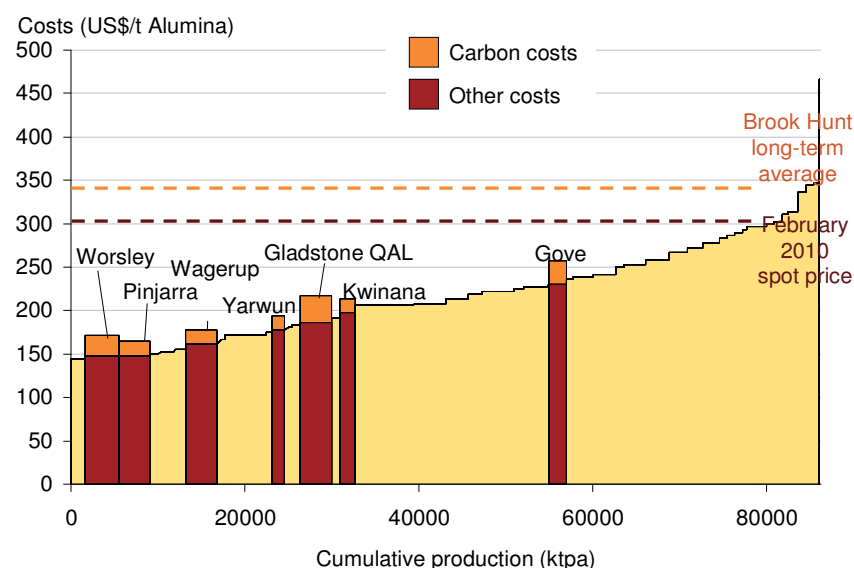


*Sources: Grattan Institute analysis compiled from: Alumina Limited (2009); Rio Tinto (2008g); Adelaide Brighton Ltd. (2009); Brook-Hunt (2008); Pervan et al (2010)*

---

[25] Pers. Comms. (2009c)
[26] Australian Aluminium Council (2000)

## 3.4 Impact of carbon pricing

Australia's alumina refineries will remain highly competitive even when they pay carbon costs.

Carbon costs for Australian alumina refineries would vary between A$19 and $37 / t alumina, as shown in Table 3.1.

**Table 3.1 Alumina refinery carbon emissions**

| Refinery | State | Primary owner/ operator | Emissions intensity (tCO$_2$/ t-alumina) | Carbon cost (A$/ t alumina) |
|---|---|---|---|---|
| Kwinana[a] | WA | Alcoa/Alumina Ltd | 0.56 | 19.46 |
| Pinjarra[a] | WA | Alcoa/Alumina Ltd | 0.56 | 19.46 |
| Wagerup[a] | WA | Alcoa/Alumina Ltd | 0.56 | 19.46 |
| Gove[b] | NT | Rio Tinto | 0.92 | 32.20 |
| Yarwun[c] | QLD | Rio Tinto | 0.54 | 18.83 |
| Gladstone (QAL)[d] | QLD | QAL (Rio Tinto & Rusal) | 1.05 | 36.75 |
| Worsley[e] | WA | BHP Billiton | 0.77 | 27.09 |

*Note: Rounding of emissions intensity numbers means costs will not precisely correspond.*

*Sources: (a) Average across Kwinana, Pinjarra and Wagerup, Alumina Ltd. (2008b); (b) RioTinto Alcan (2008c); (c) Expected emissions intensity after major refinery upgrade - RioTinto Alcan (2008b); (d) Queensland Alumina Limited (2008); (e) Worsley Alumina (2007)*

Even after adding these costs, all refineries except for Gove retain a highly competitive position in the bottom half of the international cost curve, as shown in Figure 3.3.

Australian alumina refineries are likely to continue to have substantial profit margins even when paying carbon costs. Although alumina prices collapsed to as low as US$177/t during the recent financial crisis and economic downturn, they substantially recovered to US$305/t in February 2010.[27] Long-term average real prices are forecast to be around US$340-$350/t, according to metals analysts, Brook Hunt, based on their assessment of the industry's underlying cost structure.[28] At these prices, and with cash costs including carbon costs around US$220/t, Australia's alumina refineries will be profitable.

In addition, it is reasonably likely that global alumina prices could increase to reflect carbon costs, as several of the marginal global alumina producers in Europe already pay carbon costs. As Tom Albanese, CEO of Rio Tinto (the largest global producer of aluminium), observed in an investor briefing in October 2009:

*"[It] just so happens that the marginal alumina producer is likely to have carbon pricing early on the stage, so you are likely to see the marginal cost of alumina coming up early on in the piece".*[29]

### 3.5 Impact on global carbon emissions

For the reasons discussed above, alumina production is unlikely to leave Australia as a result of carbon pricing. In the remote event that Australian production reduced, this would probably *reduce* global carbon emissions. This is because the most expensive Australian producer is the Gove refinery. Its emissions
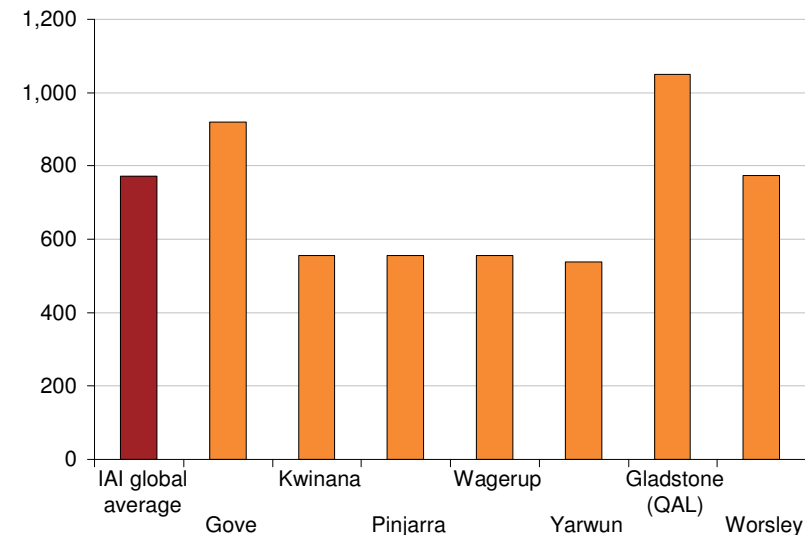
are substantially higher than the global average of 0.77t $CO_{2-e}$/t alumina, as shown in Figure 3.4.

**Figure 3.4 Alumina refinery emissions intensity (kgCO$_2$/tAlumina)**



*Source: Industry average based on International Aluminium Institute (2007)*

### 3.6 Proposed industry assistance

Given that Australian alumina refineries will remain highly competitive under full carbon pricing, the industry assistance proposed under the draft CPRS legislation is unnecessary.

Based on 2001-02 data contained in the CPRS Green Paper, alumina refining would qualify as a moderately emissions

---

[27] Pervan *et al.* (2010)
[28] Brook Hunt (2008)
[29] Rio Tinto (2009b)

intensive industry eligible for 66% free permits declining to 58.7% in 2020.  This would reduce carbon costs by about A$15/t alumina, such that the position of Australian producers on the international cost curve would barely alter.  However, it is conceivable that the industry may qualify as highly emissions intensive, thereby reducing carbon costs to zero for Kwinana, Pinjarra, Wagerup and Yarwun. The maximum carbon cost under such a scenario would be no more than A$15/t  alumina for the most emissions intensive refinery, Gladstone QAL.

### 3.7 Reducing carbon emissions

Carbon pricing would encourage alumina refining in Australia to reduce its carbon emissions by using more gas rather than coal, using alternative fuels, and making more use of co-generation plants to minimise wasted heat.

Using gas instead of more carbon-intensive coal or fuel oil would reduce emissions. Yarwun is in the process of switching to gas and the Alcoa refineries also use gas. Gove lacks physical access to gas presently but construction of a gas pipeline has been under consideration and is technically feasible due to offshore gas deposits in reasonable proximity.[30]  Switching the Worsley refinery to gas is inhibited by the recent increases in gas prices relative to coal. However switching QAL's Gladstone plant is likely to be viable considering its proximity to Yarwun and plentiful coal seam gas supplies. This has been under active management consideration according to a 2008 Rio Tinto Alcan presentation.[31]

Emissions could also be reduced by using alternative fuels for power generation.  The multi-fuel circulating fluidised bed cogeneration (CFB) units in the Worsley refinery are able to burn up to 30% biomass (waste wood product), alongside coal.[32]

Cogeneration plants use waste heat to generate electricity, reducing carbon emissions.  All Australian alumina refineries already co-generate heat and electricity.  Some with large-scale generation such as the WA refineries and Yarwun may benefit from a rise in electricity prices as coal-fired electricity generators pay carbon costs.

There may be an opportunity to use more co-generation at Gladstone (QAL), where a 150 MW co-generation plant is under investigation with a "good likelihood" of proceeding according to energy analysts McLennan Magasanik and Associates.[33] Gove is remote from major electricity demand centres and transmission infrastructure, making expansion in co-generation less viable.

---

[30] Australian Aluminium Council (2000)
[31] Rio Tinto Alcan (2008h)

[32] Worsley Alumina (2008)
[33] McLennan Magasanik Associates (2009)

# 4. Liquefied Natural Gas

## 4.1 Summary of analysis

The key business decision for Liquefied Natural Gas (LNG) producers in Australia is whether to proceed with substantial investment in new projects. If projects currently under investigation proceed, Australia could become the world's largest LNG producer.

A carbon price is very unlikely to affect these decisions. The carbon price would only be a small percentage of the projects' lifetime costs (including capital investment). Production costs (including a carbon price) are less than current gas prices and those forecast by producers. At these prices, Australian projects would provide significant return on capital invested. A carbon price would not substantially increase the uncertainty of LNG investment, which is subject to far greater uncertainties from other variables. And finally, even if Australian costs were higher than those of other countries, investment would probably proceed in Australia because it has significantly lower sovereign risk.

Consequently, it is not necessary to provide any free permits to LNG producers to avoid carbon leakage.

## 4.2 Industry background

Australia has large reserves of methane-rich gas in hydrocarbon reservoirs off the coast of North-West Australia and also within deep, unmineable coal seams in Queensland and possibly NSW. The gas resources far exceed foreseeable domestic demand.

Australia has two operating LNG projects, one in the Pilbara region of Western Australia and one in Darwin. Another two Pilbara projects are under construction. In addition many LNG projects are in different stages of development with varying prospects of proceeding to construction. As shown in Table 4.1, capacity for up to 129 addition mtpa is under development; however not all of this is likely to proceed.

**Figure 4.1 Potential LNG capacity by 2020 (mtpa)**
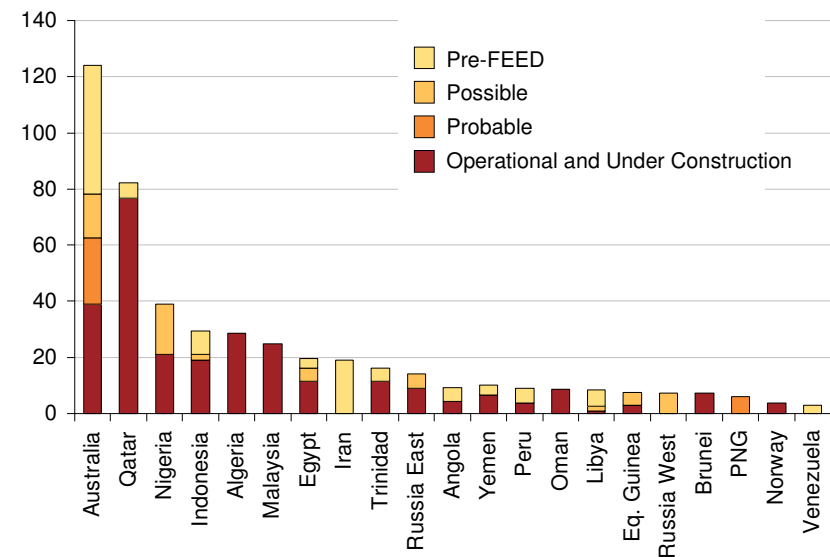


*Source: ABARE (2009a); Hirjee et al. (2009b)*
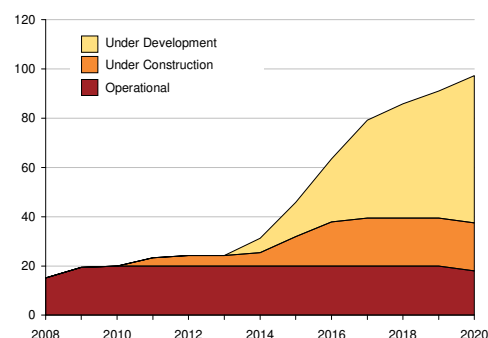
**Table 4.1 Australian LNG projects**

| LNG Project | State | Gas Field Type | Status | Major project owners | LNG capacity (m t LNG / yr) | Condensate (m barrels / yr) | Condensate (% revenue) | Capital cost (A$b) | Cost / gas capacity ($/t) |
|---|---|---|---|---|---|---|---|---|---|
| North-West Shelf | WA | Conventional | Operating | Woodside / Shell / BHP Billiton / Chevron / BP | 16.3 | 6.9 | 5.7% | 27.0 | 1,656 |
| Darwin | NT | Conventional | Operating | Conoco Phillips / Santos | 3.5 | 1.3 | 5.0% | 1.8 | 514 |
| Pluto | WA | Conventional | Under Construction | Woodside | 4.3 (up to 13.0) | 2.7 | 8.5% | 12.3 (up to 20.3) | 3,023 |
| Gorgon | WA | Conventional | Under Construction | Chevron / Shell / ExxonMobil / BP | 15.0 | 5.1 | 4.6% | 43.0 | 2,867 |
| Ichthys | WA | Conventional | Probable Dev't | INPEX / Total | 8.4 | 36.5 | 58.6% | 24.0 | 2,857 |
| Queensland Curtis LNG | Qld | Coal Seam | Probable Dev't | BG Group | 8.5 | 0 | n/a | 8.0 | 941 |
| Gladstone LNG | Qld | Coal Seam | Probable Dev't | Santos / Petronas | 3.5 (up to 10.0) | 0 | n/a | 7.7 | 2,200 |
| Fisherman's Landing | Qld | Coal Seam | Probable Dev't | LNG Ltd / Arrow | Up to 3.0 | 0 | n/a | 3.0 | 1,000 |
| Australian Pacific LNG | Qld | Coal Seam | Possible | Conoco Phillips / Origin Energy | 7.0 (up to 16.0) | 0 | n/a | 17.0 (up to 35.0) | 2,429 |
| Wheatstone | WA | Conventional | Possible | Chevron | 8.6 (up to 25) | unknown | n/a | 18.0 | 2,093 |
| Browse | WA | Conventional | Pre-FEED | Woodside | Up to 15 | significant | significant | 30.0 | 2,000 |
| Sunrise | WA | Conventional | Pre-FEED | Woodside | 5.3 | unknown | n/a | 12.0 | 2,264 |
| Prelude | WA | Conventional | Pre-FEED | Shell | 3.6 | unknown | n/a | 5.9 | 1,639 |
| Scarborough | WA | Conventional | Pre-FEED | Exxon Mobil | 6.0 | unknown | n/a | unknown | unknown |
| Shell - Curtis Is. | QLD | Coal Seam | Pre-FEED | Shell | Up to 16.0 | 0 | n/a | unknown | unknown |

Note: Assumes LNG price of US$11.30/mmBTU and liquids (condensate) price of US$80/barrel; 52.5mmBTU/tLNG. Browse condensate resources estimated at 370m barrels (see Ramsey and Hardie (2009)). "FEED" is Front-End Engineering and Design, a major stage in the development of an LNG project.
Source: ABARE (2009a) and Hirjee et al. (2009b).

If all these projects proceed, Australia would become the world's largest LNG producer, as illustrated in Figure 4.1. In supplying the Asian market and possibly the west coast of North America, our largest competitors would be the Middle East, Russia, PNG and South-East Asia. These countries are unlikely to impose a carbon price in the near future (although Russia has weak binding commitments under the Kyoto Protocol).

However, some of these projects will probably not proceed to construction by 2020, with or without carbon pricing. Several are still in early development, and will only proceed if the project is commercially feasible once informed by further work: clarifying the size of the resource; determining how the gas (& oil) will be extracted, transported and processed; obtaining the necessary state and federal government planning and environmental approvals; securing long-term customer contracts at commercially attractive prices; and securing financing. The majority of future capacity is not yet locked in, as shown in Figure 4.2.

**Figure 4.2 Illustration of timing for LNG projects (mtpa)**



*Source: Hirjee et al. (2009b). Note: does not incorporate all projects listed in Table 4.1.*

LNG projects would contribute substantially to Australian GDP and employment. Developments of 28 mtpa (about the scale of the Queensland coal-seam gas projects in development) are estimated to generate an additional $1bn / yr in GDP, and employ an average of around 2,500 people in the medium term.[34] Employment over the next 10 years may be much higher as the resource is developed, as shown in Figure 4.3.

**Figure 4.3 Estimated labour requirements to develop 28 Mtpa Qld LNG industry (persons employed)**
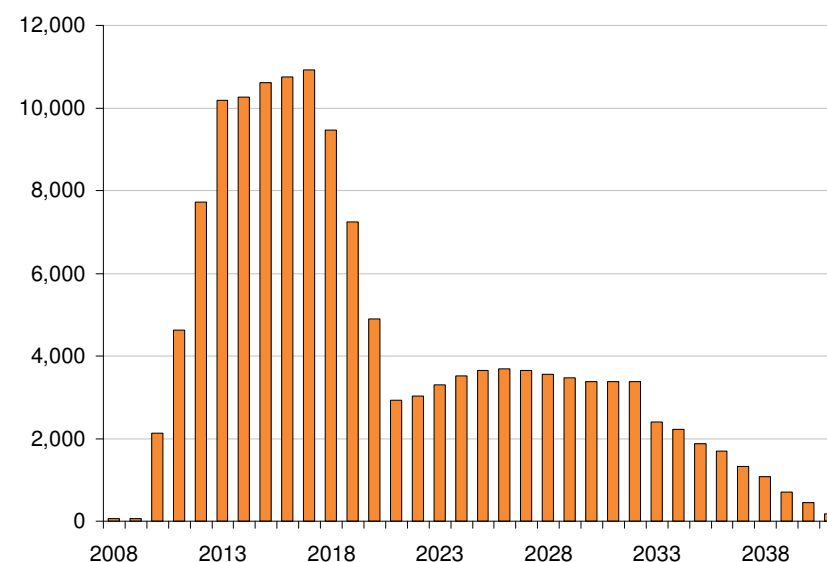


*Source: McLennan Magasanik and Associates with KPMG-Econotech (2009)*

---

[34] McLennan Magasanik Associates and KPMG-Econtech (2009)

## 4.3 Industry economics

The key business decision for Liquefied Natural Gas (LNG) producers in Australia is whether to proceed with substantial investment in new projects, rather than continue operation of existing facilities.

LNG projects take a long time to develop. Large costs (usually several billion dollars) are spent upfront to find the resource, to prove-up the reserves, and to construct long-lived equipment and infrastructure that extracts the gas (and oil), processes it, and delivers it to market. Usually a single project delivers a large chunk of supply.

Because of these high initial capital costs, project developers tend to construct new capacity only if they have secured several foundation customers contracting to take a fixed supply over ten to twenty years. In these long-term contracts, LNG prices are usually tied to oil prices by a formula with a price floor. These contractual assurances enable project developers to minimise the risk of poor returns on a major capital investment.

As a result, LNG prices, unlike many other commodity markets, are not shaped by the short-run operating costs of the marginal producer. At least to date, prices have reflected the very substantial up-front capital costs, and are much higher than the ongoing operating costs, even including a carbon price, as illustrated in Figure 4.4.

Thus the primary impact of a carbon price will be how it affects whether new LNG capacity is constructed, as it will have negligible effect on existing projects' operating decisions.

**Figure 4.4 Operating costs, carbon cost and prices for existing LNG projects ($A/mmBTU)**
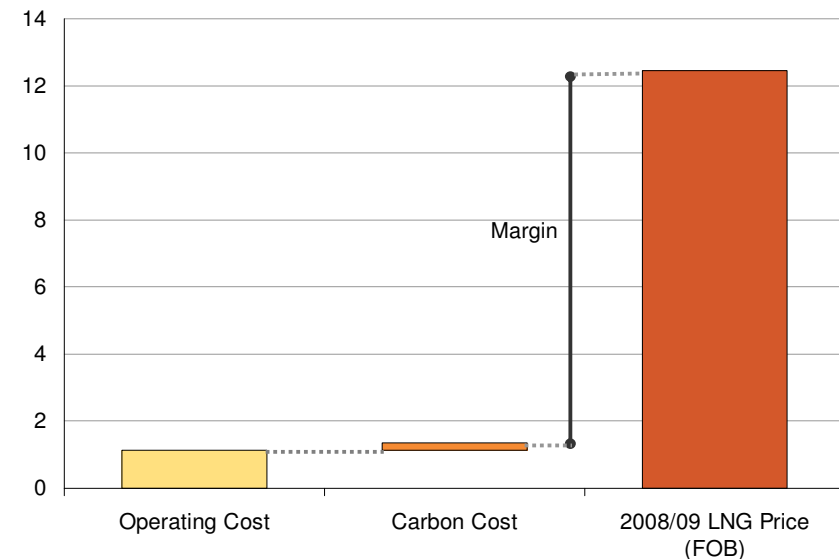


*Source: Greenwood et al. (2009) and ABARE (2009c)*
*Note: Operating costs are representative of existing LNG projects based on conventional oil & gas; operating costs for coal seam methane are higher.*

Capital costs and expected production capacity vary depending on the nature of the project, with higher costs for new projects, and more remote projects (such as Icthys). Coal seam gas projects tend to have lower capital costs but higher operating costs than the conventional projects. Costs for a representative sample of projects are shown in Table 4.1.

## 4.4 Industry greenhouse gas emissions

There is significant variability in the emissions intensity of Australian LNG projects, with the least emissions intensive projects emitting half the carbon of the most emissions intensive projects.

LNG projects vary in their greenhouse emissions intensity depending upon the following factors:

- $CO_2$ content of the gas reservoir/field. In addition to oil and gas, conventional field reservoirs may contain $CO_2$. Coal seam methane projects being developed in Queensland all have low $CO_2$. However some of the offshore oil and gas projects in the north-west of Australia have as much as 10% $CO_2$ by volume within their fields, which is extracted at the same time as the gas.

- Energy consumed in extracting and transporting the gas. Coal seam methane projects tend to require more energy than the conventional oil and gas projects in North-West Australia because they require more drill wells, water pumping, and active compression of the gas so that it flows through the pipelines. The conventional projects have naturally occurring high levels of pressure within the field that push the gas through the pipelines to liquefaction plants.

- Energy consumed in liquefying the gas. Gas for export is compressed by cooling it into a liquid so that it can readily be transported by ship (key gas markets are too far away for pipelines). The efficiency of liquefaction technology varies, although it should be relatively similar across projects.

The least emissions intensive projects emit half the carbon of the most polluting projects, as shown in Table 4.2. This table summarises the emissions intensity of several existing and proposed LNG projects for which data are available. We believe that these are a representative sample of other Australian LNG projects for which data are not available.

**Table 4.2 Australian LNG projects' emissions intensity from wellhead to liquefaction**

| LNG Project | $tCO_2$ / t LNG | $kgCO_2$/ mmBTU | Features |
|---|---|---|---|
| North-West Shelf | 0.49[a] | 9.3 | Low reservoir $CO_2$; equipment several years old |
| Darwin | 0.52[b] | 9.8 | Low reservoir $CO_2$; equipment several years old |
| Pluto | 0.32[c] | 6.1 | Low reservoir $CO_2$; modern efficient equipment |
| Gorgon | 0.35[d] | 6.7 | High reservoir $CO_2$ (7%), but captured and reinjected into underground cavity |
| Ichthys | 0.63[e] | 11.9 | High reservoir $CO_2$ (10%), no plans for sequestration |
| Queensland Curtis LNG | 0.38[f] | 7.1 | Low reservoir $CO_2$; modern efficient equipment; pumping & compression for extraction & transport |
| Gladstone LNG | 0.50[g] | 9.4 | Low reservoir $CO_2$; modern efficient equipment; pumping & compression for extraction & transport |

*Source: (a) Woodside (2009c); (b) ConocoPhillips (2009); Chevron Australia (2005); (c) Woodside (2007); (d) Chevron Australia (2006); Chevron Australia*

*(2010); (e) Inpex (2009); Morgan Stanley (2008); (f) QGC Ltd. (2009); (g) GLNG (2009)*

## 4.5 Impact of carbon pricing

A carbon price is very unlikely to affect decisions about whether to build new capacity.  The carbon price would only be a small percentage of the projects' lifetime costs (including capital investment).  Production costs (including a carbon price) are much less than current LNG prices and those forecast by major Australian producers.  At these LNG prices, Australian projects would provide significant return on capital invested.  A carbon price would not substantially increase the uncertainty of LNG investment, which is subject to far greater uncertainties from other variables.  And finally, even if Australian costs were higher than other countries, investment would probably proceed in Australia because it is significantly lower sovereign risk.

A carbon price has relatively little impact on the gas price required to justify investment.  Looking across both existing and proposed projects, Deutsche Bank has estimated the minimum gas price that would deliver a 12% return, considered the key benchmark for investment viability (see Figure 4.5).[35] This estimate takes into account capital costs, operating costs, and offsetting oil condensate revenues. A $35 carbon price marginally increases the gas price required to around $9.40/mmBTU for the most expensive project for which data are available.

---

[35] McLennan Magasanik & Associates and KPMG-Econotech (2009) also adopted a 12% weighted average cost of capital in their assessment of LNG industry viability. An ACIL Tasman (2008a) study commissioned by major LNG companies used a lower WACC of 10.4%.

**Figure 4.5 LNG price per mmBTU required for 12% return on LNG projects (AUD)**
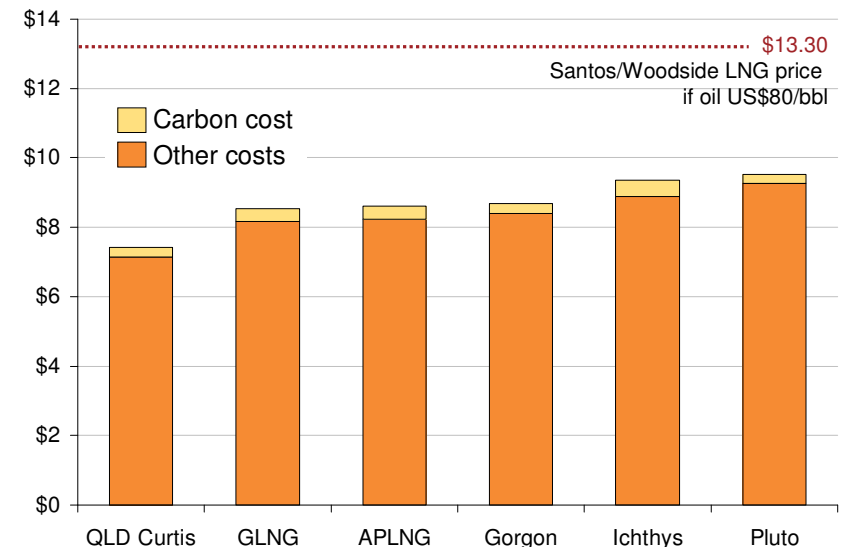


*Free on Board basis. Incorporates offsetting revenue from oil condensate. Assumes $A:$US is 0.85; APLNG assumed to have same emissions intensity as GLNG given similar size and location; 12% WACC.*
*Note: Pluto cost is inflated by pre-investment for future increases in capacity and will be lower once new LNG trains are brought on-line.*
*Sources: Hirjee et al. (2009a) with Grattan Institute estimates of carbon cost impact.  LNG price: Woodside (2009b); Santos (2009)*

Actual LNG prices are expected to substantially exceed the prices required to justify investment provided that oil prices remain above US$60/barrel. In recent investor presentations, Santos and Woodside both asserted that they expect "strong long term LNG

pricing", substantially higher than prices in past years. These presentations indicated that under more recent contracts, LNG prices were closely coupled to the oil price (on an energy equivalent basis commonly referred to as "oil parity") and a price US$12.40/mmBTU delivered could be expected at oil prices of US$80/barrel.[36] Subtracting transport costs of around US$1.10,[37] this equates to a price ex-liquefaction of US$11.30, or AUD$13.30 at our assumed exchange rate. If the oil price were to drop to US$60/barrel then so would the gas price such that gas prices per mmBTU would be US$9.30 delivered or US$8.20 ex liquefaction, equating to A$9.65. While oil prices are highly uncertain and subject to considerable volatility, base case projections from US Government Energy Information Administration (which take into account future costs of developing incremental oil capacity) and International Energy Agency suggest that future international oil prices are likely to remain above US$80/barrel in real terms over the next two decades.[38]

### 4.5.1    Investor risk and uncertainty considerations

Carbon price uncertainties are small relative to other uncertainties in LNG projects. As shown in Table 4.3, plausible variations in oil price and construction costs are far greater than uncertainties linked to carbon pricing, according to estimates in a recent study for the Queensland Government.

**Table 4.3 Investment return sensitivities to commercial variables**[39]

| Change in commercial variable | Impact on IRR |
|---|---|
| US$30 change in oil price per barrel from base case of US$80 | ±9 to 10% |
| 25% variation in liquefaction plant construction costs (from US$1b per Mtpa) | ±3% to 4% |
| A tripling in royalties by replication of the federal government petroleum resources rent tax | 1% |
| Exempting LNG from liability under CPRS | 0.6% |

*Source: McLennan Magasanik and Associates and KPMG-Econtech (2009)*

To illustrate, the Pluto LNG project exceeded budgeted construction costs by 6%-10% ($672m-$1,120m) with only one year of construction remaining.[40] The estimated cost of carbon emissions for the project at $35/tCO$_2$ is $48.6m/yr (based on capacity of 4.3m t LNG/yr). It will take around 14 to 23 years of operation of the Pluto project before the cumulative carbon costs equal this blow-out in construction costs that will be incurred in just a single year.

Sovereign risk is a significant consideration for most LNG projects outside Australia. Lower sovereign risk in Australia justifies investment in Australia even if the development costs are higher, and customers are also prepared to pay a premium for secure supply.

Large, unexploited gas resources that could be developed at reasonable cost are predominately located in regions with high

---

[36] Santos (2009); Woodside (2009b)
[37] McLennan Magasanik Associates and KPMG-Econtech (2009)
[38] Energy Information Administration (2009); International Energy Agency (2009)

[39] This study used a carbon price commencing at $27.70/tCO$_2$ in 2011 ascending by 5% per annum to $42.97/tCO$_2$ in 2020
[40] Woodside (2009a)

political or security risk such as the Middle East, Russia, and Africa, as shown in Figure 4.1.

In many of these countries, unlike Australia, private sector companies can only invest if they partner with government-owned national oil companies, thereby surrendering a degree of control over the project, and diluting their share of returns. Several of these countries have a history of seizing substantial equity (either without compensation or with below cost compensation) or outright nationalising oil and gas projects. These seizures often occur after private sector developers have expended considerable resources in developing the projects and lowering the commercial and technical risk. Some of these countries are active or recent conflict zones, subject to substantial political unrest, or involved in, or subject to, substantial terrorist activity. Many have a history of systemic government corruption. Such major problems led analysts at global investment bank UBS to observe,

> *"Australia's LNG outlook is therefore highly promising. It has more potential large-scale LNG project developments on the drawing board than any other country in the world. Australia also has positive features, such as a track record as a stable OECD country, a reliable LNG supplier, and a lack of direct Government participation in its LNG projects. We believe other potential regional LNG suppliers have a higher degree of sovereign/country risk."*[41]

---

[41] Ramsey and Hardie (2009). McLennan Magasanik & Associates and KPMG-Econtech (2009) came to a similar conclusion

### 4.5.2 Customer risk considerations

From a customer's perspective, while gas quality is relatively similar across projects, the reliability of gas suppliers is not. Like developers, customers tend to take a long-term view about LNG project development because reliability of supply is so important. This is because:

- Gas underpins the energy supply in many countries, which is an essential service. A sudden shortfall in supply, even for a short time, can cause substantial economic and social hardship.

- There is limited supply liquidity, so that if one supplier withdraws capacity, it is difficult for another producer to replace the volume quickly.

The oil crises of 1973 and 1979 are still fresh in the memories of energy import-dependent Asian countries such as Japan, South Korea and Taiwan. Their concern with long-term reliable supply is reflected by the fact that most foundation customers take an ownership stake in Australian LNG projects and other Australian energy resource projects such as coal.

Customers manage reliability by diversifying supply sources across multiple countries and projects. They also value individual projects that are more reliable. Consequently, they prefer projects developed and operated by privately owned companies rather than state-owned projects. Privately owned projects are less prone to political interference such as those of the Arab oil embargo, or Russia's more recent curtailment of gas supplies into Europe. Customers also prefer countries with cultures of

honouring and respecting contracts with strong legal frameworks to resolve contractual disputes and penalise breaches. As Deutsche Bank oil and gas analyst, Jon Hirjee, observed,

*"Traditional LNG buyers in Japan, South Korea and Taiwan have a long history of focusing on security of supply over pricing."[42]*

For these reasons, Australian projects are lower risk for customers than projects from most other competing countries, and customers may be willing to pay a price premium for Australian gas that exceeds any additional carbon costs.

## 4.6 Reducing emissions intensity

The LNG industry has a good track record of innovations that have enabled significant reductions in emissions intensity. Opportunities for improvement lie in:

• Improved energy efficiency in liquefaction.

• Capturing and sequestering reservoir $CO_2$ emissions.

Gorgon is a good case study of both these measures. Since the original 1998 concept, design refinements are expected to reduce carbon intensity by 61% (0.54tCO$_2$/t LNG), as shown in Figure 4.6. Proposed liquefaction facilities use substantially less energy than existing plant due to incremental improvements in gas turbine compressor fuel efficiency. Waste-heat recovery also

reduces energy requirements. It is also possible to capture and sequester the $CO_2$.

**Figure 4.6 Greenhouse emissions intensity improvements in Gorgon LNG project design (tCO$_2$/t LNG)**
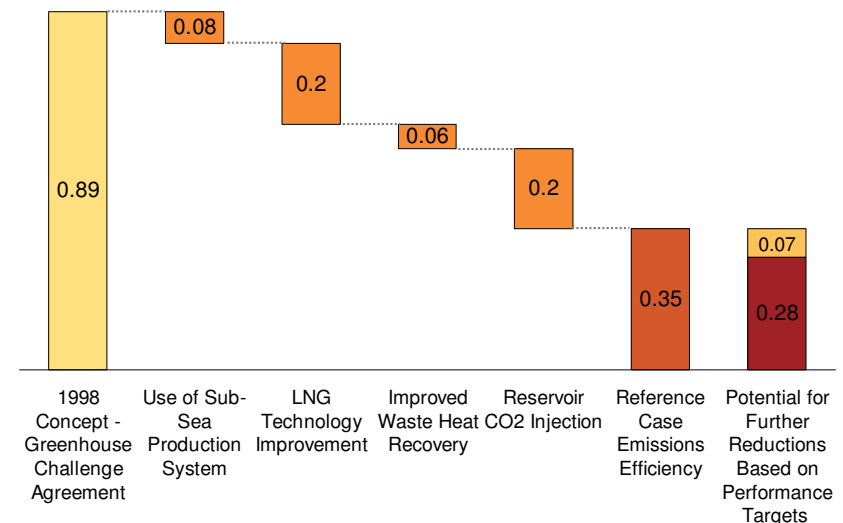


*Source: Chevron Australia (2005)*

It is difficult for existing plants to capture energy efficiency gains from better gas compression and LNG processing without costly replacement of functioning equipment.

However, there are substantial opportunities for new plants. LNG Limited which is proposing a liquefaction facility at Fisherman's Landing in Gladstone expects to emit only 0.21tCO$_2$ / t LNG,

---

[42] Hirjee, Morgan, Lewandowski (2010)

substantially less than the emissions of the liquefaction process proposed for Queensland Curtis LNG (0.24tCO$_2$) and Gladstone LNG (0.35tCO$_2$).  The Fisherman's Landing proposal would use the waste heat from the gas turbines to drive a steam turbine generator that produces electricity and also employs ammonia-based refrigeration.

The other significant option to reduce carbon emissions is to capture and store the CO$_2$ embodied within some of the conventional oil and gas reservoirs.

Capturing reservoir CO$_2$ is technically straightforward for LNG developments, with limited additional cost.  Although storage can be more challenging, the existing LNG process already has to separate the CO$_2$ from any gas prior to liquefaction (to ensure the gas meets customer requirements and to prevent blockages and break-down of the liquefaction process). Historically this CO$_2$ was vented into the atmosphere, but the relatively pure stream of CO$_2$ can also be stored underground in saline aquifiers or old oil and gas reservoirs if found to be geologically secure. There are three substantial international examples of this already occurring in the gas industry: the Sleipner project in Norway (1mtCO$_2$/yr); the Snohvit project in Norway (0.7mtCO$_2$/yr); and the Saleh project in Algeria (1mtCO$_2$/yr).[43] In Australia the Gorgon Project plans to sequester 3.2mtCO$_2$/yr. The CO$_2$ will be injected into a nearby saline aquifer around 2500 metres underground.[44]

It is conceivable that CO$_2$ sequestration could be economically attractive for some LNG projects with a carbon price of $35.

According to the International Energy Agency's Greenhouse Gas R&D Programme, the additional costs of CO$_2$ re-injection, including compression, pipeline and wells for the Gorgon project, are approximately A$300 – $400 million. Although sequestration also requires an acid gas removal plant (which strips the CO$_2$ from the natural gas) costing around A$400m, this plant is required by all LNG projects whether or not they sequester the waste CO$_2$.[45] Based on $400m capital expenditure for CO$_2$ injection and a carbon price of $35, (and excluding the $60m grant subsidy from the Federal Government) the additional costs of sequestration in the Gorgon Project will return about 20% before tax on the capital invested.[46]
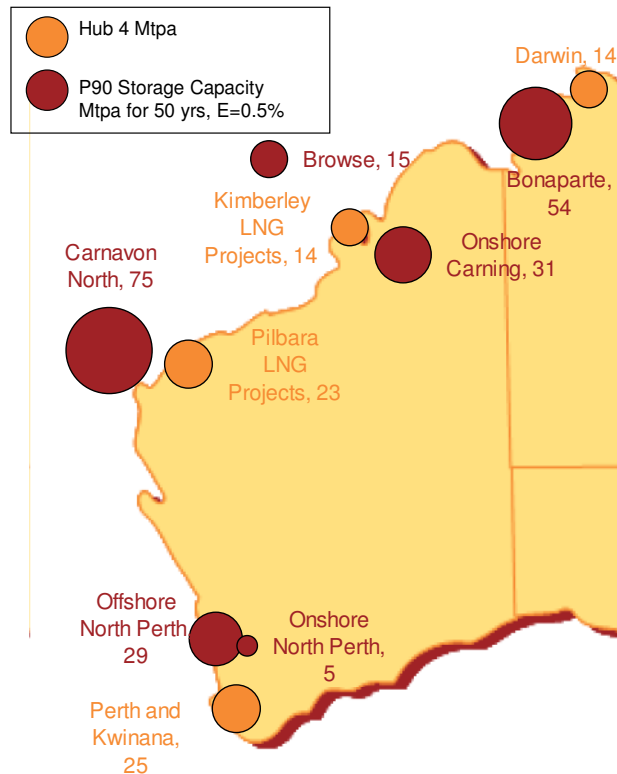
However, sequestration is only likely to be economic if there is a geologically suitable storage reservoir nearby to the LNG plant. Otherwise the costs of transporting the CO$_2$ become prohibitive. Gorgon's LNG processing plant is very close to an area with suitable geology for storage of CO$_2$, with the injection site only 2-5km from the LNG plant.[47] According to the Australian Government's National Carbon Mapping and Infrastructure Plan, a number of geological basins being considered for LNG developments are also suitable for CO$_2$ storage (see Figure 4.7). However, most LNG processing plants will be much more than 5km from the storage sites.

---

[43] International Energy Agency (2010)
[44] Chevron Australia (2005)

[45] International Energy Agency (2010)
[46] Grattan analysis based on International Energy Agency (2010) capital cost data
[47] Chevron Australia (2005)

**Figure 4.7 $CO_2$ emissions and potential $CO_2$ storage capacity in north-west Australia**



Hub 4 Mtpa

P90 Storage Capacity
Mtpa for 50 yrs, E=0.5%

Darwin, 14

Browse, 15

Bonaparte, 54

Kimberley LNG Projects, 14

Onshore Carning, 31

Carnavon North, 75

Pilbara LNG Projects, 23

Offshore North Perth 29

Onshore North Perth, 5

Perth and Kwinana, 25

*Source: Carbon Storage Taskforce (2009*

## 4.7 Impact on global emissions if Australian projects go offshore

It is difficult to be definitive about whether Australian projects emit more or less carbon per tonne of LNG produced relative to overseas developments. Comprehensive emissions intensity data are not available for many potential LNG projects being planned. However, on the limited data available, Australian projects are marginally more carbon intensive than overseas projects, as shown in Figure 4.8. It should be noted that the published data on the international projects' emissions intensity do not specify emissions measurement scope boundaries (what parts of the operation's emissions are and aren't included) which complicates comparisons.

Further analysis is required, yet it seems likely that overseas conventional projects emit less carbon than the Australian high $CO_2$ field projects of Ichthys and Browse, and also some of the more emissions intensive coal-seam methane projects that require significant energy to extract the gas from the coal.

**Figure 4.8 Emissions intensity of Australian and international LNG projects (tCO$_2$/t LNG)**
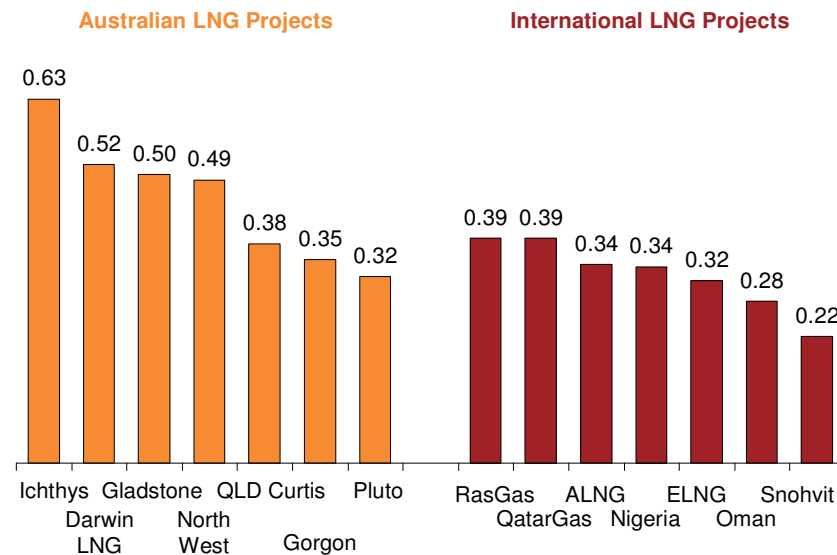


*Source: QGC Limited (2009) & Grattan Institute research*

## 4.8 Government assistance

The government has indicated that LNG is likely to qualify as a moderately emissions intensive activity[48] and therefore will be eligible for free permits even though this is unlikely to be material to their overall economics. At present it is unclear based on available information how the government will attribute an overall project's emissions between condensate and LNG, and therefore how many free permits are to be provided per unit of LNG production. Due to an absence of data we have had to assume all emissions are attributed to LNG – consistent with how industry has traditionally calculated emissions intensity in its environmental effects statements. Using this assumption we estimate that for each mmBTU of LNG produced producers would receive the equivalent of 6.3kgCO$_2$ in free permits,[49] declining to 5.5kgCO$_2$ in free permits by 2020.  High CO$_2$ projects such as Ichthys would receive at least 6kgCO$_2$ in free permits under the minimum 50% assistance level agreed in November 2009 negotiations with the coalition.  At $35/tCO$_2$ these permits are worth $0.19 - $0.22 per mmBTU compared to prices in the realm of $11.30 (at an oil price of US$80/barrel).  The total cost to the Australian government in foregone revenue over the period to 2020 would be $3.6b (based on an Australian LNG industry growing to 53Mpta by 2020, deemed probable by Deutsche Bank).[50] Yet, as discussed above, this assistance is unlikely to affect decisions to build new plants.

---

[48]Australian Government (2009a)
[49] This is based on the production weighted emissions intensity of the existing two LNG projects – North-West Shelf and Darwin which we estimate to be approximately 0.5tCO$_2$/tLNG or 9.5kgCO$_2$/mmBTU of LNG
[50] Hirjee *et al.* (2009b)

Industry-commissioned work implied that a carbon price would represent a significant risk to LNG project investment viability,[51] However, unlike this Report, the industry work:

- only examined a theoretical facility with emissions intensity greater than what our source data indicates for Ichthys ($0.71tCO_2/tLNG$);

- did not appear to account for the substantial condensate revenues that characterise Ichthys and other high emissions intensity projects such as Browse;[52] and

- assumed future LNG prices much lower than prices outlined by LNG companies in recent investor presentations; and

- assumed oil prices lower than current base case IEA and EIA forecasts.

Also this work implied a high risk to project viability because the additional carbon costs would result in LNG projects becoming cash flow negative, not under average conditions, but rather under adverse market conditions of low probability (10%). It would be a significant shift in principles of government administration to avoid a government policy merely because it might impose costs that might lead some businesses to experience losses during brief periods of adverse market conditions.

It has also been claimed by LNG industry representatives that failure to provide free permits will increase global emissions because it will make LNG less competitive against coal.[53] Yet the difference in cost between LNG and coal on an energy basis (per mmBTU) in the Asian market is stark and carbon costs applied to LNG projects would make little difference. Based on the recent contract pricing outlined by Santos[54] and Woodside[55] to investors, LNG sold into the Asian market would have a price of approximately $14.60 per mmBTU delivered at an oil price of US$80/barrel, although some analysts suggest prices of $13.90 may be more likely.[56] By comparison the forecast for coal prices this coming financial year is about US$5.50 per mmBTU.[57] A $35 carbon price would increase the cost of an mmBTU of gas by around $0.21-$0.42 – hardly likely to impact fuel choices when gas is already $8.40 - $9.10 more expensive.

---

[51] ACIL Tasman (2008a)
[52] Assumptions in ACIL Tasman (2008a) around condensate revenue were not transparent but backward calculations using gas volumes and prices provided in the report suggest little to no condensate revenue. We sought to check this with ACIL Tasman but they did not reply.

[53] Australian Petroleum Production and Exploration Association Limited (2008) Submission to the Carbon Pollution Reduction Scheme Green Paper, September 2008
[54] Santos (2009);
[55] See page 8 of Woodside (2010) Woodside Annual Report 2009, http://www.woodside.com.au/Investors+and+Media/Annual+Reports/
[56] Hirjee and Morgan (2009c)
[57] Based on delivered coal price from Australia of $120/tonne and energy content per tonne of 25.6mmBTU (27GJ) taken from ABARE (2009) Energy in Australia 2009, www.abare.gov.au

# 5. Coal mining

## 5.1 Summary of analysis

A carbon price would have only a minor impact on the competitiveness of 90% of Australia's black coal mines. For the remaining 10% the impact on profitability is significant due to substantial emissions of methane, a potent greenhouse gas.

However, while their profitability might be significantly reduced, these emissions intensive mines are unlikely to close. Most of them primarily produce coking coal that sells at a premium, at margins greater than US$30 per tonne of coal.

However, even if they did reduce production, it is likely to shift from these high emissions mines to lower emissions mines in Australia. A carbon price will have a minor impact on the profitability of other mines, but it is unlikely to change their international competitiveness.

It may be possible for some high emissions coal mines to reduce their emissions, and this may be economically viable,[58] although we have not examined the precise costs and benefits.

Free permits, such as those provided under the draft CPRS are not justified. Rather than acting to prevent perverse carbon leakage they primarily serve to protect profits of emissions-intensive mines and delay the movement of production from high emissions mines to low emissions mines in Australia, which is the very purpose of imposing a carbon price. Rather than providing

free permits, it would be better to let these mines restructure and, in the rare cases where closure might occur, target assistance to the affected communities and the individuals who lose employment and income.

## 5.2 Industry background

Coals ain't coals. Their chemical characteristics vary, affecting their performance and the cost of transport. At a broad level, brown coal has a high-water content, and black coal has a low water content.

Brown coal is less valuable. It costs more to transport per unit of energy delivered because the water does not burn, and some of the energy released from burning coal is wasted in converting the water content into steam. Brown coal and higher moisture black coals predominate in Victoria, South Australia and Western Australia where it is primarily used in domestic power stations, usually located close to the mine.[59] These coal mines are effectively a component of the electricity industry. They are not exposed to international competition, and increased costs due to carbon pricing are likely to be directly reflected in electricity prices.

---

[58] Climate Works Australia (2010)

[59] ACIL Tasman (2009); Cuevas-Cubria *et al.* (2009)

Black coal is broadly divided into:

- "metallurgical" coal, used in steel making (also known as coking coal); and

- "thermal" coal, largely used in power generation (also known as steaming coal).

While there are sub-variations within these two broad categories, metallurgical coal prices are substantially higher than thermal coal prices. They are effectively two different commodities, with different markets.

Australia has 118 privately owned coal mines. 74 of these are surface or open-cut mines and the remaining 44 are underground operations. These mines employ around 32,000 people.[60]

Figure 5.1 shows Australia's share of global thermal and metallurgical coal exports. Australia is the fourth largest producer of coal in the world. In 2008 Australia produced 185.9 million tonnes of thermal coal, exporting 115.1 million tonnes with a value of $8.4 billion. In 2008-09 Australia produced 123.8 million tonnes of metallurgical coal, exporting the vast majority at a value of $36.7 billion. Australia is the world's largest exporter of metallurgical coal and the second largest exporter of thermal coal.[61] 98% of Australia's black coal is produced in NSW and Queensland.[62]

---

[60] Knights and Hood (eds) (2009)
[61] ABARE (2009b)
[62] Cuevas-Cubria *et al.* (2009)

**Figure 5.1 World coal exports, 2007**
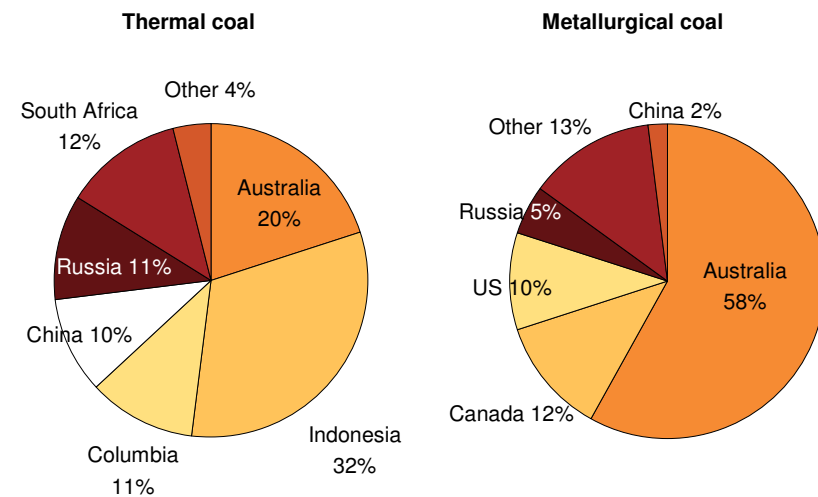


Source: Cuevas-Cubria et al. (2009)

## 5.3 Industry greenhouse gas emissions

A carbon price would have a significant impact on the profitability of 10% of Australia's black coal mines. These mines emit substantial amounts of methane and a carbon price would substantially increase their costs.

Methane is often trapped within coal seams. It is released into the atmosphere when the coal is extracted. Methane is a potent greenhouse gas that government guidelines assess as having a global warming effect twenty-one times more than the same

weight of $CO_2$.[63] Consequently even small volumes of methane can equate to substantial carbon price liabilities once converted into carbon dioxide equivalents.

A small proportion of Australian mines emit very high quantities of methane, while the remainder emit very few greenhouse gases, as shown in Figure 5.2. The variation results from the chemical characteristics of the coal basin and the depths of the mine. Shallow coal deposits (that are mined open-cut) have low emissions from mining because it is assumed that the methane has already escaped naturally to the atmosphere.[64]

As a result coal mines can vary substantially in the emissions per tonne of coal produced, and the cost impact of a carbon price, as shown in Table 5.1. This table is based on Australian Government data on methane emissions, and the non-methane emissions disclosed by the several coal mining companies' sustainability reports and mine expansion environmental effects statements. While these data do not cover all Australian coal mines, we have assumed that they provide a representative indication of non-methane emissions.

**Figure 5.2 Coal production and methane emissions of Australian black coal mines, 2006-07**

Emissions intensity (t $CO_2$-e/\$m revenue)



Black coal production (kt)
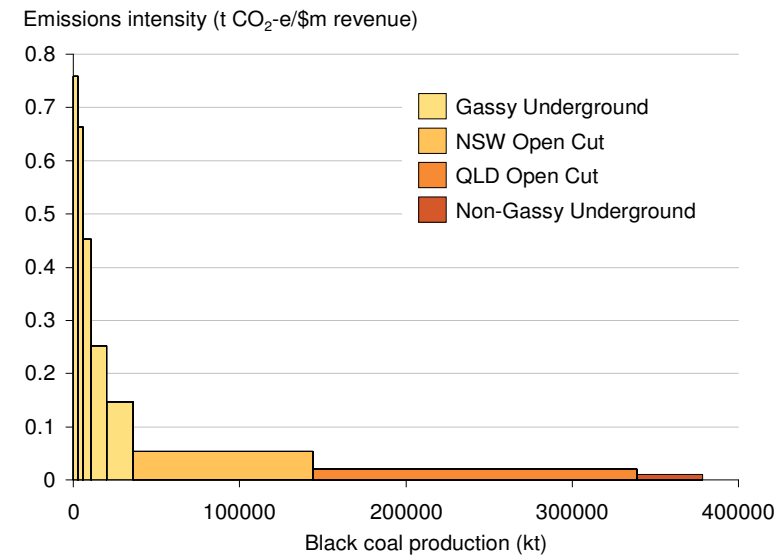
*Source: Australian Government (2008).*
*Note: Production in this graph is higher than production numbers quoted in Section 5.2. This discrepancy is likely to be due to production being measured in raw tonnes of coal rather than saleable tonnes*

---

[63] Australian Government Department of Climate Change (2009)
[64] US Environmental Protection Agency (2009)

**Table 5.1 Carbon emissions and costs for Australian coal mines**

| Mine Type | Owner | Emissions (t $CO_2$/ t coal) | Carbon cost ($/t coal) |
|---|---|---|---|
| Very low emission mines[a] | Various | 0.02 | $0.70 |
| Low emission mines[b] | Various | 0.08 | $2.80 |
| Metropolitan, NSW[c] | Peabody Energy | 0.14 | $4.90 |
| Capcoal, German Creek, Qld - open and underground combined[d] | Anglo Coal | 0.17 | $5.96 |
| Glennies Creek, NSW - longwall coal mine[e] | Integra Coal (Vale) | 0.35 | $12.12 |
| Illawarra, NSW (Appin, West Cliff and Dendrobium combined)[f] | BHP Billiton | 0.48 | $16.91 |
| Moranbah North, Qld – underground[g] | Anglo Coal | 0.48 | $16.92 |
| Very high emissions mine[h] | | 0.80 | $28.00 |

*Source: (a) Australian open cut mines such as Blair Athol, and Tarong (Rio Tinto (2006b)), Callide (Anglo American (2007)), Foxleigh (Anglo American (2008)), Baal Bone (NSW Government Department of Planning (2007)); (b) more emissions intensive open cut mines and non-gassy underground mines such as Mount Arthur (BHP Billiton (2008a)), BHP Billiton's Bowen Basin mines (BHP Billiton (2008b)), Rio Tinto's Hunter Valley Operations (Kestrel (Rio Tinto (2008f))), Mount Thorley Warkworth and Bengalla (Rio Tinto (2006b)), Invincible (NSW Government Department of Planning (2008)), and Coppabella (Macarthur Coal (2009a)); (c) Peabody (2008); (d) Anglo American (2007); (e) ERM (2009); (f) BHP Billiton (2008c); (g) Anglo American (2007); (h) Australian Government (2008)*

Based on the information in Figure 5.2, higher emission mines produce 43mt per annum, around 10% of Australian coal production. We calculate that a large proportion (at least 80%) of their production is metallurgical coal (in particular coking and hard coking), as shown in Table 5.2.

Our identification of coal mines as likely to emit more than 0.1t$CO_{2-e}$ per tonne of coal is partly based on the emissions data published by coal companies (which enable a precise understanding of emissions intensity). We have attempted to identify the other high emissions mines on the basis that they are underground mines, in a coal seam area known to be gassy. They often have installed power generation plants fuelled by methane drained from the mine. Although United Collieries is probably a gassy mine, it has not been included in our analysis as it has already been slated for closure in 2010 when the mine's economically recoverable underground reserves will have been exhausted.[65]

---

[65] Coal Mining (2009)

**Table 5.2 Australian coal mines likely to have emission intensity above 0.1tCO$_{2-e}$**

| Mine | Owner | Main type of coal produced | Annual production (mtpa) |
|---|---|---|---|
| Capcoal, German Creek, Qld - open and underground combined | Anglo Coal | Coking | 7.0 |
| Glennies Creek,-longwall (NSW) | Integra Coal (Vale) | Coking | 2.5 |
| Illawarra, NSW (Appin, West Cliff and Dendrobium combined) | BHP Billiton | Coking | 7.2 |
| Moranbah North, Qld – underground | Anglo Coal | Coking | 3.7 |
| Gujarat NRE (South Bulli, Bellambi West, Balgownie No1, Gibsons, Bellpac No1), NSW | Gujarat NRE | Coking | 1.0 |
| Tahmoor-Picton | Xstrata | Coking | 1.5 |
| Oaky Creek (No.1 & Oaky North) (QLD) | Xstrata | Coking | 11.0 |
| Metropolitan, NSW | Peabody Energy | Coking | 2.7 |
| Chain Valley, NSW | Peabody Energy | Thermal | 0.7 |
| Centenial's underground coal mines – exact mines unknown | Centennial | Thermal | Unknown |

## 5.4 Impact on profitability

### 5.4.1    Overall assessment

Figure 5.3 illustrates that for 90% of Australian coal production, carbon costs will not undermine margins such that economic competitiveness would be threatened.

**Figure 5.3 Australian coal cash margins and carbon costs**
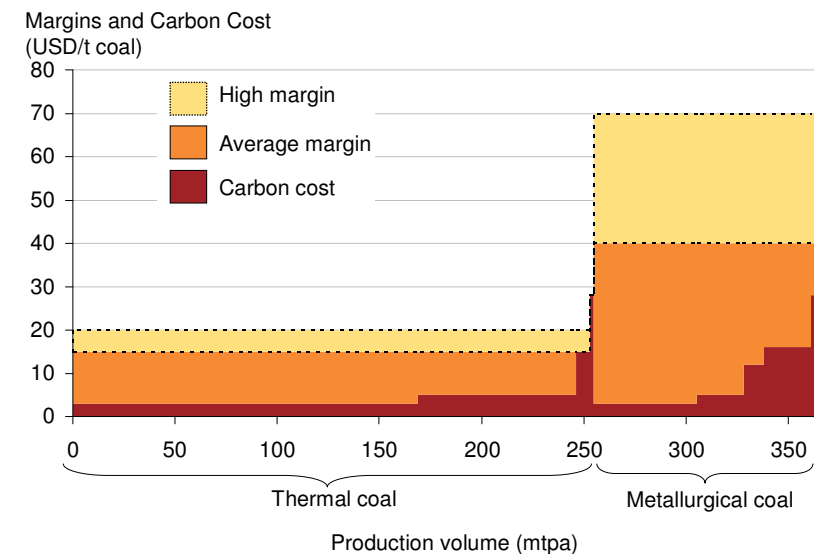


*Based on 2009 FOB coal price of Thermal: US$70/t and Metallurgical: US$129/t. Grattan Institute analysis derived from international coal mine cost curve data presented in Figure 5.4 and Figure 5.5 and emissions intensity data from Table 5.1 and information published by coal companies.*

Metallurgical and thermal coals have essentially different markets with different prices and competitive dynamics. While some coal mines' profitability could be significantly reduced, a carbon price is unlikely to cause emissions intensive mines to close.  This is because most of them primarily produce coking coal that sells at a premium, with margins greater than carbon costs. A small proportion of thermal coal is produced by gassy mines. This production might well become uneconomic, yet it is likely that any loss of thermal coal production from gassy mines would be replaced by increased production at other Australian mines within a few years, based on current coal mine expansion plans. In terms of metallurgical coal, margins are sufficiently high that closures appear unlikely.

For the remaining large majority of mines the cost increase due to carbon costs is unlikely to be more than $2.80 / t coal.

### 5.4.2 Impact on profitability – metallurgical coal

Based on the available data we estimate that over 75% of the production from the small number of gassy mines in Australia is metallurgical coal. These higher emissions mines produce approximately 30% of Australia's metallurgical coal production.

Prices and margins for metallurgical coal are substantially greater than thermal coal. The Japanese 2009-10 benchmark contract price for hard coking coal is US$129/t (FOB – on ship at the Australian port) and this is forecast to increase to around US$200 under contracts for the next financial year.[66]

Australian coal producers dominate the lower cost end of the international market for metallurgical coal, as shown in Figure 5.4. At prices of US$129/t coal, even the more marginal Australian metallurgical coal mines generate margins around US$30 per tonne, and most mines generate substantially higher margins.

**Figure 5.4 World export metallurgical coal cash costs - 2008 (US$/t coal FOB)**
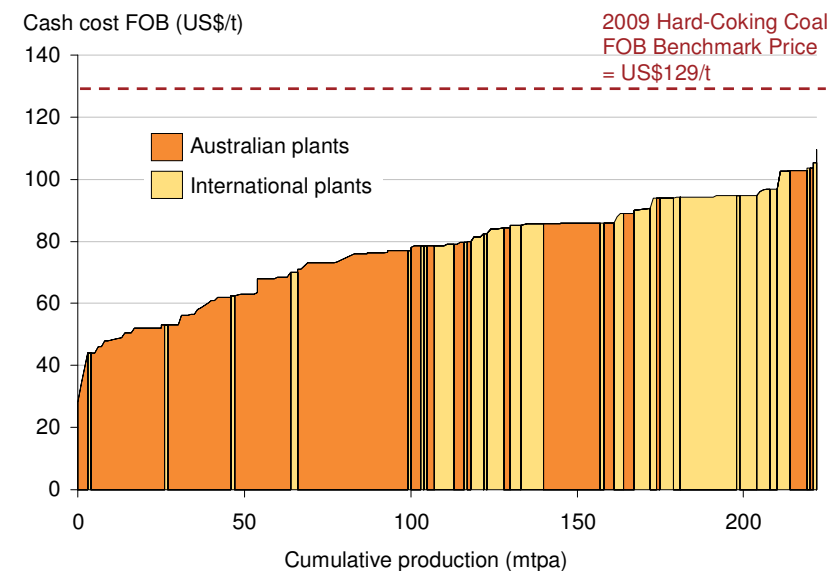


*Sources: Grattan Institute analysis compiled from: Anglo American (2009); BHP Billiton (2007b); data supplied by coal industry analysts*

---

[66] Southwood and Gray (2010c)

The margins implied by international cost curve data are consistent with reported company profits.

- For financial year 2008-09 BHP Billiton's Metallurgical coal division (all mines located in Australia) generated an EBIT to revenue margin of over 50%.[67]

- Xstrata's Australian coking coal division for calendar year 2008 generated an EBIT to revenue margin of 58% and in 2007 calendar year it was 24%.[68]

- Macarthur Coal, which predominantly produces a lower quality metallurgical coal with both mines located in Australia, achieved an EBIT to revenue margin of 37% for 2008-09 financial year and 29% for the 2007-08 financial year.[69]

The viability of most of Australia's metallurgical coal mines would not be threatened by a carbon price, although their profits would reduce. The costs of 70% of Australia's metallurgical coal mine production would increase by less than A$4/t of coal, while many of these mines have cash margins around US$65/t coal. The costs of another 8% of Australian production (BHP Billiton's Illawarra mines and Anglo Coal's Moranbah North) would increase by around A$17/t coal. If they are positioned around the middle of the international cost curve, as our research suggests,[70] this would reduce their margins of around US$45 to around US$33 per tonne of coal.

The highest emissions intensity mine in Australia – a small proportion of Australia's total metallurgical coal production – might well become a marginal producer if it paid carbon costs of $28/t coal, although it would probably just remain cash positive.

It is unlikely that much of this carbon cost increase would be passed on as price increases, even though Australia dominates supply with 70% market share of the Asian market, and nearly 50% market share of the European market. Ironically, *because* Australian mines are generally low cost producers, increases in their costs do not make them marginal producers whose costs usually set international prices.

### 5.4.3 Impact on profitability - thermal coal

A carbon price will have a minor impact on the profitability of thermal coal mines, but it is unlikely to change their international competitiveness.

95% of thermal coal is produced from mines with emissions intensity less than 0.1 t $CO_{2-e}$ / t coal.[71] The carbon cost for these mines of US$2.40/t coal[72] or less will not reorient their competitive position.

Australian thermal coal mines are low cost relative to competitors delivering to our primary Asian markets, as shown in Figure 5.5. Most Australian thermal coal production makes margins of at least

---

[67] BHP Billiton (2009a)
[68] Xstrata (2009a)
[69] Macarthur Coal (2009b)
[70] Anglo American (2009); BHP Billiton (2007b)

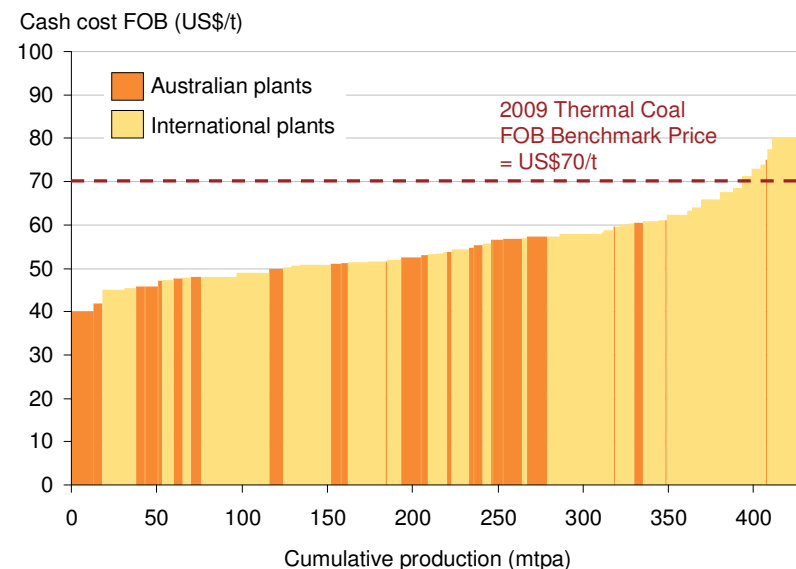[71] Deducting the metallurgical coal mine production listed in Table 5.2 from total gassy mine production implies that gassy mines produce around 10m tonnes of thermal coal, from total thermal coal production of 186mt.
[72] The equivalent of A$2.80 at exchange rate of US$0.85:A$1

US$10/t at prices of US$90 CIF (delivered) or US$70 FOB (on ship in Australian port) and averages would be closer to $15/t.

Furthermore, Japanese benchmark contract thermal coal prices are forecast to increase to between US$90-$100 FOB in 2010-11.[73] Such a price gain would more than outweigh the loss in margins due to carbon costs.

**Figure 5.5 Thermal coal FOB cash costs for mines serving Pacific Basin - 2008 (US$/t coal FOB)**



Cash cost FOB (US$/t)

Australian plants
International plants

2009 Thermal Coal FOB Benchmark Price = US$70/t

Cumulative production (mtpa)

*Source: Grattan Institute analysis based on combination of data from: BHP Billiton (2007a); Xstrata (2009b); Rio Tinto (2008e)*

A small proportion of thermal coal is produced by gassy mines. While this production might well become uneconomic, it is likely that any loss of thermal coal production from gassy mines would be replaced by increased production at other Australian mines within a few years. This is based on current plans for substantial expansions in coal mine capacity in Australia and evidence which suggests that competition from producers in other countries is limited by shipping costs, quality differences, and capacity constraints. These limits on producers from overseas are reflected by forecasts of substantial market share gains for Australian producers over the next two decades. In addition these constraints on overseas producers suggest that a carbon cost increase of US$2.40 per tonne of coal could be passed through to customers.

Thermal coal markets are divided into different regions due to the cost of shipping coal long distances. Australian producers' key thermal coal customers are in Asia and their primary competitors are from Indonesia, with some competition from China and Russia. Other major thermal coal producing regions such as South America and Southern Africa predominantly serve customers bordering the Atlantic Ocean such as East Coast USA and Europe.[74]

Australian coal is generally higher quality than is produced by Chinese and Indonesian competitors in Australia's key Asian markets. Coal quality is a particularly important issue for Australia's traditional thermal coal markets of Japan, Korea and Taiwan where stringent environmental controls apply to their

---

[73] Pervan and Robertson (2010); Southwood and Gray (2010c)

[74] BHP Billiton (2007b)

power stations. This is illustrated by Xstrata's statement in its 2008 annual report[75] when it noted,

*"In 2008, supply in the Pacific Basin was again characterised by reduced Chinese exports, higher levels of lower quality exports from Indonesia and continued infrastructure constraints in Australia. Coal production in Indonesia is split in the approximate ratio of 45% bituminous [low water content], 45% sub-bituminous coal and 10% low rank coal [high water content]. An increasing proportion of the sub-bituminous and low-rank coal has a very low energy content…and **does not compete directly with Xstrata's higher quality Australian bituminous coal production**." [our emphasis]*

Similarly, Chinese coal reserves in the central and southern provinces are lower quality. A University of Queensland publication funded by major coal producer Peabody Energy, *Coal and the Commonwealth*, concluded that these Chinese coals have "*inferior heat content, higher ash and sulphur content than the high quality Australian thermal coals*".[76]

Major Australian coal producers have told investors that Indonesian coal mining capacity is likely to be increasingly constrained. The Indonesian director general of coal, minerals and geothermal energy at the Energy and Mineral Resources Ministry has been quoted as stating that the Indonesian Government is looking to impose a cap on Indonesian coal exports at 150 million tonnes per annum.[77] This would be

substantially less than the production forecast for 2009 of 205mt.[78] Peabody Energy highlighted these constraints in a presentation to coal investors in November 2009.[79] Similarly, Xstrata noted in a recent investor presentation that Indonesian net exports are slowing, which it attributed to limits to bituminous output, infrastructure constraints, and domestic power generation growth.[80]

Although some Chinese production has relatively high methane emissions, Chinese producers are unlikely to replace any reduction in Australian production. China increasingly imports coal as Chinese demand outstrips Chinese supply: Chinese thermal coal imports are increasing rapidly.

Chinese capacity appears to be constrained, and outstripped by increases in Chinese demand. Chinese thermal coal imports from Australia are rising quickly, increasing by 69% from 2008 to 2009, with this level forecast to be maintained,[81] as shown in Figure 5.6.

---

[75] Xstrata (2009a)
[76] Knights and Hood (2009)
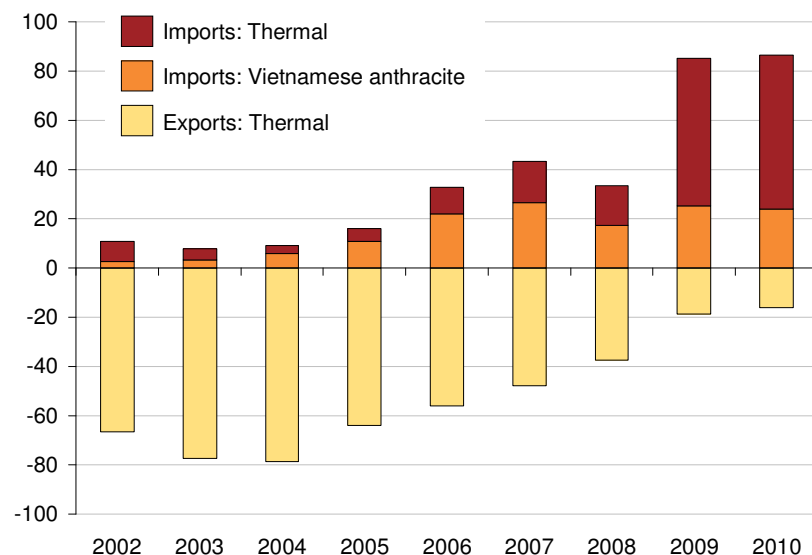[77] Sasistiya (2009); Wong (2009)

[78] ABARE (2009b)
[79] Peabody Energy (2009)
[80] Xstrata (2009c)
[81] ABARE (2009b)

**Figure 5.6 Chinese trade in thermal coal (million tonnes)**



Source: Southwood and Gray (2010c)

This is consistent with forecasts by the US Energy Information Administration for Australian exports to grow quickly to the Asian market while Indonesian and Chinese exports remain static, as shown in Figure 5.7.

**Figure 5.7 World coal flows – Major exporters and their market destinations – EIA reference case forecast (quadrillion btu)**
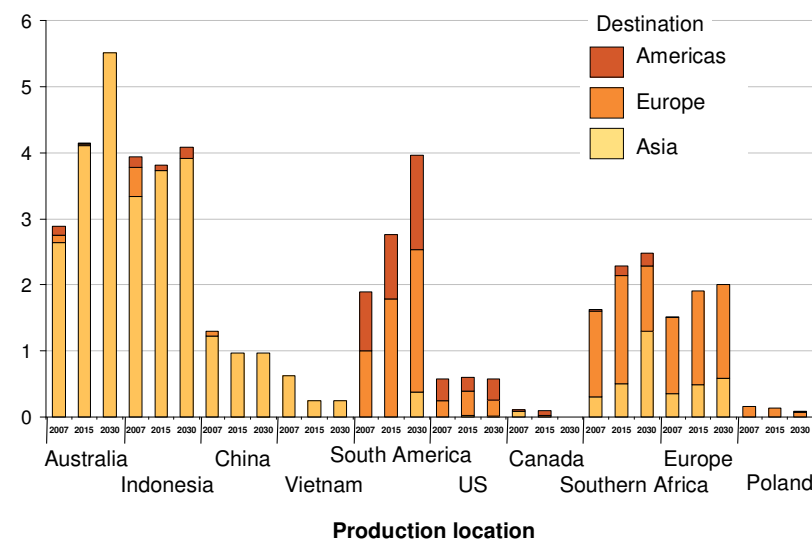


Source: Energy Information Administration (2009)

## 5.5 Impact on global greenhouse gas emissions

Even if a few Australian coal mines did reduce production, it is likely that production would shift from these high emissions mines to lower emissions mines in Australia rather than to high emissions mines overseas.

Similarly Chinese metallurgical coal imports increased from 5m tonnes per annum over the past few years to 35 million in 2009, mostly from Australia, as shown in Figure 5.8.

**Figure 5.8 Chinese seaborne metallurgical coal imports (Mt)**
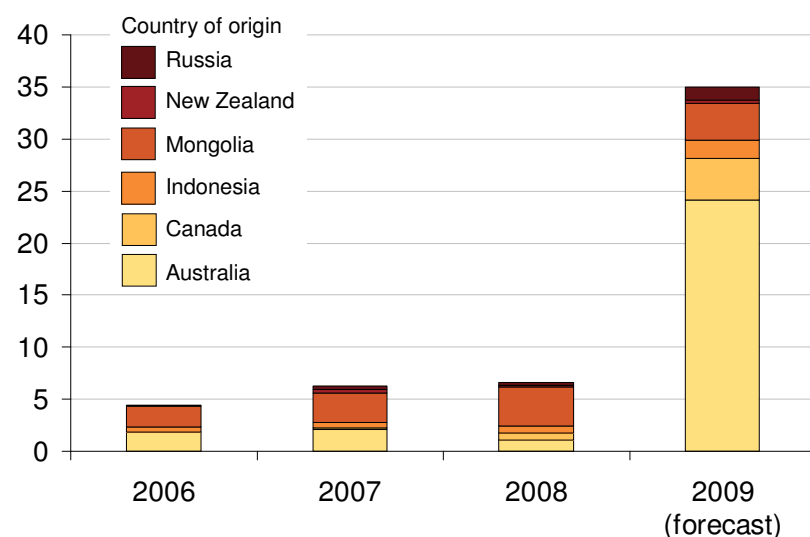


*Source: Anglo American (2009)*

## 5.6 Feasible options to reduce emissions intensity

It may be possible for some high emissions coal mines to reduce their emissions, and this may be economically viable as suggested in a recent study,[82] although we have not examined data on the precise costs and benefits to be definitive.

Gassy underground coal mines can substantially reduce their greenhouse gas emissions by capturing any methane, and burning it to convert it to $CO_2$, which has much less impact on global warming. Mines already drain methane to some extent, and further technologies are feasible.

Before they begin to mine, gassy underground coal mines routinely drain a substantial proportion of their methane, which is highly flammable, to minimise the risks of explosion. Usually this methane is concentrated and can be easily combusted. Sufficient methane is drained to make the mine safe, with the objective of beginning to mine as early as possible. More methane could usually be drained, at high concentrations, although this would come at the cost of delaying commencement of mining.

More methane can be removed once mining commences. However, this methane is combined with air pumped into the mine, and at this lower concentration cannot be readily combusted through conventional means. Technologies to oxidise the methane from mine vent air have been demonstrated, although without a carbon price they are not in widespread use.

---

[82] Climate Works Australia (2010)

Open cut mines cannot substantially reduce their methane emissions.  Drainage is not feasible because there is relatively little methane within the seam, and once mining commences it is infeasible to capture the methane.

## 5.7 Industry Assistance

Free permits, such as those provided under the draft CPRS are not justified.  Rather than acting to prevent perverse carbon leakage they primarily serve to protect profits of emissions-intensive mines and delay the movement of production from high emissions mines to low emissions mines in Australia, which is the very purpose of imposing a carbon price.

Under the current CPRS proposal (based on November 2009 negotiations which increased assistance to coal mines), the Government will provide free permits to mines with emissions intensity above 0.1t $CO_2$ / t coal to cover 60% of their fugitive methane emissions for the first five years of the scheme. This assistance will be capped at production levels that prevailed at these mines between 1 July 2007 and 30 June 2009.[83] While the assistance has been described by the Government as support to aid a "transition" for these coal mines it does not seem particularly targeted at achieving such a transition.  Instead it potentially inhibits or slows a transition to less emissions intensive mines and lessens the competitive pressure on the operators of the mines to find ways to reduce their methane emissions.

Given that there is very little possibility of carbon leakage, this proposed assistance is a poor outcome for all the reasons

discussed in Section 2 of this report and Sections 2.2 and 2.3 of the Main Report.  Rather than providing free permits, it would be better to let these mines restructure and in the rare cases where closure might occur, target assistance to the affected communities and the individuals who lose employment and income.  This assistance might take the form of assisted relocation to areas that increase coal production when high emissions mines reduce their output.

---

[83] Australian Government (2009a)

# 6. Raw steel production

## 6.1 Summary of analysis

Available data indicate that Australian steel producers have narrow cash margins likely to be between $100 and $200/t steel, around 10-18% of revenue.

Without free permits a $35/tCO$_2$ carbon price would have a substantial impact on these margins. Although generating cash in the short-term, Whyalla might close in the long-term as investments to maintain capacity would not earn sufficient return on capital. Other mills would be better placed, but at risk during economic downturns.

Global emissions would probably not reduce if Australian blast furnace steel mills were to close. However substantial increases in emissions are equally unlikely.

Concerns that global emissions would substantially increase are typically based on an expectation that Chinese production would replace that undertaken in Australia. However, while average emissions intensity of Chinese steel plants have been higher than Australia's, the substitute capacity is likely to come from large Chinese producers with emissions similar to Australian producers. Large low emissions Chinese producers are replacing small high emissions Chinese producers because large facilities are more profitable, and the Chinese central government has policies to close small steel producers.

If Australian electric arc mills closed, then emissions would substantially improve if their output was replaced by electric arc

mills in OECD countries (such as Korea, Japan or Taiwan), but emissions would substantially deteriorate if their output was replaced by blast furnaces. It is not immediately obvious which of these is the most likely outcome.

As a carbon price might cause Australian steel production to move offshore, and this might well not reduce global emissions, and might even increase them, industry assistance may be desirable to prevent perverse shifts in production.

However, there may be better mechanisms for preventing this than the free permits proposed in the draft CPRS legislation. The proposed free permits would largely preserve industry profitability, but they would delay efficient economic changes to emit less carbon. This includes the shift of some production from blast furnaces to electric arc furnaces, and greater use of steel substitutes, for example wood in house frames and plastic for water tanks.

It would be better to rebate emissions permit payments if production is exported, and to impose a carbon charge on imports. The quantity of rebated permits or import charge should be set equivalent to the level of average global emissions intensity. Australian producers would still have ample incentives to improve their carbon efficiency given that most production is sold domestically. The import carbon charge commonly called a "border tax adjustment" would be consistent with WTO rules provided that it treats imports on an equal basis to domestically

produced steel.[84] This regime would distort the economy less, and reduce costs to the Australian community.

Carbon pricing would provide incentives for Australian steel producers to take practical steps to reduce carbon emissions.

## 6.2 Industry background

Raw steel is produced by two kinds of plant:

- Integrated blast furnaces – which convert raw iron ore and coking/metallurgical coal into pig iron and then steel using heat-intensive furnaces.

- Electric arc furnaces – which recycle scrap iron and steel back into raw steel by melting it with an electric arc.

Electric arc furnaces require less capital and energy, produce fewer greenhouse emissions per tonne of steel, and have more flexible output.  However, they depend on a supply of scrap metal.

Integrated blast furnaces can produce steel from raw iron ore.[85] They can produce higher quality steel better suited to higher value uses where low levels of impurities are important.[86]

Because there is not enough scrap metal to supply global steel demand, most steel is produced by blast furnaces. A small proportion of steel is produced from an intermediate product

known as direct reduced iron which can act as a scrap substitute in electric arc furnaces.

Australia has two integrated blast furnace steel mills and three electric arc furnace mills as listed in Table 6.1,[87] which employ 10,400 people either as employees or contractors.[88]

Table 6.1 Australia's steel mills

| Steel mill | Production method | State | Primary owner/ operator | Raw steel production capacity (tonnes) |
|---|---|---|---|---|
| Port Kembla (Woolongong) | Integrated blast furnace | NSW | Bluescope Steel | 5,300,000[a] |
| Whyalla | Integrated blast furnace | SA | OneSteel | 1,300,000[b] |
| Sydney | Electric arc | NSW | OneSteel | 575,000[c] |
| Waratah (Newcastle) | Electric arc | NSW | OneSteel | 280,000[c] |
| Laverton | Electric arc | VIC | OneSteel | 725,000[c] |

*Source: (a) Bluescope Steel (2009); (b) OneSteel (2008c); (c) OneSteel (2008b)*

The raw steel produced by these mills is then converted into a range of different intermediate and finished steel products. The Port Kembla mill tends to focus on what are generically termed flat steel products such as steel slabs and rolled coil which are then further processed to produce final products such as steel

---

[84] Droge (2009)
[85] Mohr *et al.* (2009)
[86] ArcelorMittal (2007)

[87] The pig iron production facility in Kwinana, WA employs a form of direct iron reduction known as HIsmelt. This is largely an experimental operation and therefore has not been considered in this analysis.
[88] Bureau of Steel Manufacturers of Australia (2008)

sheets for car bodies, corrugated iron sheets for building roofs and tin cans for packaging.[89] The OneSteel mills tend to be focussed on what are generically termed long steel products that include rod and bar used in construction and reinforcement, as well as rails, sleepers, and wire. OneSteel's Whyalla blast furnace tends to produce intermediate long-steel products known as billets (which are then transformed into rod and bar) and blooms (which are further processed into structural and rail products) but also produces small quantities of slab which is an intermediate flat steel product. OneSteel's electric arc mills also produce steel billet.[90]

In global terms Australia is relatively small producer of steel, making up only 0.6% of total world-wide production in 2008. In 2008 Australia produced 7.7m tonnes of raw steel of which 1.8m tonnes was exported.[91] Steel production in Australia has not increased substantially over the past forty years, as shown in Figure 6.1. The mills were originally constructed behind tariff barriers, and they are more focused on serving the domestic market than expanding exports.

**Figure 6.1 Australian historical steel production (kilotonnes)**
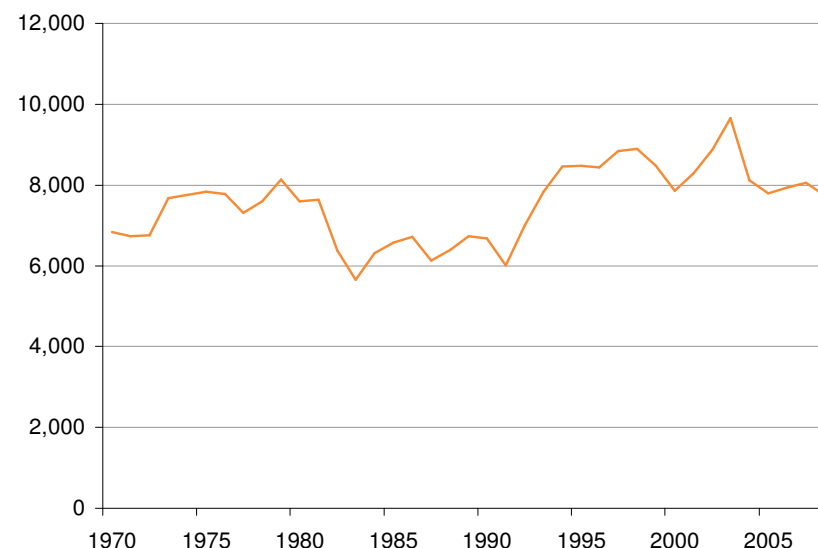


*Source: ABARE (2009c)*

Domestic steel production is supplemented by imports, which have grown steadily to around 1.6-1.9m tonnes per annum, about 20% of domestic demand (see Figure 6.2). These imports cover most of the range of products produced domestically.[92]
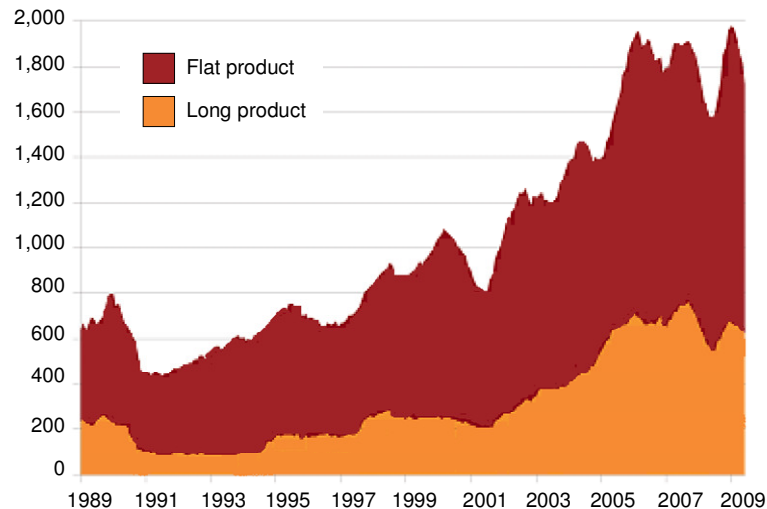
---

[89] Cornish (2008)
[90] ACCC (2007a)
[91] ABARE (2009c)

[92] ACCC (2007a)

**Figure 6.2 Australian imports of finished steel (kt – annualised)**



*Source: UBS (2009a)*

## 6.3 Australian industry economics

Australian steel producers have narrow cash margins of between $100 and $200/t steel, around 10-18% of revenue. They face robust and growing international competition from a global industry that has traditionally suffered from excess capacity.[93] Australian steel mills lack significant cost advantages over overseas producers other than proximity to the Australian market. Once depreciation is taken into account margins are 7% - 14% or $75 - $150 per tonne of steel.

Steel is traded across regions, with prices in Europe, North America and Asia tracking closely, although not globally uniform. Overseas producers are significant competitors in Australian markets, as the ACCC concluded in 2007 in its review of OneSteel's proposed acquisition of Smorgon Steel:

> "…many companies have success in operating viable and competitive businesses which rely wholly or near-wholly on imported products. These businesses had demonstrated an ability to …compete with businesses that source predominantly domestically produced steel…Additional data upon which the ACCC relied…support the general view that imports were a competitive constraint on OneSteel and Smorgon."[94]

While this finding related primarily to long steel products, substantial quantities of flat products are also imported into Australia, and they are generally more traded internationally because their shape enables lower cost shipping.

The major costs in iron ore production are raw materials and maintenance. Energy costs are important for integrated blast furnaces, as shown in Figure 6.3.

---

[93] Bureau of Steel Manufacturers of Australia (2008)

[94] ACCC (2007a)

**Figure 6.3 Steel production input costs internationally**
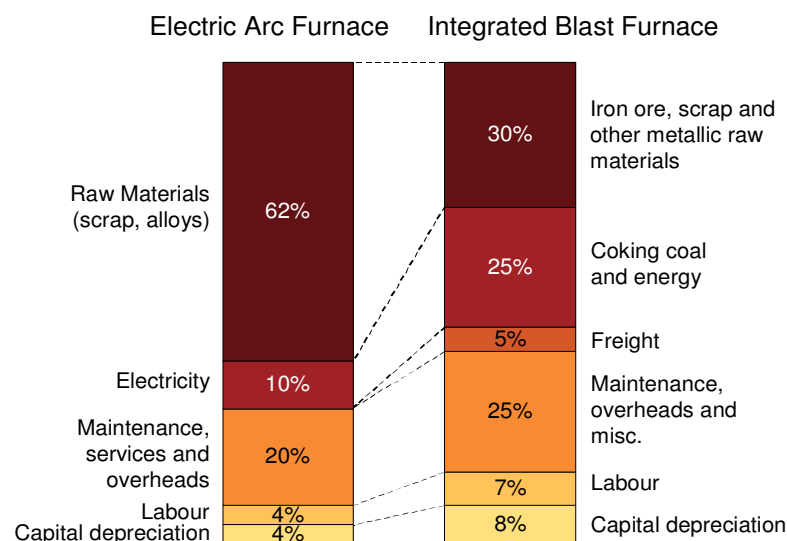


*Source: UBS (2009b); McKinsey and Company (2006); Reinaud (2005)*

Australia has few material advantages over other countries in these cost inputs. Australian integrated steel mills have a small freight cost advantage because Port Kembla is close to coking coal deposits, and Whyalla is close to iron ore deposits. We estimate that this raw material freight cost advantage is less than $10/t steel for Port Kembla and $20-$30/t steel for Whyalla. However this advantage is largely nullified by labour costs that are higher than the wage rates paid by competitors in developing countries. Australian steel mills also have lower delivery costs to Australian customers which are their primary market.

As a result of keen international competition, OneSteel has generated relatively low margins over the last 7 years through both boom and recessionary conditions, as shown in Table 6.2.

**Table 6.2 Australian steel sales margins 2003-2009**

|  | EBITDA | EBIT |
|---|---|---|
| Bluescope | 18.1% | 14.1% |
| OneSteel | 10.0% | 6.8% |

*Source: Bluescope Steel (2009); OneSteel (2004), (2005), (2006), (2007), (2008a), (2009a)*

Combining the margin data in Table 6.2 with the companies' sales tonnages suggests OneSteel's average EBITDA margin is approximately A$110/t and Bluescope's is closer to A$200/t across the range of steel products they sell (not just raw steel). We have estimated these margins are reflective of their raw steel margins. This would be in line with the raw steel EBITDA margins for other producers globally. Global steel industry average EBITDA per tonne of crude steel was between US$145 and US$210 between 2005 – 2008,[95] a relatively buoyant period for steel makers.

### 6.4 Impact of carbon pricing on steel production

Without free permits or other assistance a $35tCO$_2$ carbon price would have a substantial impact on these margins, as shown in Figure 6.4 and Table 6.3. Although generating cash in the short-term, Whyalla would be at risk of closure in the long-term as investments to maintain capacity would not earn sufficient return

---

[95] ArcelorMittal (2008)

on capital.  Other mills would be better placed, but at risk during economic downturns.

All mills would continue to be cash positive without free permits. However, Whyalla would be operating at a loss once depreciation of plant is taken into account. This indicates that it would struggle to earn sufficient returns on capital to justify investment to maintain the plant's operating capacity. Port Kembla and the electric arc mills would earn enough to cover depreciation costs, but would be operating on thin margins that would leave them vulnerable during economic downturns.

**Figure 6.4 Effect of a carbon price on EBIT margins**
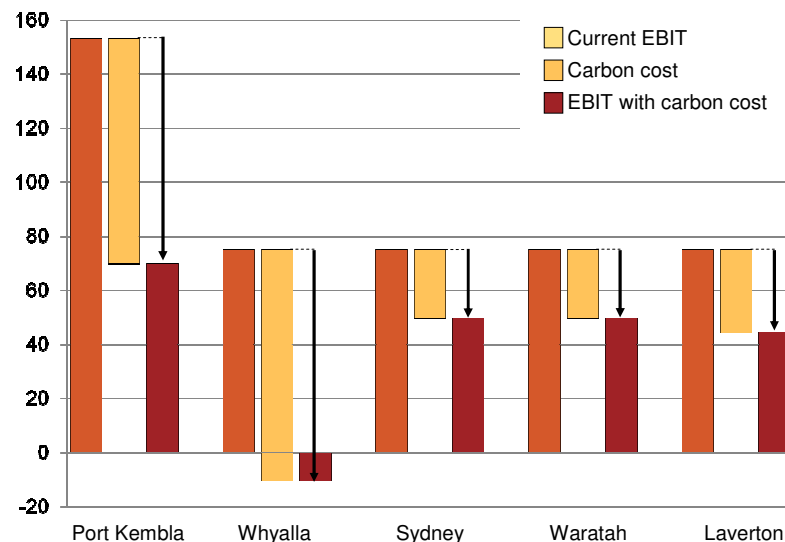


*Source: Grattan Institute analysis based on data in Table 6.3*

**Table 6.3 Carbon pricing impact on steel profit margins**

| Steel mill | tCO$_2$/ t Steel | Carbon cost / t Steel | EBITDA margin incl carbon cost | EBIT margin incl. carbon cost |
|---|---|---|---|---|
| Port Kembla | 2.38[a] | $83.44 | $113.78 | $69.70 |
| Whyalla | 2.43[b] | $85.22 | $24.97 | -$10.42 |
| Sydney | 0.72 | $25.24 | $84.94 | $49.56 |
| Waratah (Newcastle) | 0.72 | $25.24 | $84.94 | $49.56 |
| Laverton - Melbourne | 0.86[c] | $30.21 | $79.98 | $44.59 |

*Source: (a) Calculated using total emissions data from Credit Suisse (2009); total production data from Bluescope Steel (2009); (b) Calculated using total emissions data from OneSteel (2009c); total production data from OneSteel (2008c); (c) Calculated for the three EAF plants using data on electricity consumption per tonne of steel from OneSteel (2009b); emissions intensity of electricity supply from Australian Government Department of Climate Change (2009); overall EAF emissions from OneSteel (2009c); total production data from OneSteel (2008b)*

## 6.5 Global emissions if Australian steel mills close

Global emissions would probably not reduce if Australian blast furnace steel mills were to close. However substantial increases in emissions are equally unlikely.

Concerns that global emissions would substantially increase are typically based on an expectation that Chinese steel production would replace that undertaken in Australia.

Average Chinese steel production emissions are higher than in Australia. The primary source of emissions in blast furnace steel production is the use of reductant[96] – predominantly coking coal with some non-coking coal and small amounts of other fossil fuels. Based on 2005 benchmark data, Chinese blast furnace mills on average use substantially more reductant, and so emit more greenhouse gases, than producers in Australian and other countries, as shown in Figure 6.5.

**Figure 6.5 Reductant use in blast furnaces of Pacific basin steel producers (2005)  (kg per tonne of hot metal)**
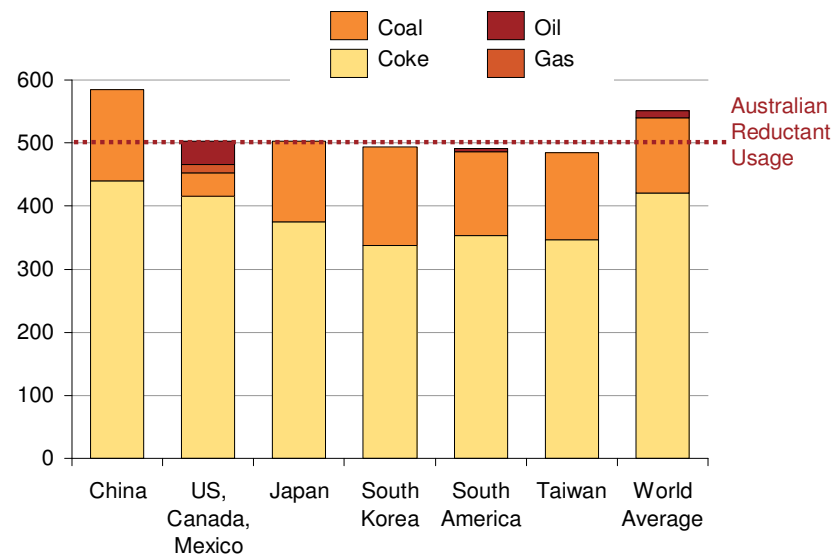


*Source: International Energy Agency (2007) and Australian steel mill coal use from: Bureau of Steel Manufacturers of Australia (2008)*

[96] Bureau of Steel Manufacturers of Australia (2008)

However the substitute capacity is likely to come from large Chinese producers with emissions similar to Australian producers. The Chinese steel industry is restructuring to improve its efficiency and emissions intensity. Small high-emissions Chinese producers are being replaced by large low-emissions Chinese producers.

This is because modern large and low emission steel mills are substantially more profitable. Steel furnace energy efficiency is related to size – smaller furnaces tend to waste more energy.[97] Smaller mills' costs are around US$30-45/t steel higher due to use of an additional 0.2-0.3 t coking coal per tonne of steel produced,[98] at a cost in China of $150/t coking coal. Goldman Sachs JB Were observed in a recent analysis of the Chinese steel sector that, *"Many small Chinese steel producers are already losing cash or close to break-even so a sharp fall in steel prices (at a time of rising raw materials costs) would lead to significantly lower steel production".*[99] According to ArcelorMittal (the world's largest steel producer), 30% of the major Chinese steel producers make net profits of less than US$30/t steel, as shown in Figure 6.6. By comparison, the average for steel companies internationally is around US$150/t steel.[100] Those Chinese steel companies that are making reasonable profits are operating newly constructed, large scale and highly efficient steel making facilities likely to have emissions intensity equal to, or better than Australian plants.
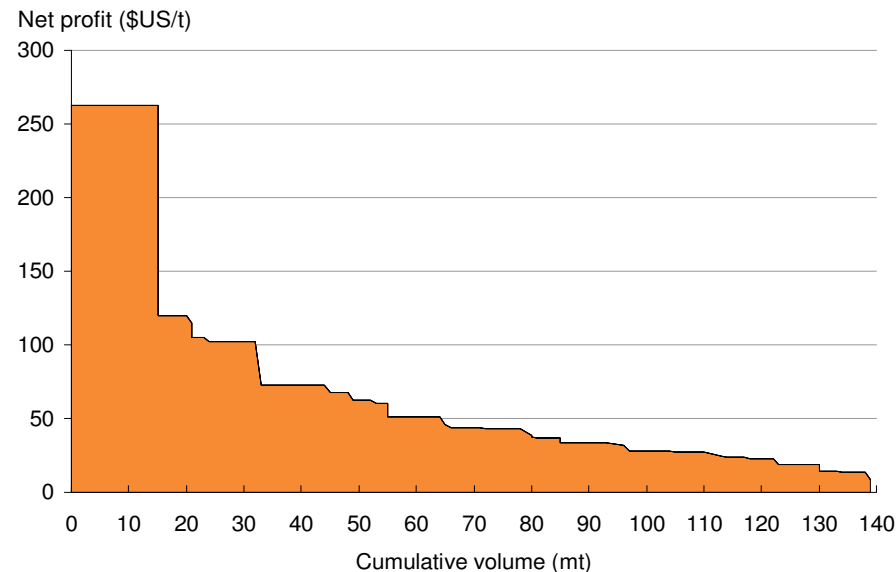
[97] International Energy Agency (2007a)
[98] Okuno (2006)
[99] Southwood and Gray (2010a)
[100] ArcelorMittal (2008)

**Figure 6.6 Profitability of top 40 Chinese steel producers (US$/t steel, H1 2008)**

Net profit ($US/t)



Cumulative volume (mt)

*Source: ArcelorMittal (2008). The top 40 producers account for 50% of Chinese steel production*

Furthermore, the Chinese central government has an explicit policy of closing high-polluting small mills down. According to the International Energy Agency the central government's policy target is to close all furnaces below 300 cubic metres in size by 2010 and phase out furnaces using obsolete technology such as open-hearth furnaces.[101] The Government has publicly stated that

it expects consolidation of the Chinese steel industry so that the top 10 producers account for 50% of national production.[102]

While the central government may have had trouble enforcing these policies in the past,[103] it seems highly unlikely that any new steel capacity will replicate the historically poor levels of energy efficiency and emissions intensity. BHP Billiton, a major supplier of coking coal to China, has noted this change towards less polluting, larger furnaces. Its CEO Marius Kloppers, noted at the company's 2010 interim results presentation that,

> *"six years ago China put out a steel policy. And the steel policy essentially said, shut down all of the small steel mills, consolidate the industry, and build big environmentally efficient blast furnaces. That has happened and is going to continue to happen."[104]*

If Australian electric arc mills closed, then emissions would substantially improve if their output were replaced by electric arc mills in OECD countries such as Korea, Japan or Taiwan. Electric arc furnace production in these countries is likely to produce fewer greenhouse gases. Emissions from electric arc furnace steel production are mainly associated with the electricity used. While Australian furnaces are reasonably energy efficient,[105] Australia's electricity supply is the most emissions intensive in the developed world.[106] Electricity generation in Japan, Taiwan and South Korea

---

[101] International Energy Agency (2007a)

[102] ArcelorMittal (2007)
[103] French (2007)
[104] BHP Billiton (2010)
[105] International Energy Agency (2007a)
[106] World Resources Institute (2009)

only produces one-third to a half of the carbon emissions of Australian electricity generation.[107]

Global emissions would substantially deteriorate if the capacity of Australian electric arc furnaces were replaced by blast furnaces. Blast furnaces can use scrap iron, and emit more carbon per tonne of steel than the electric arc furnaces. We could not discern which kind of furnace would use the scrap iron made available if Australian electric arc furnaces closed.

## 6.6 Industry assistance

A carbon price might cause Australian steel production to move offshore, and this might well not reduce global emissions, and might even increase them. Consequently, industry assistance may be desirable to prevent perverse shifts in production.

However there may be better mechanisms for preventing this than the free permits proposed in the draft CPRS legislation.

The free permits proposed under the draft CPRS legislation would largely preserve industry profitability providing 94.5% free permits at the commencement of the scheme, declining to 84% by 2020. The draft CPRS provides more free permits per unit of production to the emissions intensive blast furnaces than the less polluting electric arc furnaces. Based on November 2009 amendments, we estimate blast furnaces would receive 2.2 to 2 permits per tonne of steel, while electric arc mills would only receive 0.74 to 0.66 permits per tonne of steel. As shown in Table 6.4, steel producer EBITDA margins would actually increase in the short-term for

Sydney and Waratah were it not for anti-windfall gain provisions, and the worst loss would be no more than a 6% decline. Under 84% free permits EBITDA declines would range from 2% to 16%.

**Table 6.4 Carbon price impact on EBITDA margins ($/t steel)**

| Steel mill | No carbon price | 94.5% free permits | 84% free permits |
|---|---|---|---|
| Port Kembla | $200.00 | $195.71 | $186.92 |
| Whyalla | $110.00 | $103.94 | $95.14 |
| Sydney | $110.00 | $110.77 | $107.88 |
| Waratah (Newcastle) | $110.00 | $110.77 | $107.88 |
| Laverton - Melbourne | $110.00 | $105.80 | $102.91 |

*Note: assumes Australian industry average emissions intensity of 0.79t $CO_2$/t Steel for electric arc furnaces and 2.39t $CO_2$/t Steel for blast furnaces.*

However, the free permits proposed would inhibit efficient economic changes to emit less carbon, including the shift of some production from blast furnaces to electric arc furnaces, and the substitution of steel with alternative materials:

- Steel billet is produced both by the Whyalla blast furnace and the electric arc mills.[108] Because production at the electric arc mills receives fewer free permits, steel billet production will not efficiently shift from the more emissions intensive Whyalla blast furnace.

- Free permits would understate the true cost of steel. But a higher steel price would result in economic adjustments to use steel more efficiently. A higher price would also result in less

---

[107] World Resources Institute (2009)

[108] OneSteel (2009b)

emissions intensive materials such as wood and plastic being used instead of steel for some applications.

It would be better to rebate emissions permit payments if production is exported, and to impose a carbon charge on imports.  The quantity of rebated permits or import charge should be set equivalent to the level of average global technology emissions (with the potential for importers to refute the assumption if they could demonstrate that their actual emissions were lower than average). Australian producers would still have ample incentives to improve their carbon efficiency given that most production is sold domestically. The import carbon charge, commonly called a "border tax adjustment," would be consistent with WTO rules provided that it treats imports on an equal basis to domestically produced steel.[109] This regime would distort the economy less, and reduce costs to the Australian community.

### 6.7 Are there feasible options for reducing emissions intensity?

Carbon pricing would provide incentives for Australian steel producers to take practical steps to reduce carbon emissions.

A cogeneration power plant is under consideration for Port Kembla, which would substantially reduce its greenhouse emissions but will also involve a significant capital outlay.[110] Carbon pricing may induce production of steel billet to switch from the Whyalla blast furnace to the electric arc furnaces.  There would be sufficient steel scrap as inputs for these electric arc

furnaces as Australia currently exports steel scrap excess to the requirements of the electric arc furnaces.

Breakthrough reductions in emissions are less likely. Capturing and storing $CO_2$ from integrated blast furnaces is unlikely.  It has not been successfully demonstrated, is likely to be costly,[111] and suitable $CO_2$ storage sites are distant from both Port Kembla and Whyalla.[112]

---

[109] Droge (2009)
[110] Cornish (2008)

[111] Plummer and O'Malley (2009)
[112] Carbon Storage Taskforce (2009)

# 7. Cement clinker

### 7.1 Summary of analysis

Carbon pricing might cause Australia to use cement clinker produced offshore rather than in Australia. While relocation might reduce greenhouse emissions, the improvements appear too marginal to justify the change. However, relatively few free permits are required to prevent declines in Australian clinker production.

Carbon leakage in the cement industry is unusual: the relevant question is whether imports would substitute for local production. This contrasts with many other industries considered in this report, where the question is whether Australian exports would remain internationally competitive.

Cement is generally not an internationally traded commodity because transport costs are high relative to the value of the product. However, there is a real possibility that Australia would substitute cement clinker produced offshore for locally produced cement clinker as a result of carbon pricing. The industry's economics suggest that the additional costs of carbon pricing would make imported cement clinker cheaper than local production, despite the additional costs of freight for overseas production.

Offshore supplies usually come from South-East Asia and Japan. They are likely to emit fewer greenhouse gases than Australian supplies even after incorporating the extra emissions from shipping. Offshore producers tend to be more energy efficient than smaller, older Australian plants. However the benefit is too

marginal (emissions per tonne around 2-3% lower) to justify the change.

Although the available data do not prove exactly how many free permits or other assistance would be required to maintain local production, the CPRS proposed level of free permits appear to be greater than is required to prevent imports substituting for local Australian production. Current industry margins are healthy, and the three producers have a history of passing on significant price increases. The costs of transport provide a substantial barrier to import competition. Existing imports are largely due to a lack of critical mass demand to support an additional plant, but do not indicate that imports can undercut local production prices.

Nonetheless there is a better way to control for carbon leakage in the cement clinker sector than through providing free permits. Instead it would be more efficient for Australian clinker producers to pay for permits but also require importers of clinker and cement to pay a carbon emissions border tax adjustment for each tonne they import. According to analysis published by the UK Government's Carbon Trust, the import carbon charge commonly called a "border tax adjustment" can be structured such that it, *"complies with all relevant World Trade Organisation provisions"*.[113] This would encourage more efficient production and use of clinker and cement in the Australian economy while avoiding a situation where domestic producers might be excessively shielded from carbon costs at the expense of the rest of the Australian community.

---

[113] The Carbon Trust (2010)

## 7.2 Industry background

Cement is largely made up of an intermediate product called clinker. Clinker is produced by heating a mixture of limestone, sand and clay in a kiln to around 1500°C. Clinker is then ground and mixed with other materials including gypsum and clinker substitutes (cement extenders) such as fly ash and slag to make cement. It is clinker rather than the final product of cement that is typically traded internationally because it is easier and cheaper to transport.[114]

The creation of clinker is highly emissions intensive as the reaction releases $CO_2$ directly. It also produces significant $CO_2$ emissions through the combustion of fossil fuels for energy to create the heat for the kiln.

The Australian industry has 3 producers, with 9 cement clinker production plants, employing around 1850 people.[115]

Australia's cement plants only serve the domestic market and do not export. The capacity of these plants (around 1.9 million tonnes per quarter) is fully utilised and insufficient to meet all domestic demand. The remaining domestic demand is met largely with imported clinker with only small amounts of finished cement imports.[116] Imports have grown to be 20% of the market.
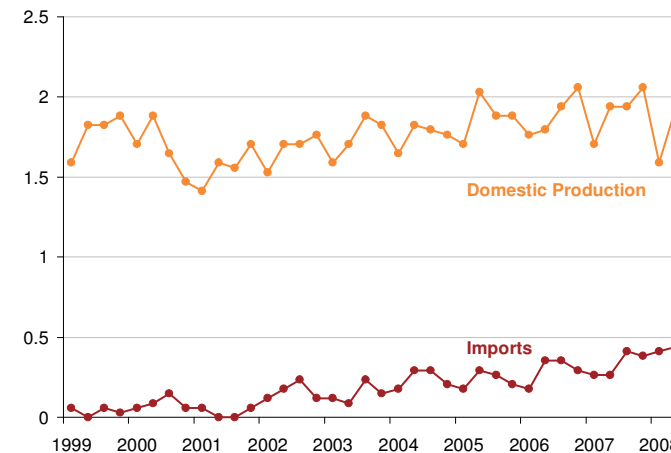
**Table 7.1 Cement clinker plants in Australia**

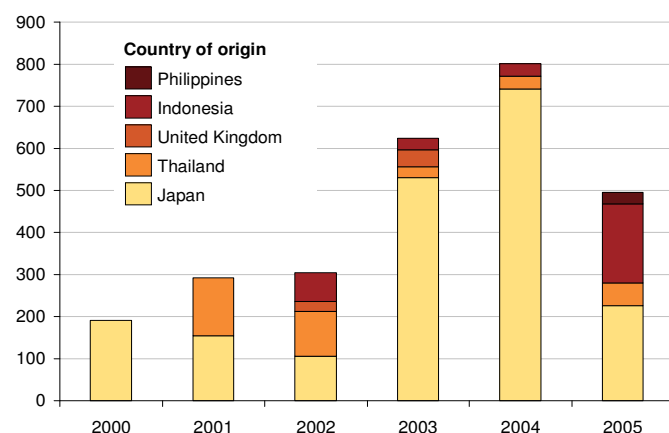| Plant | State | Company Owner |
|---|---|---|
| Maldon | NSW | Boral |
| Berrima | NSW | Boral |
| Kandos | NSW | Cement Australia |
| Fisherman's Landing - Gladstone | QLD | Cement Australia |
| Angaston | SA | Adelaide Brighton |
| Birkenhead | SA | Adelaide Brighton |
| Railton | TAS | Cement Australia |
| Waurn Ponds-Geelong | VIC | Boral |
| Munster | WA | Adelaide Brighton |

**Figure 7.1 Australian cement imports against domestic production (quarterly) (million tonnes)**



*Source: Chan (2008)*

---

[114] Cement Australia (2008)
[115] Cement Industry Federation, *Australia's Cement Industry,*
http://cement.org.au/australias-cement-industry
[116] Adelaide Brighton (2009); McNee and Staines (2009a)

Most imports to Australia come from Japan where cement demand growth is low and the industry is more likely to experience periods of excess capacity.[117] Indonesia and Thailand are periodically important sources when building activity in their own economies slows.[118]  While Japan could be considered reasonably likely to impose a form of carbon price in the near future, it seems unlikely in Indonesia.

**Figure 7.2 Australian clinker imports by country of origin (thousand tonnes)**



*Source: Australian Government Department of Industry Tourism and Resources (2006)*

### 7.3 Australian industry economics

Unlike metals, the cement clinker industry is heavily localised because the costs of transport are high and so cement prices vary significantly between regions.[119] The core question, therefore, is whether a carbon price would result in imports substituting for local production.  On our analysis, imported cement clinker might well be cheaper than Australian-produced clinker including carbon costs. Full carbon pricing would therefore make existing Australian facilities marginal on a cash basis, and it would become very unlikely that new plants would be built in Australia. This is shown in Figure 7.3 (for 75 % clinker).

Australian cement sells for around $160 - $170/tonne.[120] Cement using imported clinker (including transport) must cost less than this, as otherwise imports would currently be at a loss.

Typical domestic production has cash costs of 73% of revenue or $124/tonne and costs including depreciation are 83% of revenue or $141/tonne.[121]  We estimate that carbon costs would average about $24/tonne, but can be as high as $34/tonne, as shown in Table 7.3.

---

[117] Utilisation of Japanese cement kilns was 70% in 2005-2006 compared to 87% in Australia. Source: Cement Industry Federation (2009a)
[118] Although detailed data are only available to 2005, more recent articles suggest that Japan and Indonesia remain the primary sources: Grant-Taylor (2007); Kakoschke (2009); McNee and Hannam (2010)

[119] Climate Strategies (2008)
[120] Pers. Comms. (2009a)
[121] Chan (2009b); Boral Ltd. (2010); Behncke and Hynd (2010)

**Figure 7.3 Cement prices and carbon price impacts**
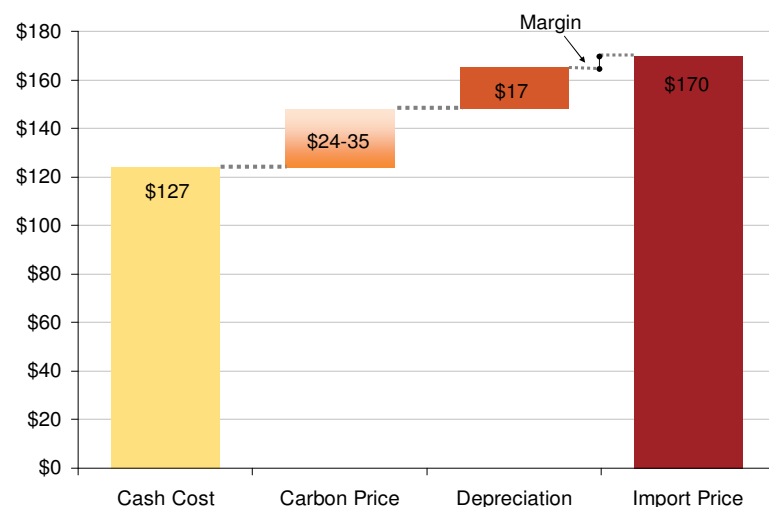


*Note: assumes cement made from 75% clinker and 25% cement extenders, in line with much of Australia's cement.*

## 7.4 Impact of carbon pricing on cement production

Data on the individual emissions intensity of each cement clinker plant are not readily available.  Australia's cement producers generally report their emissions at a group-wide level and do not separate clinker emissions from cement emissions that include additional materials.

Based on international data and analysis of plant characteristics, we estimate that emissions cost for Australian plants would range between $21 and $34, depending on clinker kiln type, the fuel

source for the kiln, State-based variations in electricity emissions, and the percentage of "cement extenders" (non clinker materials) in the cement.

We estimate industry average emissions per tonne of clinker to be 905kg $CO_{2\text{-e}}$, using the assumptions detailed in Table 7.2.

**Table 7.2 Derivation of Australian industry average clinker emissions intensity**

| Source data | | |
|---|---|---|
| A | Tonnes of $CO_2$ per tonne of cementitious material sold | 0.68[a] |
| B | Total cementious material sold | 10,500,000[a] |
| C | Clinker % of cement emissions | 90%[b] |
| D | Clinker production | 7,100,000[a] |
| Calculations | | |
| E = A x B | Total greenhouse emissions | 7,140,000 |
| F = C x E | Clinker emissions | 6,426,000 |
| G = F/D | Clinker emissions intensity | 0.905 |

*Source: (a) Cement Industry Federation (2009b) (b) Cement Australia (2008)*

**Table 7.3 Estimated Australian clinker plant emissions intensity (approximate only)**

| Plant | Chemical process emissions (kg $CO_2$/ tClinker)[a] | Kiln Type[b] | Main kiln fuel[c] | Kiln energy emissions (kg $CO_2$ / tClinker)[d] | Electricity emissions (kg $CO_2$ / tonne clinker)[e] | Total kg $CO_2$ / tClinker | Carbon cost / tClinker | Cement Carbon Cost (75% clinker content) | Cement Carbon Cost (90% clinker content) |
|---|---|---|---|---|---|---|---|---|---|
| Maldon | 544 | Wet | Coal | 495 | 54 | 1093 | $38.27 | $28.70 | $34.44 |
| Berrima | 544 | Dry 78%, Wet 22% | Coal | 341 | 54 | 939 | $32.86 | $24.64 | $29.57 |
| Kandos | 544 | Dry | Coal | 297 | 54 | 895 | $31.34 | $23.50 | $28.20 |
| Fisherman's Landing - Gladstone | 544 | Dry | Coal / Alternative fuels | 297 | 54 | 895 | $31.34 | $23.50 | $28.20 |
| Angaston | 544 | Wet/semi-dry | Gas | 282 | 47 | 873 | $30.56 | $22.92 | $27.50 |
| Birkenhead | 544 | Dry | Gas | 169 | 47 | 760 | $26.61 | $19.96 | $23.95 |
| Railton | 544 | Dry | Coal | 297 | 14 | 855 | $29.93 | $22.44 | $26.93 |
| Waurn Ponds-Geelong | 544 | Dry | Gas / Alternative fuels | 169 | 74 | 788 | $27.57 | $20.68 | $24.81 |
| Munster | 544 | Wet | Coal | 495 | 51 | 1090 | $34.69 | $28.62 | $34.34 |
| **INDUSTRY AVERAGE** | | | | | | **905** | **$31.68** | **$23.88** | **$28.66** |

*Source: (a) Australian Government Department of Climate Change (2009); (b) McNee and Staines (2009b);(c) Warnken (2003); (d) Assumptions for energy consumption: Dry - 3.3GJ/tClinker; Wet - 5.5GJ/tClinker. Source: International Energy Agency (2007). Fuel carbon intensity assumptions source: Australian Government Department of Climate Change (2009) ; (e) Emissions intensity of electricity source: Australian Government Department of Climate Change (2009); Assumes 61 kWh/tonne clinker, source: Boston Consulting Group (2008)*

## 7.5 Global emissions if Australian cement plants close

Offshore producers tend to be more energy efficient than smaller, older Australian plants. For example South-East Asian cement plants are four to ten times larger than the main Australian cement plants[122] and large kilns tend to have lower heat losses per unit of clinker produced.[123]

Japan is the most energy efficient producer of cement clinker in the world according to the International Energy Agency.[124]

According to emissions intensity data from the World Business Council for Sustainable Development, South-East Asia's and Japan's clinker production emissions intensity is about 9% lower than Australia on average. After adding emissions from shipping the clinker to the most distant capital city, the overall emissions are still slightly lower.  However, the net reduction in carbon emissions of 2-3% is too marginal to justify the shift in production.

This result is different to that in Cement Industry Federation (2009a). We believe that the differences are because:

- the CIF study benchmarked emissions on the basis of cement rather than clinker. We benchmarked clinker emissions because it is the clinker which tends to be traded and shipped around the world;

- our emissions benchmark data are for the 2007 period (and cross-checked against International Energy Agency (2007) data), whereas it appears CIF used  2004 data; and

- CIF's shipping emissions estimate is higher than the estimate we have derived from Boston Consulting Group (2008), although the CIF report's assumptions are not sufficiently transparent to identify reasons for the difference.

**Table 7.4 Emissions intensity of Australian and overseas clinker incorporating shipping and including emissions**

| Production emissions (kgCO$_2$/ tClinker) | | Approximate shipping emissions (one-way) (kgCO$_2$/t clinker)[a] | | | |
|---|---|---|---|---|---|
| | | Perth | Brisbane | Sydney | Melbourne |
| Australian industry average | 905 | 0 | 0 | 0 | 0 |
| South-East Asia (incl Indonesia) | 846[b] | 15 | 29 | 34 | 29 |
| Japan | 841[b] | 39 | 36 | 39 | 44 |

*Note: Assumes shipping emissions of 0.0486 kgCO$_2$ per km shipped per tonne of clinker. Japan emissions intensity estimate likely to be lower than indicated because benchmark data included a small contribution from higher emission Australian and New Zealand clinker production.*
*Sources: (a) Boston Consulting Group (2008); (b) World Business Council for Sustainable Development (2009)*

---

[122] Australian Government Department of Industry Tourism and Resources (2006)
[123] Ecofys and Oko-Institut e.V. (2008)
[124] International Energy Agency (2007a)

## 7.6 Industry assistance

Current industry margins are healthy, with EBITDA margins around 25%-30%, and EBIT margins around 15%-20%.[125] In terms of straight cash costs, even with no free permits, all plants recover revenues greater than costs. Under 80% free permits (as was originally proposed for 2020 in the White Paper) margins are still robust, the worst case being Maldon at 20%, and some plants EBITDA margins are maintained above 25%.

The three producers have successfully pushed through significant price increases in the recent past. Boral's 2008 annual report points out that, *"to manage energy fuel and other cost increases, Boral is increasing prices and investing in alternative fuel strategies… In Australia we have announced August / September 2008 price increases in … cement ($15 per tonne)."*[126] Adelaide Brighton in a June 2009 presentation to investors also stated it was increasing cement prices in core markets by $9 to $15 per tonne.[127]

The costs of transport are a substantial barrier to import competition. Cement and the intermediate product of clinker are heavy relative to their value, so transport can become a significant component of total costs.[128] Shipping costs for a tonne of clinker from North Africa to the UK would total €27.[129] Distances similar to those from Japan to Australian capital cities were estimated at

around €30, equivalent to an import buffer of around $45 to $50(AUD).

Currently domestic production is substantially cheaper than imports: the industry's own view is that imports meet a gap between existing domestic supply and capacity;[130] declines in cement demand in 2009 were met by reducing imports rather than domestic supply;[131] margins on imported cement are smaller than margins on domestic cement;[132] and the ACCC found in 2004 that *"there are minimal actual imports of cement entering Australia at present for competitive purposes".*[133]

There is no evidence we could obtain on the precise cost advantage of local over imported cement: it is certainly cheaper, although its advantage doesn't exceed $43/tonne cement (the current EBIT margin). The optimal level of free permits depends on this margin.

Under the draft CPRS, cement clinker plants would be eligible in 2011 for 94.5% free permits based on the industry average scope 1 & 2 emissions intensity. The impact of a carbon price, including free permits would be as shown in Table 7.5.

---

[125] Chan (2009b); Boral Limited (2010); Behncke and Hynd (2010)
[126] Boral Limited (2008)
[127] Adelaide Brighton (2009)
[128] Reinaud (2005)
[129] Boston Consulting Group (2008)

[130] Adelaide Brighton Ltd. (2009)
[131] Chan (2009a)
[132] Adelaide Brighton Ltd. (2008)
[133] ACCC (2004)

**Table 7.5 Carbon costs with free permits**

|  | No free permits | 84% free permits | 94.5% free permits |
|---|---|---|---|
| Average industry carbon price impact ($ / tonne clinker) | $23.67 | $3.79 | $1.30 |

This reduces the extent of the carbon cost to a level well below price increases in the recent past and mutes incentives for improvement. The cost of clinker production should reflect its associated carbon costs to encourage more efficient production and use of cement. A full carbon cost would encourage efficient changes:

• using less emissions-intensive substitutes including cement extenders such as fly ash and slag;

• using other building materials; and

• innovation to use cement more efficiently.[134]

In addition, if clinker producers bear the full cost of carbon permits, the threat of competitors using alternatives to clinker can drive change towards more efficient and less emissions intensive cement production processes such as conversion of wet kilns to dry (rather than just relying on the producer firm's management to respond to the opportunity cost of free permits).

Rather than provide free permits to Australian clinker producers to control for carbon leakage, it would be more efficient for them to pay for permits but also require importers of clinker and cement to pay a carbon emissions levy for each tonne they import (for example equal to the average carbon cost borne by Australian producers). According to a report published by the UK Government's Carbon Trust, this is a better option than provision of free permits for managing carbon leakage in the cement sector and can be structured such that it, *"complies with all relevant World Trade Organisation provisions"*.[135]

### 7.7 Are there feasible options for reducing emissions intensity?

Within the clinker production process, emissions can be reduced by moving to gas-fired precalciner kilns, by designing kilns for co-generation, and by using biomass as a substitute for fossil fuels.

Modern dry kilns, using gas instead of coal, produce substantially fewer emissions, as outlined in Table 7.3. However, changing wet kilns to precalciner technology requires a substantially new plant, unlikely to be justified by the carbon savings of around $5 / t cement. Switching from coal to gas is technologically more straightforward for most Australian plants: gas is generally available, and would save around $3 / t cement with a carbon price of $35 / t $CO_2$. However the Western Australian Munster plant recently converted in the opposite direction to use more coal, due to substantial gas price increases in WA. Of course, a carbon price would improve the attractiveness of gas relative to coal.

---

[134] For an example of a company specialising in producing lower emission alternatives to cement clinker see www.zeobond.com.

[135] The Carbon Trust (2010)

In kilns designed for cogeneration, the fuel both generates electricity and produces waste heat for the kiln. While there are no cement kilns in Australia currently employing co-generation, these units are standard practice in Japan and are being installed in greater numbers in countries such as China and India.[136]

Blue Circle Cement and a Victorian Government Agency undertook a feasibility study into a 7 MW co-generation plant for the Waurn Ponds cement plant in 2004-05. This study indicated that the co-generation plant would provide an internal rate of return between 10% and 14% at the time of the study.[137]  This was not considered commercially attractive at the time.  However, substantial increases in electricity prices since then and the introduction of a carbon price might make such a project cost effective.  It would reduce the plant's emissions by around 75kg of $CO_2$ per tonne of cement, saving around \$3 / t cement at a carbon price of \$35/t $CO_2$.

It is technically feasible for cement plants to use waste biomass material as a substitute for coal and gas to heat their kilns and several plants have already utilised biomass to a limited extent.[138] Relative to a gas-fuelled kiln, this could save around \$5 /t cement. However, it is not clear whether this would be cost-effective given capital investment and fuel costs.

---

[136] Cement Industry Federation (2008)
[137] Cement Industry Federation (2005)
[138] Warnken (2003)

**Mothballing Rockhampton Cement Plant: carbon leakage or inevitability?**

In August 2009 the Rockhampton clinker cement plant was mothballed with the loss of 31 jobs. Commentary in the media suggested that this was due to the anticipated costs of the forthcoming emissions trading scheme.[139] However, the Rockhampton cement plant was, like many Australian industrial plants in other industries such as oil-refining, paper and petro-chemicals, built several decades ago. These plants typically have old, inefficient technology and are sub-economic in scale. Their location can commonly be sub-optimal due to encroachment of residential development and movements of suppliers and customers to other areas, increasing transport costs. In such circumstances, carbon pricing may simply accelerate inevitable restructuring.

The Rockhampton clinker cement plant was established in 1959 and only produced 100,000 t/yr, compared to modern plants that typically produce 1 million t/yr.  Its wet kiln had substantially higher energy costs and greenhouse gas emissions than best practice.

The CEO of Cement Australia said that it could be argued that closing Rockhampton was precisely what the CPRS was designed to do: "It's old, inefficient technology and, in a carbon-constrained world, it should not exist."[140]

Three months after the plant had closed, the local newspaper found that "*almost half the workers made redundant at Cement Australia's Rockhampton plant [had] been re-employed in Gladstone.*"[141]

According to the newspaper, the former Rockhampton site manager, now Maintenance and Engineering manager at the new Gladstone mill, said that, although a shock at the time, it was a blessing in disguise, as they now worked with *"much bigger and more modern"* equipment.[142]

---

[139] Taylor (2009)
[140] Hopkins (2009)
[141] Paul (2009)
[142] Ibid

# 8. Aluminium smelting

## 8.1 Summary of analysis

Aluminium industry economics are driven by electricity prices, including any carbon price. Most Australian producers currently have low costs by global standards because their electricity is low cost to produce and is further subsidised by legacy State government contracts.

Full carbon pricing in conjunction with the expected expiry of subsidised state government electricity contracts would probably result in most Australian aluminium production moving offshore. In the medium term this would probably *reduce* global carbon emissions.

In the very short run, Australian capacity may be replaced by higher emission Chinese production, but these plants are uncompetitive and are being rationalised. In the medium term, aluminium smelters that close in Australia (with the exception of Bell Bay) are likely to be replaced by smelters overseas that on average have lower greenhouse emissions. Australian smelters emit more greenhouse gases than the current International Aluminium Institute global average, and new global capacity is also likely to have lower emissions.

In the long run it is unlikely that Australia will have lower-emissions lower cost electricity which will be essential to sustain competitive advantage in aluminium smelting. Instead, aluminium production is likely to move to "stranded" low-emissions electricity sources such as the Middle-East, Canada and Iceland, that are relatively cheap because there are few alternative uses for the electricity fuel source in these locations.

Protecting the Australian aluminium industry with carbon pricing concessions will impose significant costs on the Australian community and impedes the almost inevitable restructuring that will enable Australia to *increase* productivity and living standards. In addition to the already considerable electricity subsidies, the cost of "free" permits proposed under the December 2009 CPRS provisions would average around $811m per year.[143] These costs amount to an annual subsidy of about $161,000 per person currently directly employed in the aluminium industry.

Based on the available evidence, as legacy electricity subsidies for the industry unwind, Bell Bay and Kurri Kurri will become very high cost producers, and Point Henry will be vulnerable to swings in Aluminium demand. This loss of competitiveness is independent of a carbon price.

Keeping the remaining smelters of Portland, Boyne-Gladstone and Tomago in production with free permits would effectively cost other Australians $582m per year on average over the next decade, or $183,000 per person directly employed by these plants.

---

[143] See Section 2.3 of the main report for a discussion of the cost of "free" permits.

## 8.2 Industry background

Aluminium smelting converts Alumina (aluminium oxide) into pure aluminium metal using electrolysis. This requires substantial amounts of electricity.

Australia has six operational aluminium smelters (Table 8.1) directly employing around 5,000 people.

**Table 8.1 Australia's aluminium smelters**

| Smelter | State | Primary owner/operator |
|---|---|---|
| Portland | VIC | Alcoa/Alumina Ltd |
| Point Henry | VIC | Alcoa/Alumina Ltd |
| Boyne Island | QLD | Rio Tinto |
| Bell Bay | TAS | Rio Tinto |
| Tomago | NSW | Rio Tinto |
| Kurri Kurri | NSW | Hydro |

Australia was the fifth largest producer of aluminium in the world in 2008, producing 1.97 million tonnes that generated $5 billion of exports.[144]

As shown in Table 8.2, over 55% of global production is in countries unlikely to introduce carbon pricing legislation before 2015.

**Table 8.2 World aluminium production (2008) and carbon pricing[145]**

| Country | Aluminium production ('000 tonnes) | Market share | Prospect of binding carbon price by 2015 |
|---|---|---|---|
| Norway | 1,360 | 3% | In place |
| Germany | 550 | 1% | In place |
| Iceland | 787 | 2% | In place |
| Australia | 1,970 | 5% | Legislation proposed |
| United States | 2,658 | 7% | Legislation proposed |
| Canada | 3,120 | 8% | Legislation proposed |
| Other - OECD/EU | 2,840 | 7% | In place/Likely |
| Russia | 3,800 | 10% | Likely (weak binding caps under Kyoto Protocol) |
| Brazil | 1,660 | 4% | Unlikely |
| Bahrain | 865 | 2% | Unlikely |
| China | 13,200 | 34% | Unlikely |
| India | 1,310 | 3% | Unlikely |
| Mozambique | 536 | 1% | Unlikely |
| South Africa | 811 | 2% | Unlikely |
| Tajikistan | 339 | 1% | Unlikely |
| United Arab Emirates | 910 | 2% | Unlikely |
| Venezuela | 610 | 2% | Unlikely |
| Other non-OECD/EU | 1,716 | 4% | Unlikely |

---

[144] ABARE (2009c)

[145] USGS (2009)

## 8.3 Industry economics

Electricity costs are the major driver of Aluminium smelter plant profitability and location decisions.

As shown in Figure 8.1, raw materials – alumina and the materials to produce the carbon anodes (made largely from petroleum coke) make up around 45% of Aluminium smelting manufacturing costs. These costs do not affect location decisions because they can be transported at relatively low cost around the world.

Electricity constitutes more than half of the remaining costs. As the Industry Commission (now called the Productivity Commission) concluded in their 1998 report on the Australian Aluminium Industry, *"electricity prices are probably the most significant factor in determining the position of smelters on the international cost curve."*[146]

**Figure 8.1 Cost structure of global aluminium production**
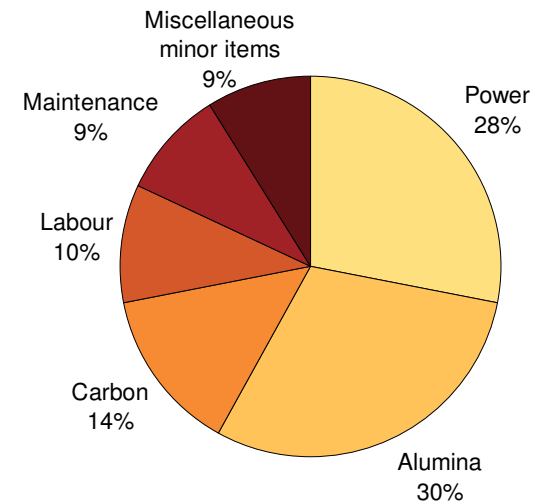


*Source: Industry Commission (1998); Pers. Comms. (2010a)*

---

[146] Industry Commission (1998)

## 8.4 International cost competitiveness

In 1997, Australian smelters were amongst the lowest cost producers in the world, as shown in Figure 8.2. This was partly because several of the Australian smelters had been constructed more recently, with more efficient equipment, than much of the smelting capacity in the US, Europe and Russia. Australian producers also benefited from favourable electricity contracts negotiated with State governments keen to attract major manufacturing facilities.

Some of the Australian production cost advantage has eroded in the last 15 years. New smelting centres have emerged in Southern Africa, Iceland and the Middle East with very low cost electricity.[147]

**Figure 8.2 Australian aluminium smelting operating costs compared internationally, 1997 (USD/t)**
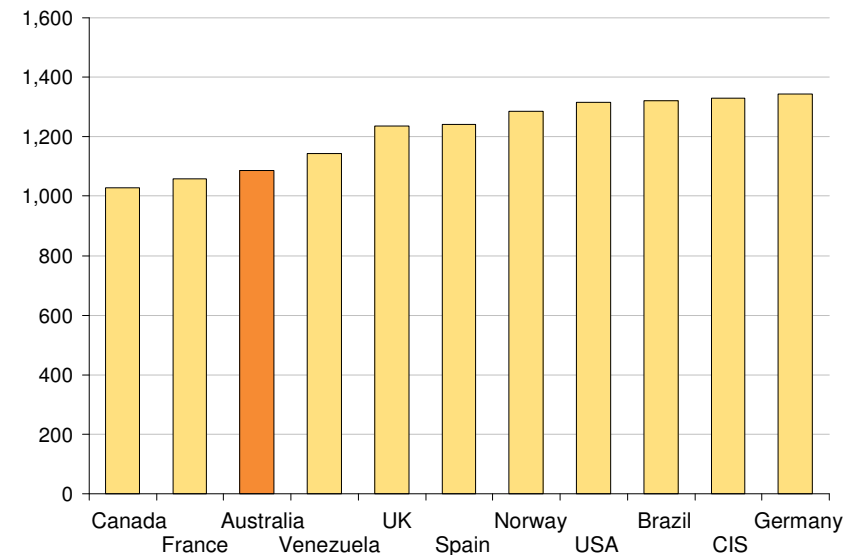


*Industry Commission (1998)*

However, Australian producers remain competitive. Based on a review of more recent data provided by Aluminium businesses we understand that Tomago is one of the very lowest cost smelters in the world,[148] and many of the others are in the 1st and 2nd quartile, as shown in Figure 8.3. We suspect that Bell Bay and Kurri Kurri are likely to be in the 3rd quartile.[149]

---

[148] CSR Limited (2009)
[149] Woods, I. (2006); AMP (2004); Rio Tinto (2006); Samuel, G. (2002); Rio Tinto (2009c); Turton (2002); Robins (2010)

---

[147] USGS (2009)

Aluminium production costs are themselves typically tied to Aluminium prices. For example the electricity contracts for the Alcoa smelters as well as Tomago and Kurri Kurri are known to tie electricity prices via a formula to the international aluminium price and Australian dollar exchange rates. These provisions aim to insulate the smelters from margin loss. Such provisions are common across the world. The Aluminium price hit a record high in 2008, and then dropped by about 40% to the first three months of 2009 as part of the global financial crisis. Industry production costs simultaneously dropped by around 25%, as shown in Figure 8.3.

The drop in demand and price for Aluminium since 2008 may make it difficult for top cost quartile producers to continue production. Aluminium prices dropped from around $2500 - $3000(USD) per tonne in 2008, to around $1600 (USD) per tonne in the first quarter of 2009. At this point smelters in quartiles 3 and 4 were losing money and even many smelters in quartile 2 were struggling to make a profit. Aluminium prices recovered to between $1900 (USD) and $2300 (USD) per tonne in the last few months, and commodity analysts generally agree that prices are likely to remain close to this level over the next few years. At this price, many 4th quartile producers will be unprofitable, or marginal, and are likely to close. If prices fall during downturns, 3rd quartile producers will also be marginal.

**Figure 8.3 Approximate position of Australian smelters on international aluminium smelter cost curve for 2008 and 2009 (1st Qtr)**
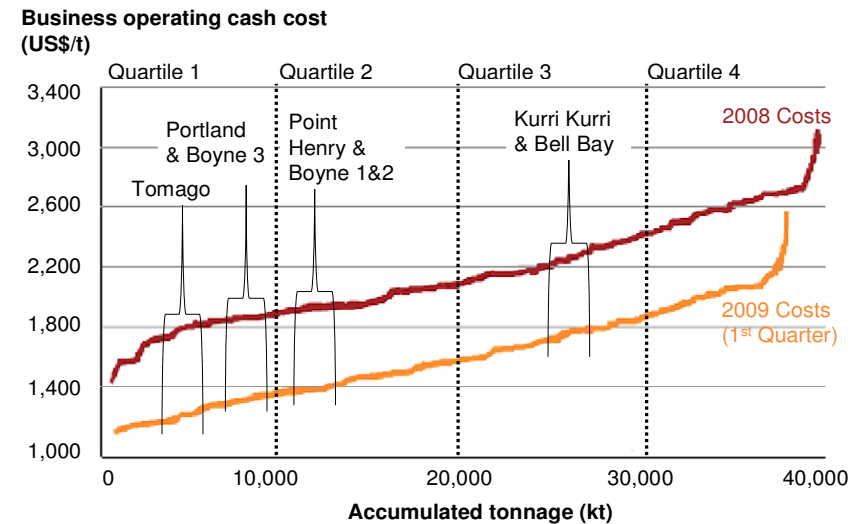


*Source: Hydro (2009b)*

## 8.5 Impact of carbon pricing on Australian economics

A carbon price with no free permits would make much of the Australian industry unviable or marginal, as shown in Table 8.3. Without exemptions, most producers' costs would increase by around US$450 to $620 / t Al. This would threaten the viability of most production as 2nd quartile producers would become 3rd or 4th quartile producers.

**Table 8.3 Carbon pricing impacts on Australian aluminium production costs**

| Smelter | Emissions intensity (tCO$_2$/tAl) | Change in production cost ($US / t Al) | | | Cost position (quartile) | | | |
|---|---|---|---|---|---|---|---|---|
| | | Zero free permits | 80% free permits | 94.5% free permits | Current | 94.5% free permits | 80% free permits | Zero free permits |
| Portland | 20.95[a] | $623 | $219 | $145 | 1st | lower 2nd | mid 2nd | Lower 4th |
| Point Henry | 20.95[a] | $623 | $219 | $145 | Lower 2nd | mid 2nd | lower 3rd | mid 4th |
| Boyne/ Gladstone | 16.40[b] | $488 | $83 | $10 | Line 1&2 - mid 2nd Line 3 – 1st | Line 1&2 - mid 2nd Line 3 – 1st | Line 1&2 – upper 2nd Line 3 – upper 1st | Line 1&2 – mid 4th Line 3 – mid 3rd |
| Bell Bay | 3.69[c] | $110 | -$295 | -$368 | Mid 3rd | 2nd | 2nd | Upper 3rd |
| Tomago | 15.04[d] | $448 | $43 | -$30 | Lower 1st | Lower 1st | 1st | Lower 3rd |
| Kurri Kurri | 17.56[e] | $522 | $118 | $45 | Mid 3rd | Mid 3rd | Upper 3rd | Upper 4th |

*Assumes AUD:USD exchange rate of 85 c, average industry emissions intensity of 17 t CO$_2$/tAl, and carbon price of $35/tCO$_2$. The emissions intensity of Portland and Point Henry is an averaged figure across both smelters*
*Source: (a) Alumina Ltd. (2008a); (b) Rio Tinto Alcan (2008b); (c) Rio Tinto Alcan (2008a); (d) Data from Rio Tinto (2009a) allow this estimation from the assumption of 2tCO$_2$ for direct emissions plus 2008 electricity consumption multiplied by NSW electricity pool emissions factor; (e) Hydro (2009a).*

The Aluminium industry would be given extensive free permits under the CPRS as proposed. Aluminium smelting was defined as a high emissions intensity industry with more than 2000tCO$_2$/$m revenue, making it eligible in 2011 for 94.5% free permits based on the industry's average emissions intensity. Free permits would be based on an industry average implied emissions intensity of 17tCO$_2$ per tonne of Aluminium under the draft CPRS regulations, calculated on the basis of average direct emissions of 2tCO$_2$ and electricity emissions of 15tCO$_2$ (using 15 MWh electricity) per tonne of Aluminium.[150]

Even with free permits, Kurri Kurri is at risk. It is an older smelter (constructed in 1967) with higher operating costs and poor energy

efficiency, 25% worse than world's best practice.[151] As a result it is currently a higher cost operator than other Australian smelters, and would be more affected by a carbon price. Point Henry might be vulnerable during downturns under 80% free permits. Bell Bay could conceivably become more profitable with free permits, because permit allocations are based on average emissions intensity, and its emissions are substantially less than the industry average.[152]

---

[150] Australian Government (2009b)

[151] Hydro (2009a) suggests Kurri Kurri consumes 16.2 MWh of electricity to produce a tonne of aluminium. By comparison world's best practice technology can achieve 12.9 MWh/tAl and Portland smelter already achieves 13.5 MWh/tAl.
[152] This conclusion is based on consistently applying a methodology that assumes 100% cost pass through of scope 2 emissions. However, in Tasmania

Other producers would generally be less profitable with free permits, but are likely to remain viable. Without the "no windfall gains" provisions, Tomago would become marginally more profitable with 94.5% free permits, reflecting that it is more efficient than the industry average.

## 8.6 Options to reduce emissions intensity

Investment to substantially reduce emissions is unlikely to be economic, although based on historical experience more incremental improvements in energy efficiency may be possible.

Australian smelters have substantially reduced their direct emissions since 1990, particularly Perfluorocarbons, which reduced from around 3 $tCO_{2-e}$ to about 0.25 $tCO_{2-e}$ per tonne of aluminium in 2007.[153]

However around 80-90% of emissions are associated with the electricity the smelters consume (except for Bell Bay whose electricity is sourced from hydro). Substantial reductions in electricity consumption would require new plant upgrades at substantial capital cost. Considering the availability of cheaper, lower carbon electricity sources in other countries it seems unlikely that Aluminium companies would invest this capital in Australian plants with weaker long-term prospects.[154]

electricity prices may increase by more than carbon costs because Tasmanian electricity prices are linked to Victorian electricity prices to some extent.
[153] Australian Aluminium Council (2008)
[154] Australian Aluminium Council (2004)

## 8.7 Global emissions impact if Australian smelters close

Today Australian aluminium smelters (with the exception of Bell Bay) emit two to three times as much greenhouse gases per tonne of aluminium produced compared to the global industry average, based on International Aluminium Institute surveys. Although they generally use relatively less electricity per tonne of aluminium, they primarily rely on emissions intensive coal fired electricity, with the exception of Bell Bay.

**Figure 8.4 Australian aluminium smelters' emissions intensity compared to the IAI global average (t $CO_2$ / t aluminium)**
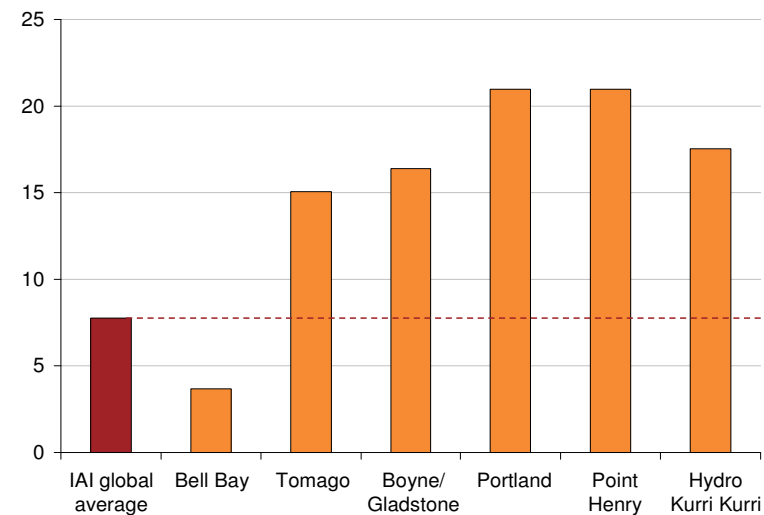


*Source: International Aluminium Institute (2007)*

In the very short run, Australian capacity may be replaced by higher emission Chinese production that use coal-fired power. However, these Chinese plants are unlikely to provide long-term capacity as they are high cost and dependent on provincial government subsidy, which the central Chinese government is seeking to phase-out. This conclusion is supported by industry commentators and Chinese plants disproportionately reduced capacity when demand dropped early in 2009.

As shown in Figure 8.5, Chinese aluminium smelters are mostly 4th quartile cost producers, despite low labour costs, because of the low quality of domestic fuel supplies, regular power outages, and inefficient plant.

Chinese plants appear to depend heavily on provincial government subsidies for continued viability. However the Chinese central government has come to realise that production of aluminium represents a poor use of the country's short supplies of fuel and electricity. In February 2008, the central government announced that it was eliminating preferential pricing of electricity to aluminium smelters and alumina refineries in response to electricity shortages.[155] In September 2009 it announced a halt to all new smelter and expansion proposals for three years.[156] It has also been pressing provincial governments to withdraw subsidies for aluminium smelters[157] and introduced an export tax of 15% on primary aluminium to discourage its production.[158]
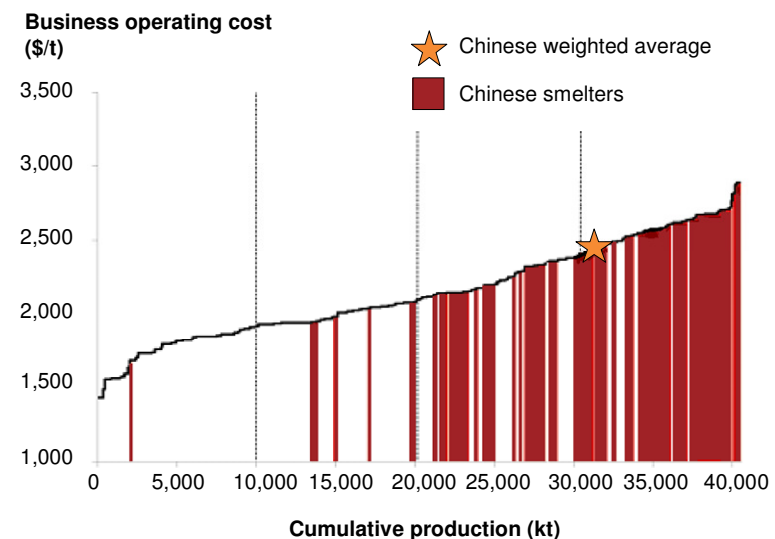
**Figure 8.5 Chinese aluminium smelters' position on the 2008 international cost curve**



Source: Rio Tinto (2008d)

Goldman Sachs metals analysts estimated in October 2008 that at least 50% of China's aluminium smelting capacity was operating at a loss.[159] Pivot Capital Management, a global hedge fund and economic analysis group, noted, *"China's position as the world's largest aluminium producer is all the more astonishing given the lack of surplus cheap energy typical of specialised aluminium exporting nations (e.g. Iceland, Canada or Russia)".*[160] Similarly, Rio Tinto Alcan, the largest aluminium producer in the

---

[155] USGS (2009)
[156] Heap and Tonks (2009)
[157] French (2007)
[158] Xinhua News Agency (2007)

[159] Southwood *et al.* (2008)
[160] Pivot Capital Management (2009)

world, noted in a presentation to investors that, *"Chinese supply is not competitively advantaged over longer term"* and suggested that numerous cost pressures would undermine the ability of Chinese smelters to compete over time.[161]

As an illustration of the precarious nature of Chinese smelters, in the recent economic slow-down Chinese smelters represented 52% of announced capacity curtailments in the first half of 2009.[162]

In the medium term, Australian smelting capacity is likely to be replaced by lower emission plants overseas. Most planned new smelter capacity will produce substantially fewer emissions than Australian smelters. As Figure 8.6 illustrates, 60% of proposed new smelter capacity will use either gas (half to a third the emissions of Australian electricity supply) or zero emissions fuelled electricity.

In addition the major Western aluminium companies' statements to investors indicate they all have a strategy of focussing new smelter investments in locations with access to low carbon electricity sources. This is driven by the need to reduce carbon cost downside risk and position themselves to potentially benefit from more widespread implementation of carbon pricing.[163]

---

[161] Rio Tinto. (2009b)
[162] Hydro (2008)
[163] Sources: See slide 15 of BHP Billiton (2009b); See statements by Jacynthe Cote on page 12 of Rio Tinto (2009b); See CEO statement page 5 of Hydro (2010); See slide 20 of Alcoa (2008)

**Figure 8.6 Proportion of new smelter capacity to 2020 by electricity fuel supply**
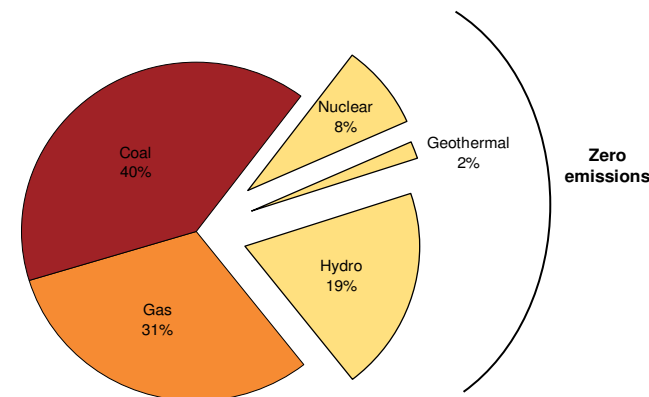


*Source: USGS (1999); USGS (2009); Brook Hunt (2008)*

## 8.8 Impact of market-based electricity pricing on industry economics

The full impacts of carbon pricing would probably just accelerate restructuring that is inevitable for the Australian aluminium industry.

The Australian aluminium smelting industry's competitive position is largely built on favourable electricity supply arrangements negotiated by State Governments before the Australian electricity market was liberalised. Several of these electricity contracts will lapse over the next decade and renegotiated contracts are likely to be on more cost-reflective terms.

Without electricity subsidies, Bell Bay and Kurri Kurri will become very high cost producers, and Point Henry will be vulnerable to swings in Aluminium demand, as summarised in Table 8.4.

**Table 8.4 Estimated changes in smelters' production costs from paying market rates for their electricity**

| Smelter | | Change in Al production cost (per tonne) | | International cost curve position (Quartile) | | | |
|---|---|---|---|---|---|---|---|
| | | Market electricity prices | Carbon price | Current | Market electricity price | Carbon price | Market electricity AND carbon price |
| Portland | | $307 | $623 | 1st | low 3rd | low 4th | high 4th |
| Point Henry | | $330 | $623 | up 1st -low 2nd | mid 3rd | mid 4th | high 4th |
| Boyne/ Glad-stone | L1&2 | $210 | $488 | mid 2nd | low 3rd | mid 4th | high 4th |
| | L3 | | | 1st | high 2nd | mid 3rd | high 4th |
| Bell Bay | | $576 | $110 | mid 3rd | high 4th | high 3rd | high 4th |
| Tomago | | $266 | $448 | low 1st | low 3rd | low 3rd | 4th |
| Kurri Kurri | | $293 | $522 | mid 3rd | 4th | high 4th | high 4th |

(a)13.5MWh/tAl For 2007 period - Alumina Limited (2008b) (b) 14.5MWh/tAl - For 2007 period - Alumina Limited (2008b)  (c) 14.9MWh/tAl -  For 2008 period - Rio Tinto (2009a) (d) 15.6MWh/tAl - Rio Tinto Alcan (2008a) (e) 14.7MWh/tAl - Data from Rio Tinto (2009a) allow this estimation from the assumption of 2tCO$_2$ for direct emissions plus 2008 electricity consumption multiplied by NSW electricity pool emissions factor.(f) 16.2MWh/tAl - For 2007 period - Hydro (2009a)

Wholesale electricity prices for aluminium smelters are likely to increase by around $14 to $37/MWh now that the Australian electricity market operates more commercially. Private companies are now the principal owners and operators of electricity generators and the main builders and financiers of new electricity generation capacity outside of NSW. When the current electricity supply contracts lapse, these private sector operators are likely to require a commercial return.

The impacts of moving to commercial electricity pricing depend on the precise terms of the legacy electricity contracts with aluminium smelters.  These are confidential, but it has been estimated that the smelters pay around $20 to $30 per MWh delivered[164] which is around half to two-thirds of the price paid by other large industrial electricity customers.[165] As an example, when the Victorian electricity industry was privatised, the cross subsidy associated with the Victorian aluminium smelter electricity contract could not be on-sold, and was dealt with explicitly by the Victorian Government. According to 2008 annual report of the SECV (the Victorian Government agency managing this contract) the net present value of the remaining 7 years of this contract is a cost to Victorian community of $600.3 million.[166]

Wholesale electricity prices are around $40 to $50/MWh, as shown in Table 8.5.  Although more recent contracts for large Australian industrial users are at prices around $60 to $100/MWh, these contracts partly take into account an expected carbon

---

[164] Turton (2002) says that Australian aluminium smelters paid delivered electricity prices on average of $21/MWh in 2002.  This equates to around $25/MWh after adjusting for inflation.
[165] Domanski (2009)
[166] State Electricity Commission of Victoria (2009)

cost.[167]  Our estimates for the impact of moving to commercial electricity prices have used the average wholesale market price over the last 5 years in each state compared to a price of $25 per MWh (delivered) assumed under existing state government contracts. These future electricity rates are likely to be conservative (underestimates) because the underlying cost of electricity generation (the cost of constructing new power plants as well as fuel costs) has increased considerably in the last three years. For example Frontier Economics estimated energy purchase costs excluding the impact of government greenhouse policies would increase to $70-$80 per MWh by 2011 and 2012.[168]

**Table 8.5 Wholesale market electricity prices ($/MWh)**

| Year | NSW | QLD | TAS | VIC |
|------|------|------|------|------|
| 2004-2005 | 39.33 | 28.96 | | 27.62 |
| 2005-2006 | 37.24 | 28.12 | 56.76 | 32.47 |
| 2006-2007 | 58.72 | 52.14 | 49.56 | 54.80 |
| 2007-2008 | 41.66 | 52.34 | 54.68 | 46.79 |
| 2008-2009 | 38.85 | 34.00 | 58.48 | 41.82 |
| AVERAGE | 43.16 | 39.11 | 54.87 | 40.70 |

*Source: Australian Energy Market Operator (2009)*

Victorian and Tasmanian smelters are likely to incur an additional charge of $7 to $9/MWh for transmission of electricity from the generator to the industrial facility, which is currently not

charged.[169]  This fee would not be material for the NSW and QLD smelters that are located next to electricity generators.

The Alcoa smelters in Victoria recently negotiated a new electricity supply contract to commence after the existing subsidised contract expires.  Based on media reports this contract is on a more commercial basis which does not link electricity prices to movements in the Aluminium price or currency exchange rates[170], has carbon cost pass-through provisions[171] and is competitive against rates prevailing in China[172] which are around US$50- $65MWh.[173]

The cumulative effect of ending electricity subsidies and introducing a carbon price would make much of the Australian aluminium industry unviable, even with extensive free permits or exemptions, as summarised in Table 8.4.

Due to substantial increases in electricity costs once subsidised contracts end in 2014 and 2016, even with 94.5% free permits, Point Henry would appear to not be viable, and Portland would become vulnerable to swings in Aluminium demand.  With 80% free permits, only Tomago would be viable. Although Boyne is in a unique position in that its below cost electricity is by virtue of being sold an asset by the Queensland government below replacement cost rather than through a contract that will expire.[174]

---

[167] Domanski, R. (2009)
[168] Frontier Economics (2010)

[169] Turton (2002)
[170] Fitzgerald (2010)
[171] Carbon Environment Daily (2010)
[172] Fitzgerald (2010)
[173] Rio Tinto (2009)
[174] Turton (2002)

### 8.9 Costs of subsidising the aluminium industry

Protecting the Australian aluminium industry with carbon pricing concessions will impose significant costs on the Australian community and impedes the almost inevitable restructuring that will enable Australia to *increase* productivity and living standards. In addition to the already considerable electricity subsidies, the cost of "free" permits proposed under the December 2009 CPRS provisions would average around $811m per year.[175] These costs amount to an annual subsidy of about $161,000 per person currently directly employed in the aluminium industry.

Based on the available evidence, as legacy electricity subsidies for the industry unwind, Bell Bay and Kurri Kurri will become very high cost producers, and Point Henry will be vulnerable to swings in Aluminium demand. This loss of competitiveness is independent of a carbon price. Keeping the remaining smelters of Portland, Boyne-Gladstone and Tomago in production with free permits would effectively cost other Australians $582m per year on average over the next decade, or $183,000 per person directly employed by these plants.

---

[175] See Section 2.3 of the main report for a discussion of the cost of "free" permits.

# 9. Oil refining

## 9.1 Summary of analysis

The current economics of Australia's oil refineries are precarious. Although they generate cash from their operations, they do not make substantial returns on capital. New plants are not being built because these investments are unlikely to generate adequate returns.

Australian oil refineries are not internationally competitive on costs, and in the long run are likely to close. More modern plants in Asia are substantially larger, more efficient, and better located. Australia's refineries only compete today against imports because their freight costs are lower, many competitor Asian refineries do not yet comply with higher Australian fuel quality standards, and Asian demand has tended to exceed supply in recent times. These barriers are likely to erode: new overseas plants' costs are likely to decrease further; Asian fuel standards will probably lift to be closer to Australian standards; Asian supply will increase; and opportunities for Australian plants to reduce costs are limited.

As a result, with or without a carbon price, many Australian oil refineries are likely to close in the long term. Carbon pricing would not result in immediate plant closures, but it is likely to bring them forward. Carbon pricing accelerates arrival at the point where Australian cash costs are higher than import prices.

If Australian refineries do close, this is likely to *reduce* global carbon emissions. Overseas plants that are taking market share are substantially more efficient than Australian plants.

Free permits under the draft CPRS will delay industry restructuring that is inevitable even without a carbon price and will increase global emissions.

If it were believed that Australia needed some domestic oil refining capacity to remain operational for energy security or defence purposes, this would be best managed through a direct and transparent subsidy for such purposes, not indirectly via free permits or other exemptions from a carbon price.

## 9.2 Industry background

The Australian oil refining industry employs 5800 people.[176] operating seven refineries across Australia (see Table 9.1). Another refinery in Adelaide (Port Stanvac) was mothballed in 2003, and Mobil recently announced it will be permanently closed and demolished.

**Table 9.1 Australian oil refineries and production capacity**

| Refinery | State | Owner | Capacity (m barrels / yr) |
|---|---|---|---|
| Kwinana (Perth) | WA | BP | 50.1 |
| Geelong | VIC | Shell | 43.4 |
| Altona (Melbourne) | VIC | Exxon-Mobil | 28.5 |
| Kurnell (Sydney) | NSW | Caltex | 49.3 |
| Clyde (Sydney) | NSW | Shell | 31.0 |
| Lytton (Brisbane) | QLD | Caltex | 39.6 |
| Bulwer Island (Brisbane) | QLD | BP | 32.1 |

*Source: ACCC (2009)*

---

[176] Cuevas-Cubria *et al.* (2009)

Australia's refineries are almost entirely focussed on serving the domestic market and in particular their immediate surrounding geographic area or state.  Exports are small and declining. The refineries predominantly utilise light and sweet crude oils from Australia and South-East Asia, which are the easiest to refine but also the most expensive to produce. The main products are automotive gasoline (44% of output), diesel (30% of output), jet aviation fuel (13.5% of output) and LPG (3%) with an assortment of other products making up the remaining 9.5%.[177]

## 9.3 Industry economics

### 9.3.1    Industry returns

The current economics of Australia's oil refineries are precarious. Although they generate cash from their operations, they do not make substantial returns on capital.

In most years recently Australian refineries have earned cash margins between $4 and $7 per barrel, an improvement over early 2000s when they only just covered their costs, as shown in Table 9.2.  However, in 2008-09 they made a small loss as shown in Figure 9.1 as the GFC led to more aggressive pricing from international refiners.

Taking an average across these periods and data-sets we estimate a margin of approximately $3.60(AUD) per barrel of crude oil processed.

**Table 9.2 Australian refining cash margins**

| Year | EBITDA[a] (A$m) | Barrels crude oil processed[b] (m) | EBITDA per barrel ($A) |
|---|---|---|---|
| 2000 | 175 | 281 | $0.62 |
| 2001 | 351 | 270 | $1.30 |
| 2002 | 155 | 280 | $0.55 |
| 2003 | 698 | 251 | $2.78 |
| 2004 | 1,243 | 254 | $4.90 |
| 2005 | 1,610 | 232 | $6.94 |
| 2006 | 1,752 | 248 | $7.06 |
| 2007 | 1,507 | 241 | $6.25 |

*Source: (a) Australian Institute of Petroleum (2008); (b) Australian Government Department of Resources, Energy and Tourism – Australian Petroleum Statistics*

---

[177] Australian Government Department of Resources, Energy and Tourism – Australian Petroleum Statistics

**Figure 9.1 Australian refining revenues and costs (AUD billion)**
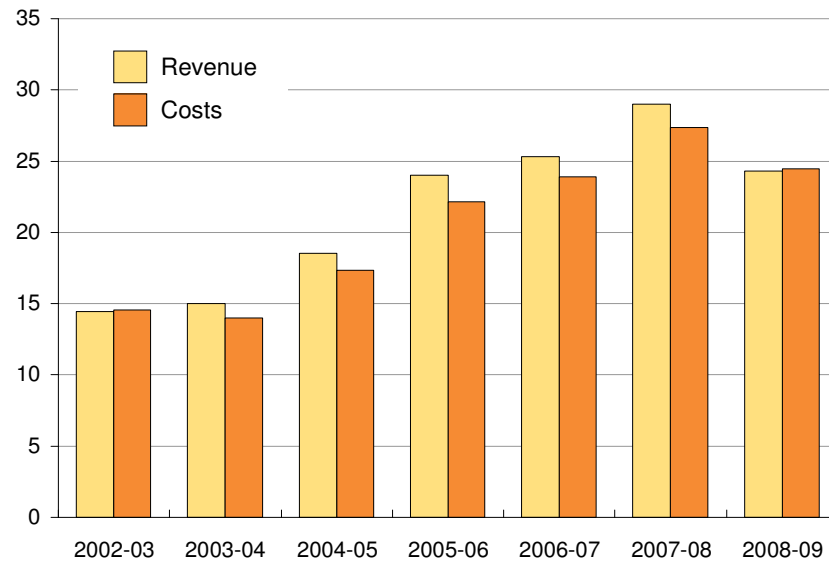


Source: ACCC (2009)

However, Australian refineries are not earning substantial returns on the capital invested in their plant. According to the Australian Institute of Petroleum in 2006, *"although industry profitability has improved in recent years, returns to Australian refiner marketers have been below the long term bond rate for most of the last twenty years and well below international benchmarks for the industry."*[178]

As a result, new plants are not being built in Australia despite increasing demand, as illustrated in Figure 9.2.

**Figure 9.2 Australian consumption and production of refined petroleum (megalitres)**
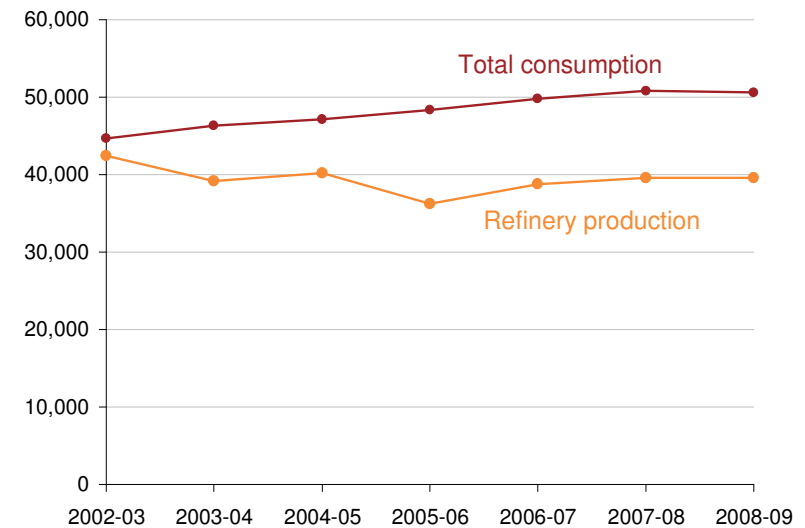


*Source: Australian Government - Department of Resources, Energy and Tourism – Australian Petroleum Statistics*

---

[178] Australian Institute of Petroleum (2006)

### 9.3.2    Australian costs

Australian oil refineries are not internationally competitive on costs. More modern plants in Asia are substantially larger, more efficient, and better located.

Although we could not obtain precise details of Australian oil refineries on international cost curves, publications by industry participants and the Australian Consumer and Competition Commission (ACCC) suggest that Australian oil refiners are substantially less efficient than international competitors because of their small scale and age.  The ACCC observed in its 2007 Inquiry into the price of unleaded petrol that,

> *"Domestic refineries are small in scale and less efficient than refineries in the Asia-Pacific region, particularly the large modern refineries in Singapore. The consequence is that domestic refineries have higher costs of production than other regional refiners….The inquiry has heard that domestic input costs, particularly labor and environmental compliance costs, are also higher than overseas. As a consequence of relatively high input costs, domestic production costs may currently be up to 20 per cent higher than the average in the Asia-Pacific region and 50 per cent higher than many refiners in the Singapore region. These cost disadvantages are likely to increase as even larger overseas refiners start production over the next few years. Indeed, it appears from the evidence that overseas refiners may enjoy a considerable cost advantage relative to domestic refineries."*[179]

Australian refineries have been characterised by poor competitiveness and profitability for some time due in large part to inadequate economies of scale and out-dated refineries.

Back in 1994, the Productivity Commission's predecessor, the Industry Commission, in an inquiry into the petroleum products industry observed,

> *"A major consideration in assessing the relative performance of Australian refineries is the technology that is employed in comparison with newer refineries in other countries. Australian refineries have introduced new production technologies when investing to expand capacity, to handle changing feedstock, or to meet new environmental requirements. However, this incremental approach to technology adaptation generally cannot replicate the performance of 'greenfield' refineries in other countries."*[180]

Caltex stated in their submission to this Inquiry that, "The relative age of Australian refineries places them at a disadvantage as the cost to retrofit generally exceeds the cost of equivalent efficiency in new plants."[181]

In addition to their out-dated equipment Australian refineries are sub-economic in scale. The ACCC observed that *"the legacy structure of domestic refiners places them at a competitive disadvantage relative to larger, more efficient refineries in the region."*[182]

---

[179] ACCC (2007b)

[180] Industry Commission (1994)
[181] Industry Commission (1994)
[182] ACCC (2007b)

Similarly, ACIL Tasman found that *"Oil refining is subject to large economies of scale (as well as scope), as capital costs rise less than proportionately to capacity. Scherer has estimated that refineries need a production capacity of 200,000 bpd in order to reach the minimum efficient scale."*[183]

Yet Australia's largest refinery, Kwinana, is only 131,000bpd, and the average size is 104,000bpd. ExxonMobil's single refinery in Singapore, at 605,000bpd,[184] is bigger than the capacity of all Australian refineries combined bar Kwinana. Australian refineries are generally smaller than their Asian region competitors, as shown in Figure 9.3.

**Figure 9.3 Asian refinery capacity ('000s barrels per day)**
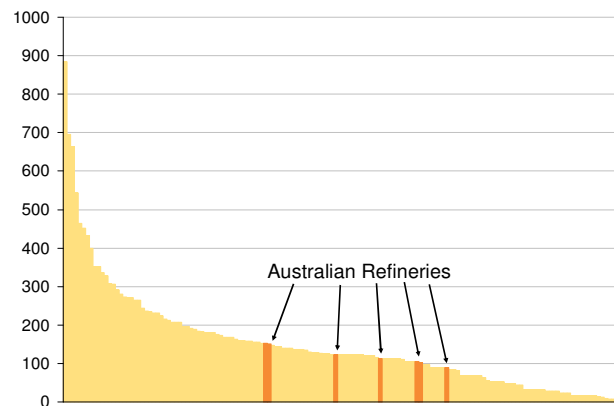


*Source: Shell Australia (2007)*

---

[183] ACIL Tasman (2008b)
[184] ACIL Tasman (2008b)

The petroleum refiner, Ampol, (which has since merged into Caltex), told the 1994 Industry Commission Inquiry that because of the Australian refineries' age and small size they could not expect to achieve leading edge performance in global benchmarking assessments, *"The broad impression gained from recent [Solomon] comparisons is that, given the age and size of Australian refineries, they compare favourably on average with overseas operations but could not be classed as at the leading edge".*[185]

### 9.3.3    Barriers to imports

Australia's refineries only compete today against imports because their freight costs are lower, many competitor Asian refineries do not yet comply with higher Australian fuel quality standards, and Asian demand has tended to exceed supply in recent years.

According to the ACCC[186] Australian refineries are able to compete with more efficient refineries in the Asia Pacific region for two reasons:

- It is cheaper to freight into Australia a litre of crude oil than a litre of refined product. Crude oil is imported in larger (up to 200 000 tonnes), 'dirtier' ships, whereas refined product is transported in smaller ships (up to 45 000 tonnes).

- Australia has higher fuel standards than many Asian countries that are the primary markets for competing international refineries. Fuels vary in their chemical characteristics (not just whether they are considered diesel or standard unleaded) such

---

[185] Industry Commission (1994)
[186] ACCC (2007b)

as their sulphur content, octane/cetane rating, benzene content, MTBE[187], and evaporation rate at various temperatures.  These characteristics affect vehicle performance and pollution levels, but require additional costs to refine. The Commonwealth Government and Australian State governments have set high standards for many of these chemical characteristics that many Asian refineries do not currently meet.

The ACCC estimated in 2007 that the freight differential and the fuel quality premium combined provide US$3-$4 per barrel of protection for Australian refiners which offsets their higher costs to enable them to be viable against more efficient overseas refineries.[188]  As illustrated in Figure 9.4, the freight differential and fuel quality premium combined provided greater import protection in recent years with the quality premium lifting as new fuel standards were introduced.

**Figure 9.4 Freight differential and quality premium for Australian petrol (A$/barrel)**
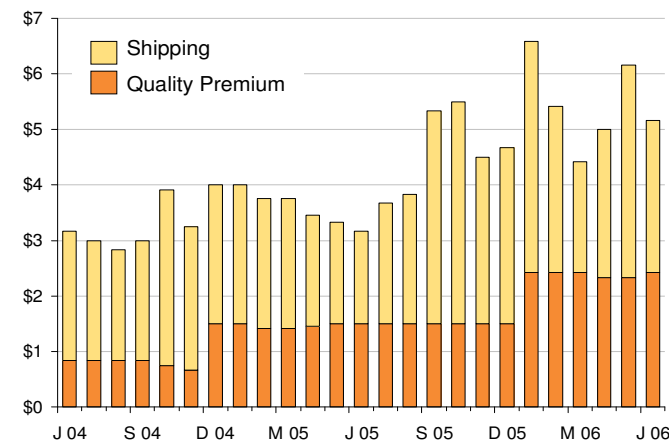


*Source: Australian Institute of Petroleum (2006)*

Australian refineries have also remained viable because demand has generally exceeded industry supply.

Australian-refined supply reduced when the Port Stanvac Refinery was mothballed in 2003 because Mobil was unwilling to invest in equipment upgrades to produce fuel to the new standards.

Asian refined supply has generally failed to keep up with the rapid growth in Asian demand for refined petroleum products.  As shown in Figure 9.5, increases in supply tend to be lumpy, and therefore margins are cyclical.[189] When supply last exceeded
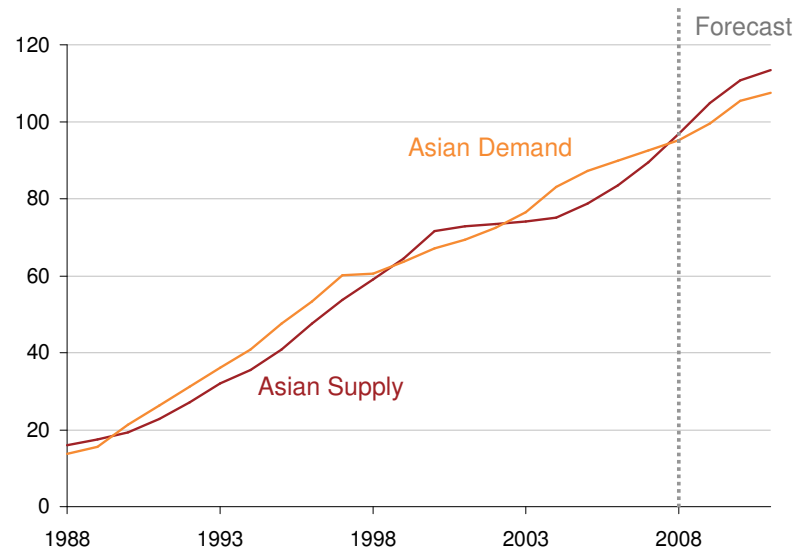
---

[187] Methyl Tertiary Butyl Ether, a petrol octane enhancer
[188] ACCC (2007b)

[189] Senate Standing Committeee on Economics (2006)

demand in the early 2000s, Australian refining margins dropped away.  For much of the last few years the situation reversed.

**Figure 9.5 Asian refinery product supply and demand (mbpd)**



*Source: Hepworth (2008)*

### 9.3.4    Increasing import competition

These barriers are likely to erode: new overseas plants are likely to become even cheaper; Asian fuel standards will probably lift to be closer to Australian standards; Asian supply will increase; and opportunities for Australian plants to reduce costs are limited.  As a result, with or without a carbon price, many Australian oil refineries are likely to close.

Fuel standards in other Asian countries are catching up to Australian standards, eroding the advantage of Australian refineries. The ACCC observed in its 2007 inquiry into petrol prices that,

> *"Over time, however, more and more refiners in the Asia-Pacific region could provide petrol refined to Australian standards. This supply response is partially a result of the tightening of fuel standards overseas across the region to be more in line with Australian standards. As supply increases, the quality premium applicable to imported petrol is likely to be eroded by competition."[190]*

At the same time supply is starting to catch up with demand as significant new low-cost plants are being built in Asia.

As a result, the closure of a number of Australian refineries may be inevitable, whether or not a carbon pricing scheme is introduced. When upgraded fuel standards were introduced, Shell and ExxonMobil considered closing the Clyde[191] and Altona[192] refineries respectively and ExxonMobil shut-down its Port Stanvac refinery in Adelaide.

More recently ACIL Tasman reported in its 2008 study that the Managing Director of Caltex (at the time), Mr Des King felt that at least two of Australia's remaining seven refineries are likely to

---

[190] ACCC (2007b)
[191] ACIL Tasman (2008b)
[192] Fitzgerald (2004)

close within the next decade because they will not be able to compete with surplus Asian refined petroleum products.[193]

Similarly, the ACCC noted in its 2007 report that,

*"The inquiry was not provided with evidence of significant plans for expansion of local refining activities or entry by overseas refiners. Instead, the picture is one of declining capacity as a result of tightening fuel standards and refinery closure."*[194]

Older, smaller plants are closing across the globe. For example, Chevron plans to rationalise its older and smaller refineries in mature markets such as Europe and the United States because they cannot compete with modern world-scale facilities being built in Asia and the Middle East.[195]

### 9.4 Impact of carbon pricing

Carbon pricing would not result in immediate plant closures, but it is likely to bring them forward. Carbon pricing accelerates arrival at the point where Australian cash costs are higher than import prices.

Australian oil refineries achieving industry average margins would continue to be profitable in the short term, even with a carbon price of $35/tCO_2$, as shown in Table 9.3. Obviously, they still do not provide a commercial return on capital invested.

However, by reducing current cash margins by around 30%, carbon pricing would bring Australia refineries closer to the point that they cannot compete with imports. As described above, imports are likely to become more competitive over the next few years, and will probably ultimately get to the point where imported refined petrol including freight is cheaper than local refining.

**Table 9.3 Impact of carbon price on Australian oil refinery margins**

| Refinery | Emissions ($tCO_2$/barrel) | Carbon cost ($/barrel) | EBITDA margin with carbon price ($/barrel) |
|---|---|---|---|
| Kwinana | 0.018[a] | $0.63 | $2.97 |
| Geelong | 0.039[b] | $1.37 | $2.23 |
| Altona | 0.043[c] | $1.50 | $2.10 |
| Kurnell | 0.029[d] | $1.02 | $2.58 |
| Clyde | 0.039[b] | $1.37 | $2.23 |
| Lytton | 0.027[e] | $0.94 | $2.66 |
| Bulwer Island Brisbane | 0.033[f] | $1.15 | $2.45 |

*Assumes industry average margin of $3.60/barrel; carbon price of $35/tCO_2$; 90% capacity utilisation for all refineries, as per estimates in chart 13.12 of ACCC (2009)*
*Source: (a) Victorian EPA (2008) These results were for the 2005 period and were cross-checked for currency against BP Australia (2008); (b) Data on actual emissions are not available, and calculated as the residual of industry-wide emissions after subtracting plants for which data are available; (c) Pers. Comms. (2009b); (d) Pers. Comms. (2010c); (e) Pers. Comms. (2010b); (f) BP Australia (2009).*

---

[193] ACIL Tasman (2008b)
[194] ACCC (2007b)
[195] Garvey (2009)

Carbon pricing would have even less impact if, as seems likely, major competitors also impose a carbon price. Three quarters of Australian imports come from Singapore, South Korea and Japan, as shown in Figure 9.6. Recent media reports from these countries suggest that carbon prices are being actively considered by their governments.[196]

Although energy efficiency measures are possible, these are unlikely to reduce costs enough to alter decisions about whether to keep a refinery open. Australian oil refineries could reduce their carbon emissions substantially, but investment in the new equipment required is unlikely to be economically justifiable. Incremental improvements could probably be achieved without wholesale replacement of refining equipment. For example between 2002 and 2008 BP reduced energy use at Kwinana by 10% and at Bulwer Island by 11% through incremental changes.[197]. However, efficiency increases of 10% would only save around $0.10 per barrel in carbon costs, and are unlikely to change decisions about whether plants should be shut.

**Figure 9.6 Origin of Australian imports of refined petroleum products**
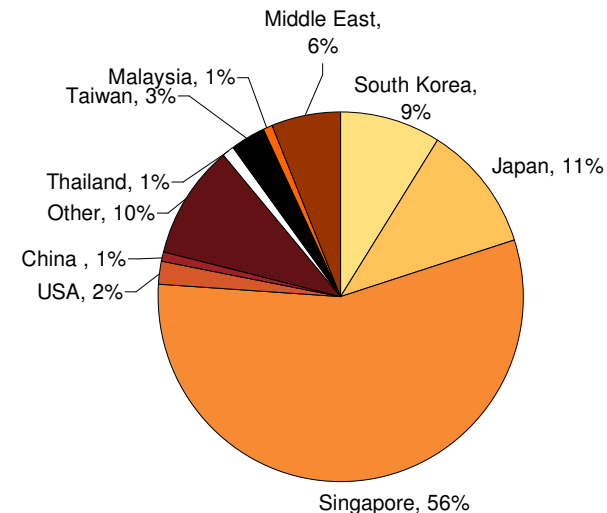


*Note: For 2008 and 2009 calendar years combined; market share by volume*
*Source: Australian Government Department of Resources, Energy and Tourism*
*– Australian Petroleum Statistics*

### 9.5 Impact of closure on global emissions

If Australian refineries do close, this is likely to *reduce* global carbon emissions. Overseas plants that are taking market share are substantially more energy efficient than Australian plants.

Australian oil refineries were largely established in the 1950s and 1960s and the technology they employ is less energy-efficient than that employed in significantly more modern refineries built

---

[196] For Singapore: Point Carbon (2010). For Korea: Kim (2010). For Japan: Sakamaki and Hirokawa (2009)
[197] BP Australia (2008)

since the 1980s in Asia. The company Solomon Associates undertake extensive benchmarking of the energy efficiency of oil refineries across the globe ranking them on an energy intensity index.[198] This index adjusts for "complexity" – the additional energy needed to produce high value, cleaner fuels from different types of crude oil. According to their 2008 assessment, all Australian refineries are in the worst quartile of oil refineries in the Asia Pacific region for their energy efficiency.[199] The vast majority of Australia's imported fuel is sourced from Asia, as illustrated in Figure 9.6. If Australian refineries were to close it is most likely that more energy efficient refineries in this region would replace them.

## 9.6 Industry Assistance

Free permits under the draft CPRS will delay industry restructuring that is inevitable even without a carbon price and will not assist reductions in global emissions.

Under the draft CPRS legislation, refineries would receive free permits for approximately 0.02 tonnes of $CO_{2\text{-e}}$ per barrel of crude oil processed, worth approximately $0.70 per barrel of crude. These free permits are calculated on the basis that average industry-wide greenhouse emissions were 7.7m $tCO_2$/yr over the period 2000 to 2007[200] from processing 257m barrels/yr.[201] On

these figures refining would qualify under the draft CPRS as a moderately emissions intensive activity on a value-added basis eligible in 2011 for 66% free permits.

Given the analysis above, these free permits might delay the closure of Australian oil refining capacity, but they are unlikely to prevent closures in the long run that are a consequence of producers building larger more modern facilities closer to the large markets of Asia. Global emissions are very likely to reduce as production moves to these more energy efficient plants.

If it is believed that Australia needed some domestic oil refining capacity to remain operational for energy security or defence purposes, this would be best managed through a direct and transparent subsidy for such purposes, not indirectly via free permits or other exemptions from a carbon price.

At best this subsidy could only provide limited supplies for defence purposes. Australia is reliant on overseas crude oil for its domestic refineries. Local crude oil production only supplies 20%-30% of domestic consumption[202]. Arguably overseas refining would *increase* security of domestic supply as Australia's old domestic refineries are more vulnerable to outages than overseas imports where plants are more modern and shipments are readily substituted.

Australia could refine local oil for defence needs but this would require modification of the existing refineries that are not optimised to exclusively refine Australia's very light crude oils

---

[198] See http://solomononline.com for further information on Solomon Associates and its Energy Intensity Index benchmarking studies.
[199] Source for information on performance of Australian refineries on the Solomon Associates Oil Refinery Energy Intensity Index: Pers. Comms. (2010d)
[200] Australian Institute of Petroleum (2008)
[201] Australian Government Department of Resources, Energy and Tourism - Australian Petroleum Statistics

[202] Australian Government Department of Resources, Energy and Tourism - Australian Petroleum Statistics

## 10. Households

A carbon price would have a small impact on household budgets relative to other changes in the cost of living, and could be affordably offset by government through cash transfers or reductions in other taxes.

A carbon price would have most impact on the cost of energy goods – petrol, electricity and gas - and relatively little impact on other household expenditures.

Figure 10.1 illustrates that these increases in energy costs would be small relative to total household expenditures. Although low income earners would be proportionately more affected, the percentage increase in household expenditure would still be only 1% of weekly household budgets, as shown in Figure 10.2.

**Figure 10.1 Carbon price impact on Australian average household weekly expenditure (AUD)**
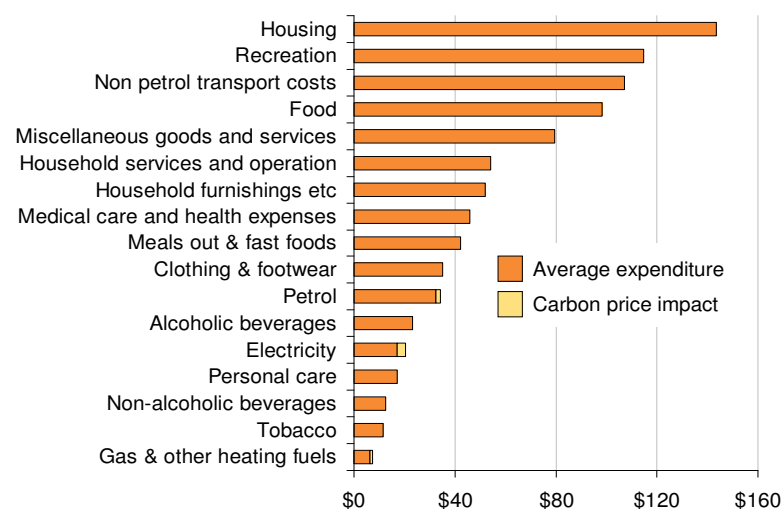


*Source: ABS (2006a) with $35/tCO$_2$ carbon price impact based on Grattan Institute analysis*

**Figure 10.2 Carbon price impact on lowest quintile household weekly expenditure**
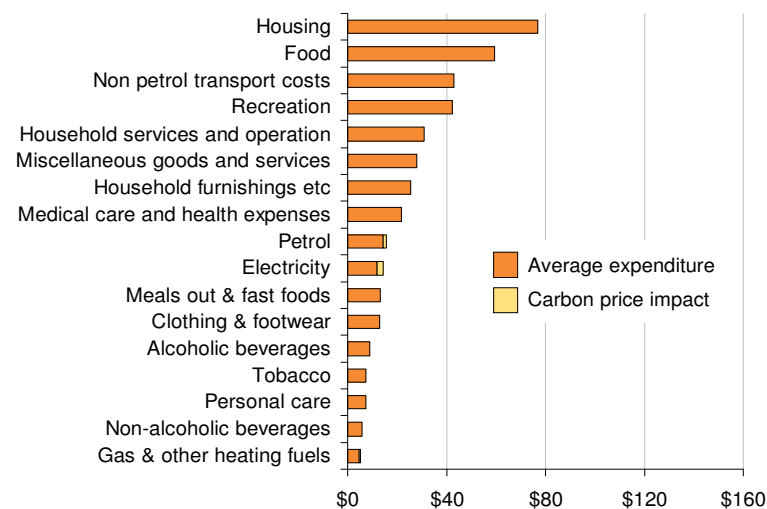


*Source: ABS (2006a) with $35/tCO$_2$ carbon price impact based on Grattan Institute analysis*

According to the modelling of the CPRS in Australian Government Treasury (2008), the overall rise in the price level (all items, not just energy) was expected to be only 1%-1.5%, hence this is not illustrated in the graphs above.

Table 10.1 breaks down the results above to provide a simplified illustration of how a carbon price of $35/tCO$_2$ (or 3.5 cents per kilogram) would flow through to price rises in the domestic supplies of petrol, electricity and gas as a result of their current carbon emissions intensity. This does not take into account the government's plans for compensation through tax cuts. Ultimately the impacts would probably be lower than indicated for petrol and electricity. In the case of petrol the government intends to completely offset the carbon costs through matching reductions in fuel excise tax at least for the first three years of the scheme. In the case of electricity, we have used current emissions intensity levels however it is likely that by the time the carbon price reaches $35tCO$_2$ the emissions intensity of electricity supply could be expected to decline. Throughout we have worked in real dollar terms.

**Table 10.1 Impact of $35 Carbon price on residential energy prices**

| Energy source | Unit | Retail price per unit[a] | | CO$_{2-e}$ per unit (kilograms)[b] | Cost increase @ $35/tCO$_2$ (3.5c/kgCO$_2$) | % price increase | |
|---|---|---|---|---|---|---|---|
| | | Low | High | | | Low retail prices | High retail prices |
| Petrol | Litre | $1.10 | $1.40 | 2.29 | $0.080 | 7.3% | 5.7% |
| Electricity | Kilowatt-hour | $0.15 | $0.25 | 1.06 | $0.037 | 24.8% | 14.9% |
| Gas | Megajoule | $0.012 | $0.020 | 0.07 | $0.002 | 19.8% | 11.9% |

*Note: Assumes 100% pass through of carbon costs to consumer prices. Does not take into account compensating reductions in fuel excise over the first three years of the CPRS.*

*(a)Petrol prices source: Australian Automobile Association (2009). Electricity price data source: Australian Energy Regulator (2009) and Government of Western Australia Office of Energy (2009). Gas prices exclude Brisbane (which is an outlier - small gas penetration and high prices), Gas prices sources: Australian Energy Regulator (2009); AGL; Origin Energy; Synergy.*

*(b) Scope 1 emissions for petrol (trade exposed so therefore should be no pass-through of refinery emissions), full fuel cycle emissions for electricity and gas. Source: Australian Government Department of Climate Change (2009)*

Relative to past changes in prices, these increases that will transpire over about a decade, are relatively small. For example, in four out of the nine years between 1999 and 2008, petrol prices increased by more than 8c/litre (see Figure 10.3), and the cumulative change is almost nine times the impact of the carbon price.

**Figure 10.3 Changes in petrol price 1999-2008 compared to effect of $35/tCO$_2$ carbon price (c/L)**
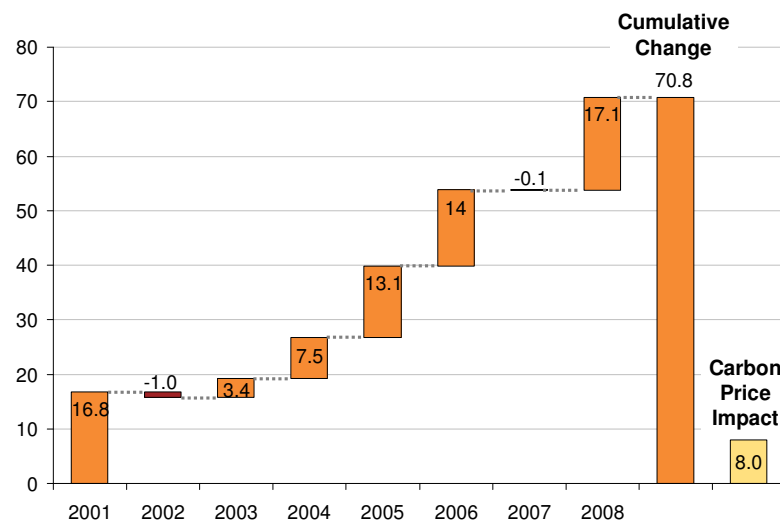


*Source: Grattan Institute analysis of Australian Automobile Association (2009) Fueltrac data*

Similarly, the nearly 4c/kWh or roughly 20% increase in electricity prices is smaller in percentage terms than increases experienced over the last 10 years, as shown in Figure 10.4.

**Figure 10.4 Percentage increase in residential real electricity prices 2000-01 to 2009-10 compared to $35/tCO$_2$ carbon price**
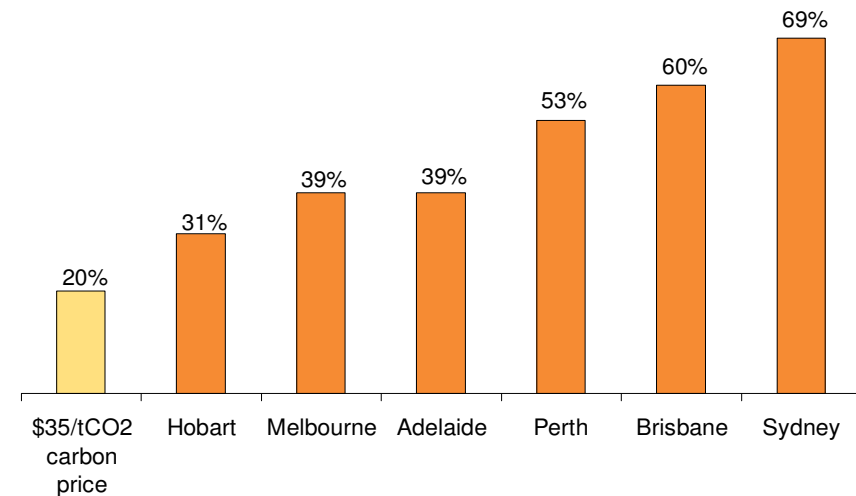


*Source: ABS (2009); Government of Western Australia Office of Energy (2009)*

For some vulnerable sections of the community any price rise in the necessities of life such as energy (electricity, gas and petrol), can be difficult to cope with. This analysis does not intend to belittle their challenges. Rather it shows that the change is of a magnitude that government should be able to readily assist through cash transfers or tax cuts (funded through auctioning emissions permits) that do not blunt the incentive to reduce emissions.

For those less vulnerable sections of the community, these price rises are likely to be subsumed amongst general fluctuations in prices driven by other factors including:

- Substantial rises in electricity network investment in order to maintain supply reliability with the growth in electricity demand caused by greater air conditioner usage;

- Typical changes in crude oil prices;

- Increases in gas prices due to the development of Australia's LNG export industry; and

- Movements in the Australian dollar exchange rate.

# 11. Glossary

| | | | | |
|---|---|---|---|---|
| ABARE | Australian Bureau of Agricultural and Resource Economics | | Clinker | The precursor to cement, made by heating a mixture of limestone, sand and clay |
| ABS | Australian Bureau of Statistics | | $CO_2$ | Carbon dioxide |
| ACCC | Australian Competition and Consumer Commission | | $CO_2$ equivalent | A measure used to compare the emissions from greenhouse gases based upon their global warming potential |
| Al | Aluminium | | | |
| Alumina | Aluminium oxide, the raw material produced from bauxite and used to produce aluminium | | $CO_2$-e | See $CO_2$ equivalent |
| | | | Coking coal | See 'metallurgical coal' |
| AUD | Australian dollars | | CPI | Consumer Price Index |
| Bauxite | The principal ore of Aluminium metal | | CPRS | Carbon Pollution Reduction Scheme – the label the government has applied to its emissions cap-and-trade scheme |
| Billet | A long, rectangular or cylindrical unfinished bar of iron or steel | | | |
| Black coal | A lower water-content form of coal | | EAF | Electric Arc Furnace |
| BPD | Barrels per day | | EBIT | Earnings Before Interest and Taxes – profit taking into account the amortised cost of capital equipment, although positive EBIT may not provide sufficient return on capital to justify investment |
| Brown coal | A higher water-content form of coal | | | |
| BTU | British Thermal Units | | | |
| Carbon leakage | The effect when a firm facing increased costs in one country due to an emissions price chooses to reduce, close or relocate production to a country with less stringent climate change policies | | EBITDA | Earnings Before Interest, Taxes, Depreciation and Amortisation – pure cash profit of a business without regard to the cost of capital equipment |
| | | | EIA | Energy Information Administration |
| Carbon price | The cost of emitting carbon into the atmosphere. It can be a tax imposed by government, the outcome of an emissions trading market, or a hybrid of taxes and permit prices | | EITE | Emissions Intensive Trade Exposed |
| | | | Electric Arc Furnace | Furnace for producing steel by recycling scrap iron and steel by melting it with an electric arc |
| CIF | In relation to cement: Cement Industry Foundation | | Emissions intensity | The amount of greenhouse gas produced per unit of production |
| CIF | In relation to a price of a commodity: Price including cost, insurance and freight – i.e. the price at the port where goods are imported – compare to FOB | | | |

| | |
|---|---|
| FEED | Front End Engineering Design – key stage in development of major industrial project involving extensive engineering studies to determine how an industrial facility will function and the equipment it will employ |
| FOB | Price for goods free on board – i.e. the price at the port where goods are exported from, and excluding the costs of international insurance and freight – compare to CIF |
| Free permit | A certificate created under an emissions trading scheme that the holder does not pay for, and which entitles the holder to emit a specified amount of greenhouse gases |
| Garnaut Report | An independent study conducted by economist Professor Ross Garnaut, commissioned by Australia's Commonwealth, State and Territory governments in 2007 |
| GDP | Gross Domestic Product |
| GFC | Global Financial Crisis |
| GJ | GigaJoule |
| Greenhouse gas | The atmospheric gases responsible for causing global warming and climate change |
| GST | Goods and Services Tax |
| IAI | International Aluminium Institute |
| IBF | Integrated Blast Furnace |
| IEA | International Energy Agency |
| Integrated Blast Furnace | Furnace for producing steel by converting iron ore and metallurgical coal into pig iron and then steel using heat-intensive furnace |
| Kyoto Protocol | an international agreement linked to the United Nations Framework Convention on Climate Change, adopted in Kyoto, Japan on 11 December, 1997 |
| LNG | Liquified Natural Gas |

| | |
|---|---|
| Metallurgical coal | Coal used in steel making |
| Methane | A greenhouse gas, estimated to have a global warming effect twenty-one times that of the same weight of carbon-dioxide |
| Mtpa | Million tonnes per annum |
| MWh | Megawatt hour |
| OECD | Organisation for Economic Co-operation and Development |
| Sequestration | The removal of atmospheric carbon dioxide, either through biological processes (eg. photosynthesis in plants and trees) or geological processes (eg. storage in underground reservoirs) |
| t | tonne |
| Thermal coal | Coal used in power generation |
| USD | United States Dollars |
| Windfall gain | A benefit accruing to a company without any effort on their part as a result of government regulation |
| WTO | World Trade Organisation |

## 12. References

ABARE (Australian Bureau of Agricultural and Resource Economics) (2009a) *ABARE's list of major minerals and energy projects*, April 2009. www.abare.gov.au

ABARE (2009b) *Australian Commodities*, September Quarter 09.03, Vol16 No.3. www.abare.gov.au

ABARE (2009c) *Australian Mineral Statistics*. www.abare.gov.au

ABS (Australian Bureau of Statistics) (2006a) *Cat. No. 6535.0.55.001 Household Expenditure Survey, Australia: Detailed Expenditure Items, 2003-04*

ABS (2006b) *Cat. No. 6345.0 Labour Price Index, Australia, September 2006*

ABS (2006c) *5209.0.55.001 Australian National Accounts: Input-Output Tables – 2004-05 Final*

ABS (2009) *6401.0 - Consumer Price Index, Australia, Dec 2009*, 27 January 2010

ABS (2010) *5206.0 - Australian National Accounts: National Income, Expenditure and Product, Dec 2009*, Issued 3 March 2010

ACCC (Australian Competition and Consumer Commission) (2004) *ACCC assessment of Boral Limited's proposed acquisition of Adelaide Brighton Limited*, 12 May 2004

ACCC (2007a) *Public competition assessment – OneSteel Limited – Proposed acquisition of Smorgon Steel Group Limited*, 22 June 2007. www.accc.gov.au

ACCC (2007b) *Petrol Prices and Australian Consumers – report of the ACCC inquiry into the price of unleaded petrol*, December 2007

ACCC (2009) *Petrol Prices and Australian Consumers – report of the ACCC inquiry into the price of unleaded petrol*, December 2009

ACIL Tasman (2008a) *The CPRS and the LNG Industry – An assessment of the impacts*. Report prepared for Chevron Australia Pty Ltd. ConocoPhilips, ExxonMobil and Woodside Energy Ltd., October 2008

ACIL Tasman (2008b) *An Assessment of Australia's Liquid Fuel Vulnerability*. Prepared for Department of Resources, Energy and Tourism, November 2008

ACIL Tasman (2009) *Fuel resource, new entry and generation costs in the NEM*, Report prepared for NEMMCO, April 2009

Adelaide Brighton Ltd. (2008) *Annual Report*

Adelaide Brighton Ltd. (2009) *Presentation to Merrill Lynch Emerging Companies Conference*, 19 June 2009

AGL, www.agl.com.au

Alcoa (2008) *2nd Quarter 2008 Analyst Conference*, July 8, 2008. Available from: http://www.alcoa.com/global/en/investment/pdfs/2Q08_Analyst_Presentation.pdf

Alumina Ltd. (2008a) *CDP6 Greenhouse Gas Emissions Questionnaire*. http://www.cdproject.net/responses/public/Alumina_Ltd_8889_Corporate_GHG_Emissions_Response_CDP6_2008.asp

Alumina Ltd. (2008b) *Alumina Ltd Carbon Disclosure Project Survey Return for 2007*

Alumina Ltd. (2008c) *Sustainability section of website*: http://www.aluminalimited.com/index.php?s=about&ss=sustainability&p=our_performance

Alumina Ltd. (2009) *Alumina Limited 2008 Full Year Results Presentation*, 3 February 2009

AMP (2004) *Capital Investors*, June 2004

Anglo American (2007) *Anglo Coal sustainable development report*

Anglo American (2008) *Anglo Coal factsheet*, www.anglocoal.com

Anglo American (2009) *Presentation by Anglo Coal CEO Ian Cockerill to the Credit Suisse Global Steel and Mining Conference*, 23 September 2009

ArcelorMittal (2007) *Prospectus for the merger of ArcelorMittal into Arcelor*. September 28, 2007

ArcelorMittal (2008) *Delivering returns in the new steel horizon*. Presentation to Investor Day, London, 17 September 2008

Armstrong, K., Bailey, D., De Ruyter, A., Mahdon, M. and Thomas, H. (2008) *Auto plant closures, policy responses and labour market outcomes: a comparison of MG Rover in the UK and Mitsubishi in Australia*, Policy Studies 29:3, p 343

Australian Aluminium Council (2000) *Aluminium and the Australian Economy*, May 2000

Australian Aluminium Council (2004) *Submission to the Productivity Commission Inquiry into Energy Efficiency*. http://www.pc.gov.au/__data/assets/pdf_file/0017/45134/sub029.pdf

Australian Aluminium Council (2008) *Australian Aluminium Council Sustainability Report 2007*, www.aluminium.org.au

Australian Automobile Association (2009), *Fueltrac data*, http://www.aaa.asn.au/issues/petrol.htm

Australian Energy Market Operator (2009) see: www.aemo.com.au

Australian Energy Regulator (2009) *State of the energy market - 2009*, www.aer.gov.au

Australian Government (2007) *Australia's Climate Change Policy – our economy, our environment, our future*, July 2007

Australian Government (2008) *Carbon Pollution Reduction Scheme Australia's Low Pollution Future*, White Paper, December 2008

Australian Government (2009a) Details of Proposed CPRS Changes, 24 November 2009, available from http://www.climatechange.gov.au/en/government/initiatives/cprs/~/media/publications/cprs/CPRS-Implementation-of-Nov09-changes-pdf.ashx

Australian Government (2009b) *Carbon Pollution Reduction Scheme Regulations 2009, Consultation Draft*, released for comment December 2009

Australian Government Department of Agriculture, Fisheries and Forestry *Commonwealth Forestry Industry Structural Adjustment Program*, www.daff.gov.au

Australian Government Department of Climate Change (2008) *Carbon Pollution Reduction Scheme Green Paper*, July 2008

Australian Government Department of Climate Change (2009a) *Australian National Greenhouse Accounts – National Inventory by Economic Sector – 2007*, May 2009, Available from: http://www.climatechange.gov.au/en/climate-change/emissions.aspx

Australian Government Department of Climate Change (2009b) *National Greenhouse Account Factors*, June 2009. www.climatechange.gov.au

Australian Government Department of Climate Change (2010) *2008-09 NGER data by corporate group – data reported to the GEDO as at 19 February 2010*, available from: http://www.climatechange.gov.au/government/initiatives/national-greenhouse-energy-reporting/publication-of-data.aspx

Australian Government Department of Industry Tourism and Resources (2006) *Punching Above Its Weight – Australia's Cement Industry*, Report to the Australian Government from the Strategic Industry Leaders Group 2006-2012

Australian Government Department of Resources, Energy and Tourism – Australian Petroleum Statistics. http://www.ret.gov.au/resources/fuels/aps/Pages/default.aspx

Australian Government Prime Ministerial Task Group on Emissions Trading (2007) *Report of the Task Group on Emissions Trading ("The Shergold Report")*, Australian Government, 31 May 2007

Australian Government Productivity Commission (1997a) *The automotive industry: Volume 1 – the report*, Report No. 58, 26 May 1997, www.pc.gov.au

Australian Government Productivity Commission (1997b) *The automotive industry: Volume 2 – Appendices*, Report No. 58, 26 May 1997, www.pc.gov.au

Australian Government Productivity Commission (1998) *Aspects of structural change in Australia: Commission research paper*, www.pc.gov.au

Australian Government Productivity Commission (2001) *Structural adjustment – key policy issues: Commission research paper*, www.pc.gov.au

Australian Government Productivity Commission (2005) *Review of national competition policy reforms: Inquiry report*, www.pc.gov.au

Australian Government Treasury (2008) Australia's Low Pollution Future – The Economics of Climate Change Mitigation, 30 October 2008, http://www.treasury.gov.au/lowpollutionfuture/

Australian Institute of Petroleum (2006) *Submission to the Inquiry into the Price of Petrol in Australia* – Federal Parliament Senate Economics Committee, August 2006.

Australian Institute of Petroleum (2008) *Submission to the Department of Climate Change Green Paper on the Carbon Pollution Reduction Scheme*, 10 September 2008. http://www.aip.com.au/topics/submissions.htm

Behncke, E. and Hynd, J. (2010) *Adelaide Brighton Strong FY09 result; outlook less upbeat due to pricing*, Deutsche Bank Global Markets Research, 18 Feburary 2010

BHP Billiton (2007a) *Presentation by Coal CSG President Dave Murray to analyst visit*, Hunter Valley Energy, 2 November 2007

BHP Billiton (2007b) *Presentation by Coal CSG President Dave Murray to analyst visit*, Queensland & NSW, 31 October 2007

BHP Billiton (2008a) *BHP Mt Arthur Coal annual environmental management report*

BHP Billiton (2008b) *BHP Billiton Mitsubishi Alliance sustainable development report*

BHP Billiton (2008c) *Illawarra Coal sustainability report*

BHP Billiton (2008d) *Aluminium Investor Presentation Australia Analysts Site Visit*, 29 October 2008

BHP Billiton (2009a) *BHP Billiton Annual Report 2009*, available from http://www.bhpbilliton.com/bb/investorsMedia/reports/annualReports.jsp

BHP Billiton (2009b) *A focused Strategy in Aluminium,* presentation by Jon Judas to investors, 8 October 2009

BHP Billiton (2010) *Transcript from BHP Billiton Interim Results* – Presentation, Wednesday 10 February 2010, page 15. http://www.bhpbilliton.com.au/bbContentRepository/docs/bhpBillitonInterimResultsPresentationTranscript2010.pdf

Binh Tran-Man (2000) *The Implementation Costs of the GST in Australia: Concepts, Preliminary Estimates and Implications*, Journal of Australian Taxation, 5, pp 331-343

Bluescope Steel (2009) *Financial History*, http://www.bluescopesteel.com/go/investors/financial-/-production-history

Boral Limited (2008) *Boral Limited Annual Review 2008*, www.boral.com.au

Boral Ltd. (2010) *Boral Limited Half Year Results ended 31 December 2009* – Management Discussion and Analysis, 10 February 2010.

Boston Consulting Group (2008) *Assessment of impact of 2013-2020 ETS Proposal on European Cement Industry – Methodology and assumptions*, 6 November 2008, prepared for Cembureau (the European Cement Industry Association)

BP Australia (2008) *BP in Australia Sustainability Review* – 2007-08

BP Australia (2009a) *BP-Bulwer Island Refinery Verified Site Report 2008*, Sept 2009

Brook Hunt (2008) *The long-term outlook for Aluminium.* Brook Hunt – Wood Mackenzie, September 2008

Bureau of Steel Manufacturers of Australia (2008) *Submission response to Carbon Pollution Reduction Scheme Green Paper*, September 2008

Carbon Environment Daily (2010) *Alcoa and Loy Yang Power slot carbon agreement into long-term smelter power deal*, 2 March 2010

Carbon Storage Taskforce (2009) *National Carbon Mapping and Infrastructure Plan – Australia*: Concise Report, Department of Resources, Energy and Tourism, Canberra. http://www.ret.gov.au/resources/Documents/Programs/CS%20Taskforce.pdf

Cement Australia (2008) *Carbon Pollution Reduction Scheme Green Paper Submission*, 12 Septermber 2008

Cement Industry Federation (2005) *Submission to Productivity Commission Inquiry into Private Cost Effectiveness of Energy Efficiency*

Cement Industry Federation (2008) *Cement Kiln Cogeneration – Asia Pacific Clean Development and Climate Cement Task Force Demonstration Project*, Cement Industry Federation. www.cement.org.au/file_download/5/Cement

Cement Industry Federation (2009a) *Submission to the Senate Select Committee on Climate Policy*, 26 March 2009

Cement Industry Federation (2009b) *Cement Industry Statistics 2008*, www.cement.org.au

Chan, B. (2008) *Cement dodges a carbon bullet*; Merrill Lynch, 15 December 2008

Chan, B. (2009a) *Adelaide Brighton Ltd. 1H09 Result – Import tap being turned off*, Merrill Lynch Equity Analysis, 20 August 2009

Chan, B. (2009b) *Building Materials – Australia: Calm before the storm, or no storm at all*? Merrill Lynch Equity Analysis, 24 June 2009

Chevron Australia (2005) *Draft Environmental Impact Statement/Environmental Review and Management Programme for the Proposed Gorgon Development*, September 2005. http://www.chevronaustralia.com/ourbusinesses/gorgon/environmentalresponsibility/environmentalapprovals.aspx

Chevron Australia (2006) *Final environmental impact statement/response to submissions on the environmental review and management programme for the proposed Gorgon development*, May 2006

Chevron Australia (2010) *Gorgon downstream joint venture fact sheet*. http://www.gorgon.com.au/06-news/factsheets/Gorgon%20Fact%20Sheet%20-%20Downstream%20Joint%20Venture.pdf accessed 25/03/2010

Climate Strategies (2008) *EU ETS impacts on profitability and trade – A sector by sector analysis*; UK Carbon Trust, January 2008. www.carbontrust.co.uk

Climate Works Australia (2010) *Low carbon growth plan for Australia*, March 2010. www.climateworksaustralia.org

Coal and Allied (2008) *Coal and Allied Hunter Valley Operations South Coal Project Environmental Assessment Report*, Jan 2008

Conner, D. (1998) *Leading at the Edge of Chaos: How to Create the Nimble Organisation*, Canada: John Wiley and Sons

Credit Suisse (2009) *CPRS – Choking potential reinvestment in steel*, 17 September 2009

CSR Limited (2009) *Submission – Treatment of electricity intensity, trade-exposed industries under the expanded national Renewable Energy Target scheme* – 13 February 2009

Coal Mining (2009) *Xstrata Coal's United Collieries mine to close*, 15 June 2009. Accessed from: http://www.miningcoal.com.au/news/Xstrata-Coals-United-Collieries-mine-to-close

ConocoPhillips (2009) *Submission to Senate Comittee on the Carbon Pollution Reduction Scheme*. March 2009

Cornish, N. (2008) *Bluescope Steel Port Kembla steelworks and prinhill analyst site visit*, 15-16 May 2008, http://www.bluescopesteel.com/investors/presentations

Cuevas-Cubria, C., Penney, K., Schultz, A., Lampard, M. and Copeland, A. (2009) *Energy in Australia 2009*, ABARE. http://www.abare.gov.au/publications_html/energy/energy_09/auEnergy09.pdf

DeCanio, S. (2009) *Is economics the wrong language for addressing climate policy?* Paper presented to the joint University of California/American Council for an Energy-Efficient Economy (ACEEE) workshop, *Energy and economic policy models: A re-examination of some fundamentals*, Washington DC, November 16-17 2009

DeCanio, S. and Watkins. W. (1998) "Investment in energy efficiency: Do the characteristics of firms matter?" *The Review Of Economics and Statistics*, 80:1 pp.95-107

Domanski, R. (2009) *Address to the Energy Users Association of Australia Annual Conference*, Energy Users Association of Australia

Downer, A. (1998) *Emissions Trading: Harnessing the Power of the Market*. Address by the Hon Alexander Downer, MP, to the ABARE International Conference on Greenhouse Gas Emission Trading, 21 May 1998

Droge, S. (2009) *Tackling Leakage in a World of Unequal Carbon Prices*, Climate Strategies, 1 July 2009, www.climatestrategies.org

Ecofys and Oko-Institut e.V. (2008) *Pilot on Benchmarking in the EU ETS – Report prepared for the German Federal Ministry for the Environment*, Nature

Conservation and Nuclear Safety and the Dutch Ministry of Economic Affairs, November 2008

Energy Supply Association of Australia (2007) *Electricity Gas Australia 2007*

Energy Supply Association of Australia (2009) *Australia's Energy Supply Industry Facts in Brief*, http://www.esaa.com.au/images/stories/FactSheets/2009facts.pdf

Energy Information Administration (2009) *International Energy Outlook 2009*, May 2009, US Department of Energy, www.eia.doe.gov/oiaf/ieo/index.html

ERM (2009) *Environmental assessment, proposed Integra underground coal project*, July 2009

Fitzgerald, B. (2004) *ExxonMobil's new helmsman has big calls to make*, *The Age*, 20 July 2004

Fitzgerald, B. (2010) *Smelter Power Deals*, The Age, 2 March 2010

Fitzpatrick, M. (1983) *The definition and assessment of political risk in international business: A review of the literature*, Academy of Management Review, 8 (2), 249-254

French, H. (2007) *Far from Beijing's Reach, Officials Bend Energy Rules*, New York Times, 24 November 2007

Frontier Economics (2010) *Energy purchase costs* – A final report prepared for IPART, March 2010, available from: http://www.ipart.nsw.gov.au/files/Consultant%20Report%20-%20Frontier%20Economics%20-%20Final%20Report%20-%20Energy%20Purchase%20Costs%20-%20March%202010%20-%20WEBSITE%20DOCUMENT.PDF

Garnaut, R. (2008a) *The Garnaut Climate Change Review, Interim Report to the Commonwealth, State and Territory Govermnets*, February 2008, www.garnautreview.org.au

Garnaut, R. (2008b) *The Garnaut Climate Change Review, Final Report*, www.garnautreview.org.au

Garvey, P. (2009) *Chevron cuts deep, puts Caltex in doubt*, The Australian Financial Review, 11 March 2010

GLNG (2009) *Environmental Impact Statement*

Government of Western Australia Office of Energy (2009) *Electricity retail market review – final recommendations report, review of electricity tariff arrangements*, Jauary 2009

Grant-Taylor, T. (2007) *Wagners concretes its future*, Courier Mail, 12 July 2007

Greenwood, M., Wilson, B. and Sweet, A. (2009) *Woodside Petroleum North West Shelf and Browse: a marriage made in heaven, or not?* JP Morgan Asia Pacific Equity Research, 17 September 2009

Heap, A. and Tonks, A. (2009) *Commodity Heap – Aluminium: China Capacity Measures No Major Impact*, Citi Investment Research and Analysis, 2 October 2009

Hepburn, C (2006) *Regulation by prices, quantities or both: a review of instrument choice,* Oxford Review of Economic Policy, Summer 2006 v22 i2, p226

Hepworth, S. (2008) *A tale of two businesses* – Presentation to Macquarie Capital Securities Australia Conference, Caltex Australia Limited, 8 May 2008

Hetherington (2008) *The Full-Cost Economics of Climate Change Aluminium: A Case Study*, Per Capita July 2008

High Court of Australia (2009) *ICM Agriculture Pty Ltd v The Commonwealth* [2009] HCA 51

Hirjee, Morgan and Lewandowski (2009a) *Australian LNG Projects – Gorgon Project Overview*, Deutsche Bank Global Markets Research, 10 September 2009

Hirjee, Morgan and Lewandowski (2009b) *Australian LNG Sector - Refreshing the view and becoming bearish LNG pricing*, Deutsche Bank Global Markets Research, 14 October 2009

Hirjee, J. and Morgan, H. (2009c) *Santos $3bn raised, PNG LNG funded*, Deutche Bank Global Markets Research, 16 June 2009

Hirjee, Morgan, Lewandowski (2010) *Australian LNG Projects Not so quiet on the Western Front*, Deutsche Bank Global Markets Research, 15 March 2010

Hopkins, P. (2009) *Carbon offset scheme forces cement plant to close*, Sydney Morning Herald, 21 August 2009.

Hughes, J. (1987) *Sovereign risk*, Euromoney Publications, London

Hydro (2008) *Hydro 2008 Annual Report*, Norsk Hydro ASA, 18 March 2009, www.hydro.com

Hydro (2009a) *Submission to Senate Select Committee on Climate Policy*, 8 April 2009

Hydro (2009b) *Investor Presentation Quarter 2 - July 2009*, www.hydro.com

Hydro (2010) *Hydro Annual Report – 2009*, available from: http://www.hydro.com/upload/Annual_reporting/annual_2009/downloadcenter/Reports/01_annual_report.pdf

Industry Commission (1994) *Petroleum Products* – Report No. 40, 5 July 1994, Australian Government Printing Service

Industry Commission (1998) *Micro Reform – Impacts on Firms: Aluminium Case Study*, Research Paper, AusInfo, Canberra, March 1998

Inpex (2009) *Ichthys fact sheet*. http://www.inpex.com.au/media/4443/ichthys-proposal-fact-sheet.pdf

International Aluminium Institute (2007) *Life cycle assessment of aluminium: Inventory data for the primary aluminium industry year 2005 update*. International Aluminium Institute, September 2007

International Aluminium Institute (2009) *Alumina Production Statistics issued 20 November 2009*. http://stats.world-aluminium.org/iai/stats_new/formServer.asp?form=5, accessed 25/11/09

International Energy Agency (2007a) *Tracking Industrial Energy Efficiency and $CO_2$ Emissions*, International Energy Agency, Paris, 2007

International Energy Agency (2007b) *Climate Policy, Uncertainty, and Investment Risk* International Energy Agency, Paris, 2007

International Energy Agency (2009) *World Energy Outlook 2009 Fact Sheet*, International Energy Agency. http://www.worldenergyoutlook.org/docs/weo2009/fact_sheets_WEO_2009.pdf

International Energy Agency (2010) *Greenhouse Gas R&D Programme - $CO_2$ Capture and Storage*,

http://www.co2captureandstorage.info/project_specific.php?project_id=122 accessed 09/02/2010

International Iron and Steel Institute (2006) *World Steel in figures*

International Iron and Steel Institute (2008) *World crude steel production*, January 2008

Kakoschke, B. (2009) *Adelaide Brighton Limited, In need of a catalyst*; Patersons Securities Limited – Research Note, 24 August 2009

Kim, Y.M. (2010) *Carbon Tax Plan Floated*, The Korea Herald, 17 February 2010

Knights, P. and Hood, M. (eds) (2009) *Coal and the Commonwealth – The Greatness of an Australian Resource*, The University of Queensland, Australia, October 2009

McColl, J. C. and Young, M. D. (2005) *Managing change: Australian structural adjustment lessons for water*, CSIRO, www.csiro.au

McKinsey and Company (2006) *EU ETS Review – Report on International Competitiveness*, December 2006

McLennan Magasanik Associates and KPMG-Econtech (2009) *Queesland LNG Industry Viability and Economic Impact Study* – Final Report to Queensland Department of Infrastructure and Planning, 1 May 2009.; ACIL Tasman

McNee, M. and Hannam, J. (2010) *Adelaide Brighton Limited FY09 Result – Solid Performance in Weak Market*; Goldman Sachs JBWere Investment Research, 18 February 2010

McNee, M. and Staines, A. (2009a) *Boral Limited – Can concrete prices increase in a declining volume environment*, Goldman Sachs JBWere Investment Research, 18 March 2009

McNee, M. and Staines, A. (2009b*) Boral Limited/Adelaide Brighton - Holcim Acquires Cemex*, Goldman Sachs JBWere Investment Research Australia, 15 June 2009

Macarthur Coal (2009a) *Financial Results Year Ended 30 June 2009*, 26 August 2009, http://www.macarthurcoal.com.au/InvestorInformation/tabid/57/Default.aspx

Macarthur Coal (2009b) *Full year financial report*

Mohr, L., Graichen, V. and Schumacher, K. (2009) *Trade flows and cost structure analysis for exposed industries int he EU-27*, Climate strategies working paper, 19 March 2009. www.climatestrategies.org

Morgan Stanley (2008) *Australian Extractive Industries*

National Academies of Science of the United States, France, Brazil, Canada, China, Germany, India, Italy, Japan, Russia, United Kingdom (2005) *Joint Science Academies' statement: Global response to climate change*, 6 July 2005, available from: http://www.nationalacademies.org/onpi/06072005.pdf

Navarre, R. (2009) *Presentation by Rick Navarre President Peabody Energy to Raymond James 2nd Annual Coal Investors Conference*, 10 November 2009

NSW Government Department of Planning (2007) *NSW Planning application P07_0035*, NSW Department of Planning Assessment Report, October 2007

NSW Government Department of Planning (2008) *Major project assessment Invincible coal project*, December 2008

Okuno, Y. (2006) *Prospects of Iron and Steel Production and Progress of Blast Furnace Route in China*, Nippon Steel Technical Report No. 94, July 2006

OneSteel (2004) *OneSteel lifts net operating profit after tax to $108.1 million*, media release 17 August 2004

OneSteel (2005) *Full year results presentation*, 16 August 2005

OneSteel (2006) *OneSteel lifts net operating profit after tax by 12.1% to $171.6 million*, media release 22 August 2006

OneSteel (2007) *OneSteel lifts net operating profit after tax by 15.1% to $197.5 million*, media release 21 August 2007

OneSteel (2008a) *EBITDA of $767 million at upper end of market guidance*, ASX release, 19 August 2008

OneSteel (2008b) *Presentation to Macquarie Asian Investor by Geoff Plummer*, CEO OneSteel, 30 October 2008

OneSteel (2008c) *Annual Report*

OneSteel (2009a) *FY09 Statutory net profit after tax $230 million; underlying net profit after tax $125 million*, ASX release 18 August 1009

OneSteel (2009b) *Operational Site Tour*, 22 September 2009

OneSteel (2009c) J.P. Morgan Conference Presentation by Geoff Plummer, October 2009

Origin Energy, www.originenergy.com.au

Paul, N. (2009) *New Mill Cements Work Opportunities*, The Morning Bulletin, 6 November 2009.http://www.themorningbulletin.com.au/story/2009/11/06/new-mill-cements-work-opportunities/_accessed on 1 February 2010

Peabody Enery (2008) *Metropolitan coal project environmental assessment*

Pers. Comms. (2009a) *Grattan Institute correspondence with Cement Industry Federation staff* – 04/12/2009

Pers. Comms. (2009b) *Grattan Institute email correspondence with ExxonMobil staff* – 09/12/2009

Pers. Comms. (2009c) *Confidential discussions with aluminium industry analysts*

Pers. Comms. (2010a) *Grattan Institute discussions with Aluminium industry analysts* -  12/2009 and 01/2010

Pers. Comms. (2010b) *Grattan Institute email correspondence with Caltex staff regarding the 2007 period* – 09/12/2009 and 05/02/2010

Pers. Comms. (2010c) *Grattan Institute email correspondence with Caltex staff regarding the 2008 period* – 16/02/2010

Pers. Comms. (2010d) *Grattan Institute discussions with Australian oil industry analysts regarding the 2008 period* - 2010

Pervan, M. and Robertson, N. (2010) *ANZ Commodity Weekly*, Australia and New Zealand Banking Group Limited, 29 March 2010

Pervan, M., Robertson, N., Briggs S., Lim, S. and Deane, P. (2010) *ANZ Commodity Weekly*, 22 February 2010, Australia and New Zealand Banking Group Limited

Pivot Capital Management (2009) *China's Investment Boom: the Great Leap into the Unknown*, 21 August 2009, http://www.pivotcapital.com/research.html

Plummer, G. and O'Malley, P. (2009) *Opening statement, BlueScope Steel and OneSteel Senate Committe on Climate Policy*, 22 April 2009

Point Carbon (2010) *Singapore eyes carbon tax*, 23 February 2010. www.pointcarbon.com

QGC Limited (2009) *Queensland Curtis LNG Environmental Impact Statement*, July 2009

Queensland Alumina Limited (2008) *Health, Safety, Environment and Communities Report*

Ramsey, G. and Hardie, C. (2009) *Australian Energy – Cooking with LNG,* UBS Global Equity Research, 1 October 2009

Reinaud, J. (2005) *Industrial competitiveness under the European Union Emissions Trading Scheme*, International Energy Agency, Paris, February 2005

RBA (Reserve Bank of Australia) *Table F15*, www.rba.gov.au

Rio Tinto (2006a) *Rio Tinto Aluminium Financial community site visit* – June 2006

Rio Tinto (2006b) *Coal Australia sustainable development report*

RioTinto Alcan (2008a) *Bell Bay Sustainable Development Report*

RioTinto Alcan (2008b) *Gladstone Sustainable Development Report*

RioTinto Alcan (2008c) *Gove Sustainable Development Review*

Rio Tinto (2008d) *London Investor Meetings* – Presentation by Dick Evans, Chief Executive Rio Tinto Alcan, 15 October 2008

Rio Tinto (2008e) *Energy and Minerals Seminar*, 25 July 2008

Rio Tinto (2008f) *Coal Australia sustainable development report*

Rio Tinto (2008g) *Presentation by Dick Evans to the Rio Tinto Alcan financial community site visit – Saguenay*, 12 March 2008

Rio Tinto (2008h) *Rio Tinto Alcan financial community site visit*, 15-20 June 2008

Rio Tinto (2009a) *Submission to COAG Working Group on Climate Change and Water discussion paper Treatment of electricity-intensive, trade exposed industries under the expanded national Renewable Energy Target scheme*, 13 Feb 2009

Rio Tinto (2009b) *Rio Tinto 2009 Investor Seminar QA Transcript - London, 30 October 2009* http://www.riotinto.com/documents/Investors/Rio_Tinto_annual_investor_seminar_2009_QA.PDF

Rio Tinto (2009c) *Investor Seminar*, 2 November 2009

Robins, B. (2010) *Carbon plan may break us: generator*, Sydney Morning Herald, 16 January 2010

Sakamaki, S. and Hirokawa, T. (2009) *DPJ to Raise Target for Japan's Greenhouse-Gas Cuts, Okada Says,* Bloomberg, 27 July 2009

Samuel, G. (2002) *Independent Expert Report – Schemes of arrangement between WMC Limited and its shareholders and option holders in relation to the demerger of WMC Limited*

Santos (2009) 2009 *Investor Seminar – Delivering Transformational Growth*, 9 December 2009

Sasistiya, R. (2009) *Indonesia to Limit Coal Exports as Domestic Demand Grows*, Jakata Globe, 14 October 2009

Senate Standing Committeee on Economics (2006) *Petrol Prices in Australia*, December 2006

Shell Australia (2007) *Shell Australia's Submission to the Australian Competition and Consumer Commission Inquiry into the Price of Unleaded Petrol*, July 2007

Simon, H. (1978) *Rationality decision making in business organisations*, Nobel Memorial Lecture, 8 December 1978

Southwood, M., Gray, P. and Veitch, K. (2008) *Base Metals: Revisiting "Cost-Support" Levels*, Goldman Sachs JBWere Investment Research, 4 November 2008

Southwood, M. and Gray, P. (2010a) *Commodities. Focus on Chinese Steel Production – Implications for Iron Ore*, Goldman Sachs JB Were Investment Research

Southwood, M. and Gray, P. (2010b) *Iron Ore and Coking Coal: Price Forecast Upgrade*, Goldman Sachs JBWere Investment Research, 9 March 2010.

Southwood, M. and Gray, P. (2010c) *Thermal Coal: Contract Price Forecast Upgrade to US$90/t*, Goldman Sachs JBWere Investment Research, 4 February 2010

State Electricity Commission of Victoria (2009) *State Electricity Commission 2008-2009 Annual Report*, http://www.vicpower.com.au/docs/SECV%20Annual%20Report%202008-2009.pdf

Synergy, www.synergy.net.au

Tanners, T., Snowdowne, A., Luther, P.T. and Zilberberg, M. (2009) *China vs. ROW: A tale of two steel markets*, UBS Investment Research, 23 September 2009

Taylor, A. (2009) *Cement plant closes*, The Morning Bulletin, 21 August 2009

Thaler, R. and Sunstein, C. (2008) *Nudge: Improving decisions about health, wealth and happiness*, London: Penguin Books

The Carbon Trust (2010) *Tackling carbon leakage – Sector-specific solutions for a world of unequal carbon prices*, The Carbon Trust – United Kingdom, March, 2010. www.carbontrust.co.uk

Transend (2009) *Transmission Shared Network Prices for 2009-10*

Tulloh, C., Ahammad, H., Mi, R. and Ford, M. (2009) *Effects of the Carbon Pollution Reduction Scheme on the economic value of farm production* – Issues Insights 09.6, ABARE, June 2009. www.abare.gov.au

Turton, H. (2002) *The Aluminium Smelting Industry – Structure, market power, subsdies and greenhouse gas emissions*, Number 44, January 2002, Australia Institute

UBS (2009a) *UBS Investment Research – Australian Steel, Sifting through the CPRS*, 11 September 2009

UBS (2009b) *UBS Investment Research - Australian Steel, CPRS – Choking potential reinvestment in steel*, 19 October 2009

US EPA (2009) *Coal mine methane recovery: a primer*. EPA-430-R-09-013, September 2009, http://www.epa.gov/cmop/docs/cmm_primer.pdf

USGS(1999) *Primary Aluminium Plants Worldwide - 1998*, July 1999

USGS (2009) *2008 Minerals Yearbook*, United States Geological Survey, November 2009

Valadkhani, A. and Layton, A. P. (2004) *Quantifying the effect of GST on inflation in eight Australian cities: an intervention analysis.* Australian Economic Review, 37 (2). pp. 125-138

Victorian EPA (2008) *Greenhouse Gas Emissions Reporting and Disclosure Pilot - Combined participant's emission reports*. http://www.epa.vic.gov.au/greenhouse/greenhouse_pilot/default.asp

Warnken, M. (2003) *Use of Biomass as a Fossil Fuel Replacement in Australian Cement Kilns*, Warnken ISE. http://www.warnkenise.com.au/pdfs/Use%20of%20Biomass%20as%20Fossil%20Fuel%20Repalcements%20in%20Australian%20Cement%20Kilns.pdf

Woods, I. (2006) *Emissions Trading and the Aluminium Industry*

Woodside (2007) *Pluto LNG project greenhouse gas abatement program*, October 2007

Woodside (2009a) *Update on the Pluto LNG Project*, ASX Announcement 20 November 2009

Woodside (2009b) *Energy To Deliver – Woodside Annual Investor Briefing Day*, 24 November 2009

Woodside (2009c) *Sustainable Development Report* 2008

Wong, F. (2009) *Indonesian coal miners:sold big volumes of 2010 to China*, Reuters, 11 November 2009

World Business Council for Sustainable Development (2009) *Cement Sustainability Initiative Database*. http://www.wbcsdcement.org/index.php?option=com_content&task=view&id=57&Itemid=118

World Resources Institute (2009) *Climate Analysis Indicators Tool version 7.0*, http://cait.wri.org/

Worsley Alumina (2007) *Health, Safety, Environment and Community Report*

Worsley Alumina (2008) *Work starts on new power station*. News release, November 2008

Xinhua News Agency (2007) *China adjusts tariff on aluminum products to cut energy consumption, pollution*, 20 July 2007, http://au.china-embassy.org/eng/zt/GlobeClimateChange/t342616.htm

Xstrata (2009a) *Xstrata Coal Steaming Ahead*, Presentation to investment analysts site visit to Hunter Valley, New South Wales, 28 May

Xstrata (2009b) *Xstrata Annual Report 2008*, available from http://www.xstrata.com/investors/reports/2008

Xstrata (2009c) *Investor Seminar 2009 Progressing Xstrata's Strategy: The Growth Within*, 3 and 8 December 2009, London